MECHANICAL CULTIVATION IN INDIA

Tractor cultivation in progress in *Tarai* tracts of Uttar Pradesh

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MECHANICAL CULTIVATION IN INDIA

BY

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FOREWORD

Mechanization of agriculture has lagged behind that of industries. In the advanced countries of the West, introduction of machine on the farm started late in the last century. Even so, while in industry, we are proceeding from rationalization to automation, in agriculture mechanization continues to be an object of controversy. Any slavish copying of the West with its 50 to 100 acre average farms, without a full and careful study of the farming conditions in India, would spell disaster. The form or pattern which may do well in one country, may not necessarily suit another. And conditions in agriculture depending upon terrain, climate, rainfall, farming practices and land system, differ widely from one part of the world to the other. In deciding whether we should resort to mechanization of agriculture (and if so, the extent to which we should go) many factors would need thorough examination.

The enthusiasts of mechanization claim all the virtues for it. Equally strongly the opponents refuse to attribute any increase of production to mechanization. The truth lies somewhere between the two. While it is wrong that mechanization of agriculture can be done under all conditions, it is apparent that where there are large holdings, paucity of labour, and limitation of time within which some operations have to be done, mechanization has its own place. In certain heavy operations like land reclamation, soil conservation and the like, which require considerable labour, mechanization appears to be inescapable. Nonetheless, in a country like India where the vast majority of agriculturists have only a two to three acre farm, mechanization is hardly a feasible proposition on any large scale. The financial resources of the agriculturist and his capacity to find the wherewithal for buying and maintaining the machinery are other important factors. Any generalization from the study of a particular tract or set of conditions would suffer from over-simplification and would not correspond to facts.

In dealing with agricultural problems, sometimes we are apt to forget the man behind the plough. Money and implements are important, but the human factor is even more important. I am glad that this monograph has not altogether overlooked the human aspect of the problem. It has been observed that " One man on a 50-acre holding might show increase in productivity through mechanization, whereas his neighbour even with more land might find it a liability. The tractor is merely a machine; it cannot think; it cannot act; and can be made productive only by efficient management." The unsophisticated Indian farmer is not machine minded, and any attempt to force rapid mechanization in agriculture may prove fatal. Fortunately, agriculture is the occupation of that sector of humanity which does not change by fits and starts. Any change in it will come only from within the totality of rural life. This by itself is a guarantee, at least in a democratic country, against over-hasty mechanization. Wherever new agricultural implements and machines have found large-scale acceptance, we may legitimately infer that the prevailing conditions have warranted the change.

Our progress is inexorably bound up with the use of the latest and most efficient technological processes, and the change-over to modern methods of production is essential. It is necessary to strike a new equation between the traditions handed down to us from the past and the necessities of the present. While our approach should be cautious, we cannot rule out the utility of mechanization under all conditions. At any rate, a closed mind is a sign of retrogression; and a time has been reached when we should study the prospects of mechanization in the field of our agriculture. This monograph, produced by the Indian Council of Agricultural Research, sets out in a scientific way the available information on the subject. The problem has been dealt with in a practical manner, keeping in forefront the conditions of our countryside. The subject has been approached with objectivity, and anyone who reads these few pages with an open mind will, I am sure, receive new light.

AJIT PRASAD JAIN
Minister for Food and Agriculture
Government of India

New Delhi
March, 1957

PREFACE

Mechanization of production is a fact of the modern age that Indian thought must reckon with. It demands a revaluation of the accepted beliefs, and a fundamental change of outlook. But in a country like ours, which is predominently agricultural and is incrustate with rigid traditions, break with the past will not be easy. And in spite of the fermentation of thought taking place, the mass-mind will change only gradually. However, the ground would have to be prepared, and new ideas broadcast so that in the fullness of time release may come from the slough of the past. For this, proper understanding of the needs peculiar to our growth has to be secured on the widest possible scale. This will put a stop to loose thinking, and make for fruitful planning. It is for this reason that Dr. Gadkary's book ' Mechanical Cultivation in India ' acquires its special significance.

In 1935, the Imperial Council of Agricultural Research, now named Indian Council of Agricultural Research, published a monograph by Mr. C.P.G. Wade, containing a history of the experiments carried out by the Burmah-Shell Oil Storage and Distributing Company of India in the field of mechanical cultivation. That book is out of print now. Since rapid technological advancement has taken place during the last two decades in agricultural machinery and implements, need has been felt for making a thorough study of the subject afresh. The work was entrusted to Dr. D. A. Gadkary, Joint Director of Agriculture, Bombay State in 1952. A large mass of information was collected by him from various States in the country. The book he has written is, therefore, based on tested experience. It covers an extensive field, dealing as it does with subjects like the scope for mechanical cultivation in the country, farm machinery and implements suitable for different areas, maintenance of machinery, and organizational problems.

The book has been ably edited by Mr. Prem Nath, Editor, Indian Council of Agricultural Research. The art work has been done by Mr. B. S. Matella of the Art Section of the Council. It is hoped that in its present form it will prove of interest to the progressive farmer, the student of agriculture, and the agricultural executive, alike.

New Delhi
March, 1957

M. S. RANDHAWA, D.Sc., I.C.S.
Vice-President
Indian Council of Agricultural Research

CONTENTS

LIST OF ILLUSTRATIONS

PLATE I

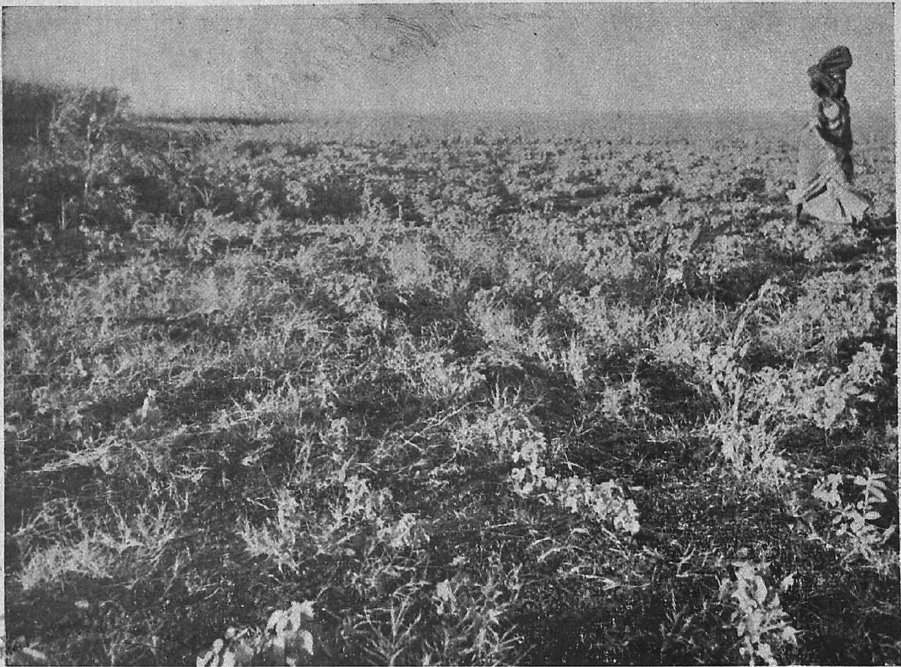


FIG. 1—A field covered with *hariali* before tractor ploughing

FIG. 2—*Hariali* uprooted by tractor ploughing

CHAPTER I

SCOPE FOR MECHANICAL CULTIVATION

MECHANIZATION of agricultural operations has undergone great changes during the last 50 years. With the development of the diesel engine and other mobile power units, it was natural that agricultural engineering should concentrate attention on the fullest employment of these for various farm-needs. In India, as in other countries, the earliest efforts at reducing drudgery and strain on human muscles had led to the use of animal traction-power. But mechanization in its fullest sense is comparatively a Western achievement; and it is only in recent times that advantage is being taken of its potentialities for increasing agricultural production in other parts of the world as well. The experience gathered under the rapidly evolving schemes of mechanized farming in advanced countries has, however, thrown into relief both the possibilities and limitations of use of machinery in relation to farming. Naturally, we in India are anxious to know as to how far it is desirable to proceed with the mechanization of agriculture under the conditions peculiar to our country. Mr. C. P. G. Wade had written a monograph on this subject in 1934, which outlined the scope for tractor ploughing in India, and had suggested a typical organization for contract tractor ploughing. The information given in that monograph has become out-of-date now, mainly on account of the rapid strides made during the last two decades in the design and construction of tractors and tractor-drawn implements. It is, therefore, necessary to review the subject afresh.

To determine whether mechanical cultivation is economically feasible under a particular set of conditions, it is necessary to consider the question in all its bearings from various standpoints. In this connection, the Food and Agriculture Organization of the United Nations has brought out several analytic studies, perusal of which will serve as a corrective to loose thinking on the subject. In a recent monograph issued by the Organization, it is observed: " The success of mechanization in highly developed farming countries has led a number of Governments to conclude that they could solve their food production problems by following similar lines. But, almost without exception, the rapid introduction of tractors and the equipment that goes with them into countries long dependent on animal power has been very expensive and anything but successful. Some Governments, because of the poor results achieved, are reviewing the whole matter of power mechanization, and a few are even advocating a return to, or continuation of, the traditional primitive tillage methods. The pendulum swung too far in one direction and it is now being pushed back. "

Before taking a decision on the issue of mechanical cultivation, a very careful review of the existing conditions and the various factors involved is extremely essential.

At present public opinion is sharply divided on it. It is outside the scope of this book to discuss the merits of the arguments advanced for and against the use of machinery on the farm; but an attempt is made in this chapter to focus attention on some of the major considerations which are relevant to the subject.

Mechanized farming to be a practical proposition, should be considered in its essential economic aspects, some of which are mentioned below:

(a) Topography, physical conditions and size of farm units;

(b) Existing techniques of various agricultural operations, and the human and animal factor in relations to farming;

(c) Character of village economy and agricultural needs;

(d) Cost of maintenance of machinery; and

(e) Organizational set-up needed for optimum utilization of machinery.

Topographical conditions in India show marked variations from State to State. Even within a defined geographical unit, soil conditions often vary considerably in various parts. Thus, any generalization made from the study of a particular tract or area would suffer from over-simplification, and would hardly correspond to facts. The extent to which mechanization will be useful and feasible in any particular region will depend entirely on the physical features and other factors peculiar to that region. The fact that mechanization has proved successful in a particular tract should not be taken to prove its general feasibility for other areas.

Some of the important factors on which economy and feasibility of mechanical cultivation are dependent are:

(1) Whether there is scarcity of labour for carrying out cultivation. In this connection, one has not merely to see the overall scarcity of labour but the scarcity during the peak periods when it is required for ploughing, sowing and/or harvesting. The labour may be human or animal. In the latter case, we have to consider whether enough animal power is available.

(2) The necessity or otherwise of carrying out a given operation in a given time. In case such a necessity does not exist, there would be no point in finishing a particular task earlier except to give leisure to the agricultural labour.

(3) The size of the holding and its fragmentation. Unless mechanical cultivation is carried out on cooperative basis, individual efforts in this direction are dependent upon the size of holding of land of that individual.

(4) Whether mechanical cultivation is necessary on account of certain operations being not capable of being carried out by human or animal labour.

(5) Whether higher production can be had by resorting to mechanical cultivation.

It may be argued that mechanization has justification other than economical. It would make the farm work less tedious, relieve drudgery and in short make farm life more attractive.

So far as the present Indian conditions are concerned, normally, there is not much scarcity of agricultural labour though recently a tendency has been observed where agricultural labour is not prepared to give its best during the peak periods. The labour scarcity is more acute in areas adjacent to big cities and industrial centres and in irrigated tracts. Similarly, though this country has a very large cattle population, the animals suitable for cultivation are not many.

The necessity of carrying out a given operation in a given time exists in India also in the case of certain agricultural operations, such as transplantation of paddy, sowing and harvesting of money crops, vegetables, etc.

The average holding in India is very small. The Famine Enquiry Committee (1945) observed that " Under all the land systems, the small holdings are the rule, large holding being relatively few in number and the general tendency is for the number of small holdings to increase. " Further, the result of the Agricultural Labour Enquiry conducted recently shows that the largest percentage of holdings is below two acres. The size of small holdings is due to sub-division and the primary cause of sub-division is the pressure of population on land, apart from the laws of inheritance in vogue among the Hindus and Muslims in India.

We will have, therefore, to deal separately with these two classes of cultivators so far as mechanical cultivation is concerned. In the case of small land holders having land of less than 25 acres, previous observers have remarked that the agricultural holdings have been reduced to a condition in which effective cultivation is now becoming impossible.

It would, therefore, be unwise to embark on a programme of ambitious mechanization without creating the necessary conditions under which the small holders could be induced to work co-operatively.

In countries where industry, trade and the professions are developing progressively, the need for labour-saving devices in all fields of production becomes paramount. However, in the absence of such development, mechanization must necessarily lead to a serious unemployment situation. Till recently, the growth of industry and other non-agricultural activities was very slow with the result that an overwhelming majority of the people had to depend entirely on land for their sustenance. This created a strong public prejudice against mechanization of agriculture; and the best economic and social thinkers threw their weight in favour of simple farming practices which had been carried on since times immemorial. However, the dynamics of changing economic conditions necessitate a review of the matter. Rightly understood, the point at issue at present is not whether mechanization should be adopted in relation to farm policies, but what should be the pace of mechanization in the context of the developmental programmes launched under the Five-Year Plans. While commenting on the ' unemployment ' argument in his book " Co-operation and Indian Agriculture ", Mr. A. K. Y. Narayana Aiyer, who was at one time Director of Agriculture in Mysore, observes thus: " It must also be pointed out that there is a strong body of opinion especially among actual farmers in the villages whether large or small that far from there being a surplus of labour, there is chronic shortage of labour in the villages and that the fear of machinery leading to unemployment and so on is not well founded. "

What is true about labour force also holds good to a great extent for the animal factor in Indian agriculture. So long as the demand for agricultural machinery does not expand, bullock-power must remain indispensable. Mechanization, by altering the methods of cultivation, would ultimately replace animal traction by mechanically operated machines. On first consideration this may appear to be a disturbing prospect, for not only the vast cattle force employed at present will be supplanted, but the sentiments generally governing the upkeep of cattle will also be disturbed. There is no doubt that in a tradition-bound country this will give rise to serious problems. However, as mechanization is to be a regulated process, the transition can be achieved without serious jolts. In any case, this would prove to be a boon to the cattle themselves for whom the orthodox critics are so solicitous. Our cattle are notoriously ill-fed, and fodder supply is generally not equal to the demand in the villages. The gradual replacement of animal-power by machines would result in a healthy dairying activity in which the health and well-being of the cattle would be regarded as a matter of paramount importance.

The village economy is in a process of rapid change. With the extension of communications and the spread of literacy, a deep metamorphosis is taking place. The Community Projects and National Extension Service schemes and the other developmental programmes taken up by the State are changing the outlook of the village-world very fast. It is obvious that the antiquated methods of production, whether in the field of agriculture or in that of industry, will have to go. With the opening of new occupational fields, manual labour, which is cheap at present compared to the machines, will increasingly become expensive. Besides, the growing requirements of village industries and trade will require a general reorientation of the existing agricultural techniques.

One of the most important and universal factors discouraging the adoption of mechanical equipment is its high initial as well as maintenance cost. With the present *per capita* income of farmers, it will be wrong to suppose that mechanization, even where it is economically justified and necessary, will be undertaken on any extensive scale on individual initiative. The State will, therefore, have to shoulder most of the responsibility in this regard. In selecting machinery it should be ensured that only such equipment is ordered as would be economical in all respects. Very complex machines, notwithstanding their great production attractiveness, should be avoided as far as possible. Apart from their high initial cost, which in most cases is prohibitive, they require expensive servicing and high technical personnel to handle them. Selection of suitable farm-machinery is, therefore, of utmost importance. This has been dealt with in Chapter III, where practical hints are provided for making a correct choice. The question of maintenance and servicing of equipment has also been treated in Chapter III.

Since the State will have to provide the necessary initiative, it is necessary that the organizational problems should be viewed as pertaining primarily to large administrative units. For the adoption of a coordinated policy and to ensure the best mechanical working, a proper administrative set-up will have to be devised. Attempt has been made in Chapter IV to outline the main factors that must receive careful attention in planning this set-up.

Enquiries made from the various Departments of Agriculture in the Indian Union to ascertain the scope of such cultivation in their States reveal the following:

I. *Factors coming in the way of expansion of mechanical cultivation:*

(i) present high cost of various mechanical operations.

(ii) difficulties in obtaining spares promptly.

(iii) high cost of repair work and lack of adequate servicing facilities.

(iv) low earning capacity and general poverty of cultivators even to the extent of inability to pay for tractor ploughing and other mechanical operations.

(v) lack of easy credit facilities and of the facility to make payment on instalment basis.

(vi) fragmentation of holdings.

(vii) scarcity of trained operational personnel.

(viii) lack of concentrated and adequately large demand.

(ix) absence of motorable approach roads to villages to carry oil and spares.

II. *Scope*—There is a steadily growing demand from the public for the use of tractors and bulldozers. Progressive cultivators are purchasing tractors either at their own cost or on a *taccavi* basis and are ploughing up their own as well as the lands of the neighbouring cultivators. Private cultivators owning large acreage exceeding 100 acres can economically undertake mechanical farming. Sugar factories offer a great scope for introduction of mechanical cultivation and are actually using large fleets of tractors. Cooperative societies formed for mechanical cultivation are very few and it is stated that lack of finance is coming in the way of their successful working. Reclamation of culturable waste land and old fallow offer great opportunity for utilization of mechanical cultivation. In view of the undulating terrain in some of the States, there is a great scope for bulldozing work, particularly in the areas coming under the irrigation command of major irrigation projects at present under construction. Similarly, the use of bulldozers for conversion of certain lands into paddy fields is being progressively made. In a few States like Madras, tractors are finding favour for puddling green manure, its incorporation and trampling in wet lands. Increasing use is being made of bulldozers in soil conservation work in certain States, particularly where labour cost is high. In the case of reclamation of ravine lands, bulldozing operations would be imperative.

It is, however, apparent that it would not be possible nor would it be advisable to recommend mechanical cultivation to the farmers having very small holdings unless they are prepared to form themselves into cooperative societies and have a central pool of machines for mechanical cultivation. It would also be necessary for the State Governments, cooperative bodies, or the tractor dealers to make adequate repair and servicing arrangements as well as have requisite stocks of spares on hand. Credit facilities and repayment in easy instalments will have to be provided. Not much progress in mechanical cultivation, it may be stated, can be anticipated in the near future through the formation of cooperative societies. Efforts will, however, have to be made on these lines in view of the general smallness of the holdings and the financial inability and inadvisability of cultivators to own their own mechanical equipments.

Another solution of this difficulty would be to do contract mechanical cultivation. In this connection, apart from the fact that the demand for concentrated work from an area would be lacking, there would be the difficulty of recovering charges of mechanical cultivation. Due to small holdings and fragmentation, the demand for mechanical cultivation from a few cultivators would not suffice and since machinery may have to be moved over appreciable distances to carry out the work offered, it will be found uneconomical to undertake such work on contract. Moreover, since cultivators do not usually have and will not be in a position to make cash payments in advance and since it may subsequently be found difficult to effect recoveries of bills towards cultivation work carried out, a private contractor will find it disadvantageous to start work except on strictly cash basis, which, as already stated above, would be very limited and normally uneconomical.

One major consideration deserving careful attention relates to the ownership of mechanical equipment. In a country like ours where the income of the farmers is very low, and where tradition continues to exercise decisive influence in all fields of life, the importance of this aspect of the question of mechanization cannot be

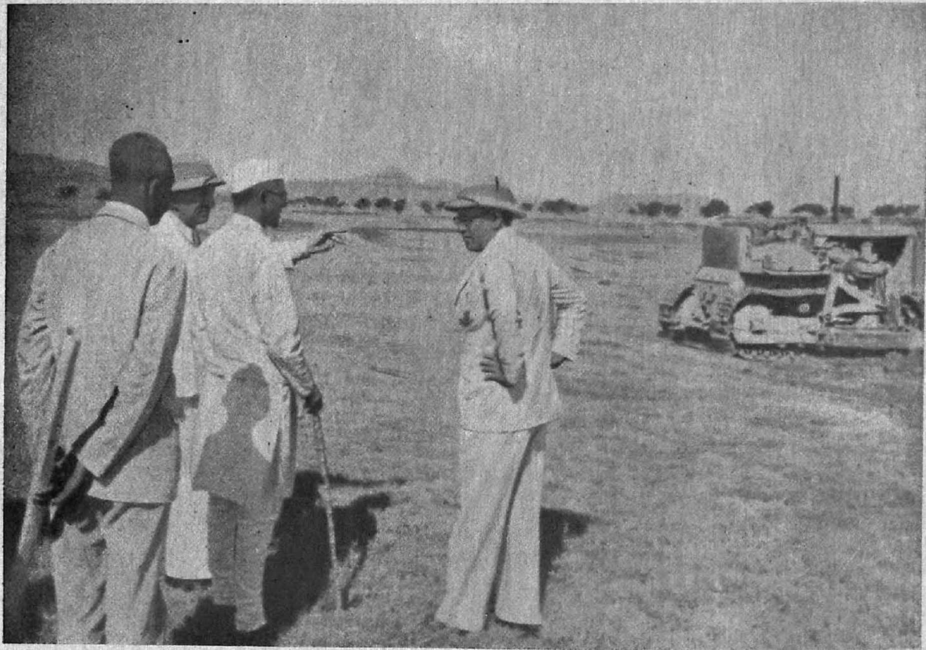


FIG. 1—Shri Morarji R. Desai, former Chief Minister of Bombay State, inspecting soil conservation work done with bulldozers

FIG. 2—Shri B. G. Kher, former Chief Minister of Bombay State, inspecting soil conservation work done with bulldozers at Narayangaon in Poona District

PLATE III

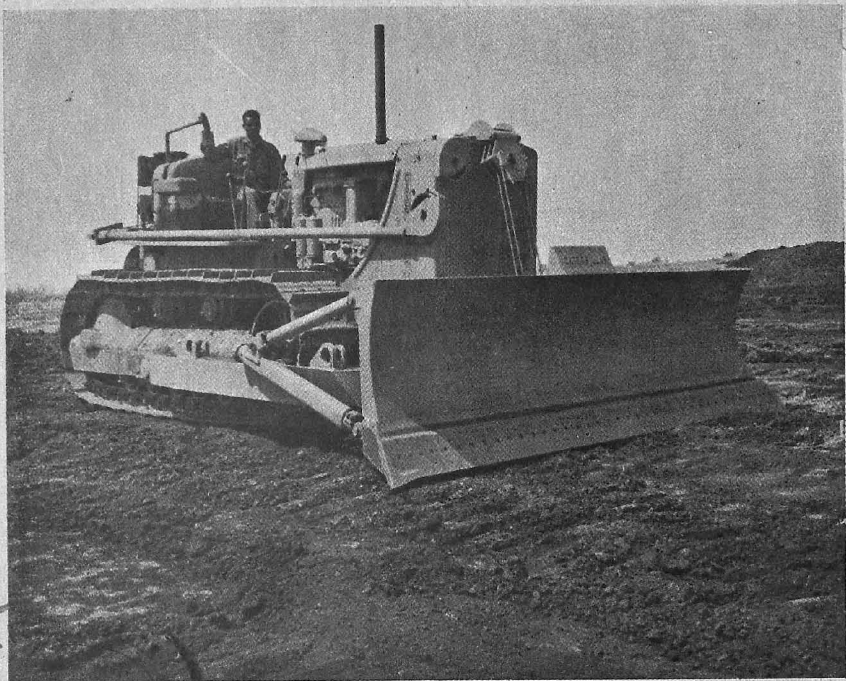


FIG. 1—Levelling: A view of land levelled by bulldozers

FIG. 2—Bunding : Area bunded by bulldozers

overstressed. Machinery may be owned and operated in one or more of the following ways:

*(a) By individual farmers who use it either exclusively on their own farms or also for hire or contract work among neighbours. In countries where this type of ownership and use prevails, machinery manufacturers usually have dealers who sell the equipment and maintain repair and maintenance shops.

(b) By individuals who use it for hire or contract work on farms at a charge per unit of land worked, per hour worked, or per unit of measure—for example, per bushel of grain threshed. Such individuals may own one tractor and its attachable implements or they may operate a large business with many machines.

(c) By farmers organized in machinery cooperatives which employ skilled operators of machines for work on members' farms. This method has not developed as rapidly as the first two methods because of the complicated problems of skilful cooperative management of the machinery.

(d) By public machine stations, where the Government or other public institution owns, maintains and operates machinery on farms, charging farmers at rates per hour or per unit of area or measure.

The initiative must necessarily come from Government, for in the beginning the farmers and individual contractors would have a natural hesitation in making investments in costly equipment until they are convinced of the returns. However, as the new ideas catch the imagination of the cultivators, and they are educated in the use and management of equipment, private machines stations may also develop eventually and reduce the amount of work to be done by the State agencies. But, the existing small holdings and the inevitable disappearance of large holdings in the near future under the impact of the land reform policies on which most of the States have already embarked, will be a serious obstacle in the way of progress of mechanization, unless cooperative methods of working can be evolved and popularized extensively. In the United Kingdom, where mechanized agriculture has recently made large strides, there are about 1·61 lakh tractors of 10 horse-power and over employed on an acreage of 19 millions, i.e., a tractor for every 118 acres. In addition, there are another 1·73 lakh tractors of the Market-garden type which are of less than 10 horse-power. Even if these smaller tractors are considered separately, the average acreage per tractor (all types included) works out to 56. This would give indication about the minimum acreage that is required for the economic employment of tractors. It follows, therefore, that cooperative working alone can make the use of machines a

* Reproduced from "Essential Considerations in Mechanization of Farming" issued by the F.A.O.

profitable proposition in India. In Sweden at present, most of the mechanical operations on land are generally done either by farmers and contractors who own the machines and operate them for others in return for payment, or by the Cooperative Farm Machinery Associations that jointly own the mechinical equipment and, besides, catering for the needs of the members do contract work for the non-members also. There are thousands of Cooperative Associations of this type, most of them serving 20 to 30 farms. Under the Indian conditions, too, some such working arrangement would have to be brought into existence.

To ascertain whether mechanized cultivation is economical and whether it does lead to increase in production or not, it may be worth-while to take stock of contemporary public opinion from the areas where mechanized cultivation is practised. The general consensus of opinion is that a good deal of importance has to be attached to individual endeavour. One man on a 50-acre holding might show an increase in productivity through mechanization, whereas his neighbour even with more land might find it a liability. The tractor is merely a machine; it cannot think; it cannot act and can be made productive only by efficient management. Management is dependent upon national farming policies and unless farming can be made a sound risk from an investment point of view, the capital for effective mechanization will not be forthcoming. Agricultural development is slow compared to that of other industries which do not have to consider the vagaries of soil and weather. It is a less flexible industry than those which are run under controlled conditions, and hence to achieve the desired stability, a long-term policy has to be assured.

Mechanization may be resorted to by a farmer usually for the following three main considerations:

(i) A farmer may purchase a machine to save labour with the idea of using the labour saved on other urgent work, or, as is so often the case in certain countries, labour is just not available.

(ii) The use of machine may make it possible to do work with less skilled labour than usual.

(iii) The machine may make a task easier.

By a small farm in foreign countries is meant a farm of 60 to 130 acres. While certain authorities believe that mechanization should be complete rather than partial, others feel that it is useless to mechanize operations if there is no alternative use for labour and if the machines have not enough work. Though mechanization allows a higher standard of living to those who live by the land, by making farm work less tedious, by relieving drudgery and by making farm life more attractive, it has also created a need for technical workers having sound knowledge of husbandry and mechanical ability. Normally, with the wages at their present level and a shortage of skilled labour there should be enough incentive for achieving efficiency but the factor lacking is the "know how". The three main factors in securing efficient management are: (i) choice of equipment, (ii) detailed supervision and (iii) adequate maintenance. While considering purchase of a machine, it has to be seen whether it could do a given job at the right time. A machine which does a job better, more quickly and at the right time, enables an increase in output both per acre and per man. Every proposal for capital investment should be carefully treated on its merits and the calculations made of the cost and revenue should slightly exaggerate the former and minimize the latter. The extent to which machinery can be substituted for labour would vary with the price of machinery, wage rates and price of the product.

The contemporary and scientific opinion in the various States in India on the issue of mechanization has been synthesized by Dr. Panjabrao Deshmukh, Minister for Agriculture, Government of India, in his article "Mechanization of Agriculture, Our Basic Industry". It will be useful to quote at some length from this well-reasoned article. He states: "It is necessary to assess what are the advantages of tractors and of mechanization of agriculture. In the first place, there are certain kinds of work which cannot be done by any other means except by using tractors. The clearing of jungle land especially in areas which were under cultivation previously, as in the case of the Naini Tal Tarai area, can be done only by tractors. Again there are deep-rooted grasses, such as Kans and Hariali, which can be controlled only by means of deep ploughing.

"Initial reclamation work cannot be done economically by any other means except by the use of heavy tractors.

"There is no evidence to show that conducting agricultural operations with tractor-power has by itself any advantage in respect of yield, though there are theoretical reasons for holding that the use of a machine must give better results, as it will give better tillage and more uniform depth of ploughing. But there is no question whatever that the use of a tractor will enable agricultural operations to be conducted in a more timely manner.

"There are no conclusive data to show that, per agricultural operation per acre, under present conditions, tractor cultivation is cheaper than cultivation by bullocks. But where there are large holdings, there seems to be some advantage in having only a small number of bullocks and one or two tractors in addition. Tractors, in such cases, can also be used for transport purposes, as for example, when compost or farmyard manure has to be transported from a nearby town.

"It is obvious that due to such reasons the tractors have become popular in this country, and every farmer who has a large holding and can afford to buy a tractor, either with his own resources or with a *taccavi* loan from the Government, is anxious to do so. But there are many more agricultural operations which are now done by manual labour or animal power which can be done by a tractor. At present, tractors are used in heavy land reclamation and also upto the stage of preparing the seed bed.

" But the use of tractors is not very common after the preparation of seed bed.

" Tractors can also be used with suitable adaptors for spraying of insecticides, fungicides, etc., and also for spreading of manure. These operations also are not for the present commonly done by the use of tractors in our country.

" Tractors can also be used for forming bunds, terraces, ridges, ditches, etc. The more a tractor is used, the better its operational economy, and I feel sure that with the extention of applications, mechanized agriculture will become more popular in the country.

" There is another application of tractors to which I have not referred so far and that is in the work of soil conservation. Where agriculture is taken up on undulating land or in an area where there are many water courses, soil conservation is very necessary. The use of dozers, graders and scrapers for this purpose will pay rich dividends, and there is good scope for this kind of work, especially on the part of State Governments.

" I feel I must also mention the limitations in regard to mechanization. One limiting factor is the smallness of holdings in our country. Our land policy naturally favours creation of more and more small holdings, and unless some kind of cooperative mechanization is envisaged, individual farmers will find it difficult to afford the money for buying a tractor. Another alternative is contract ploughing, which is possible if an enterprising farmer with a mechanical bent of mind can do mechanical cultivation on his land first and spare his machine to work on the fields of his neighbours on the basis of contract.

" There are also other problems attending the mechanization of agriculture. One is the difficulty of getting trained operators. Another difficulty arises from the fact that several distributors and sub-distributors have not got sufficient capital for stocking spare parts and for laying on service facilities. Experienced engineers with a good background of mechanized agriculture are also not available in large numbers in the country. In the U.S.A. and elsewhere, many of these engineers grow up on farms, and as such agricultural engineering comes to them naturally. In our country, the average engineering student is an urban product and he has only the remotest idea as to how agriculture is conducted.

" In spite of these limiting factors and other difficulties, I am convinced that mechanization of agriculture has a definite part to play in this country and it is bound to make progress in the years to come.

" It would not be supposed, however, that I am in favour of wholesale mechanization of our agriculture. We must at all stages pay due heed to the vast numbers of persons that are available for manual labour and in trying to secure some advantage we must be careful in not upsetting the economy of vast multitudes. We would have always to strike a happy balance between mechanization and manual labour, otherwise thoughtless recourse to mechanization may create problems of acute and large scale unemployment which may be beyond our power and capacities to solve satisfactorily. The remedy in that case would be worse than the disease".

The use of machinery in agriculture is a business proposition, and mechanical equipment will come in general use only if it pays the farmer to employ it. Tools and machines should be designed and chosen to suit the operations to be performed under different geographical and soil conditions. All improvements and adaptation should be a process of gradual growth, and must not be conceived in imitation of what has proved to be good in other parts of the world. Given a carefully planned policy, each State would, after assessing its real needs in respect of mechanization, formulate plans for the orientation of its agriculture.

CHAPTER II

FARM MACHINERY AND IMPLEMENTS

WHEN mechanical power was first introduced in the field of agriculture, a stationary steam-engine with a cable arrangement for hauling was adopted. This, however, proved to be of limited utility, for it could not be employed for different operations. Nevertheless, the advent of the internal combustion engine completely revolutionized the scope of agricultural planning, opening a vast field of possibilities and paving way for the introduction of machines and implements over the entire range of agricultural work which had been done from the earliest times by manual labour. In course of time, machines mounted on wheels replaced the stationary steam-engine, and later petrol and diesel engines of different sizes and horse-powers came to be adopted universally. Some of the major agricultural machines and implements in use today are described below.

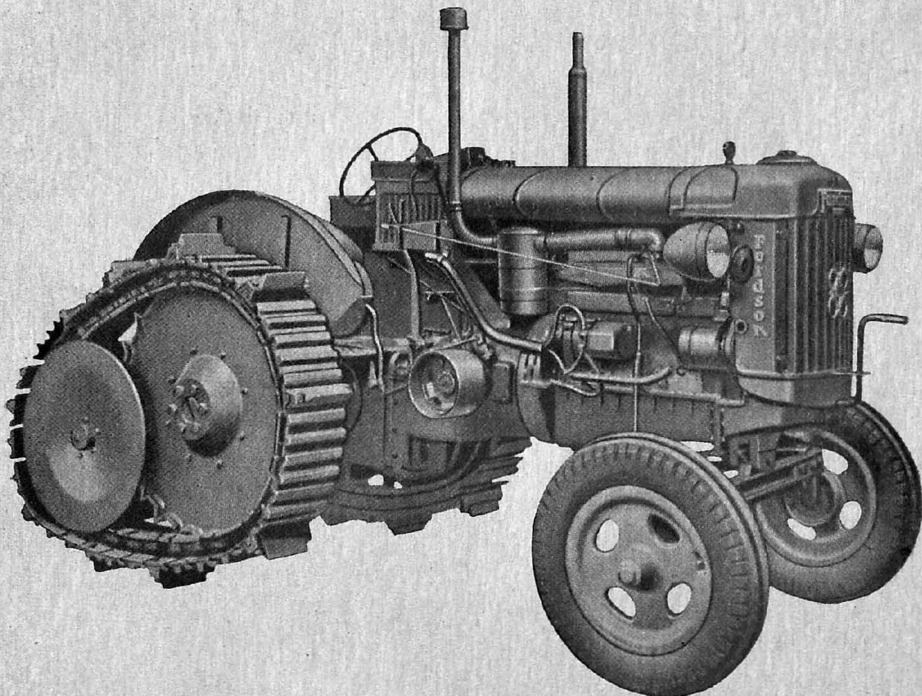
Tractors

Tractors may be classified into two main categories: the wheel type, and the track-laying or crawler type. A third category recently being manufactured is half track type. Tractors are divided into five general classes, namely, (i) Crawler or track laying, (ii) General purpose, (iii) Standard, (iv) Rowcrop and (v) Market Garden. Tractors are also further sub-divided into different types according to the type of fuel used for working the tractor engine, i.e., petrol, kerosene and high speed diesel.

Most of the tractors, particularly the medium and heavy types, are run on diesel oil in preference to petrol. Fuel consumption of the diesel engine is lower as compared to that of the petrol engine on account of its higher combustion pressure. In view of its high thermal efficiency and freedom from electrical ignition troubles, the diesel engine has, therefore, been steadily gaining in popularity. Moreover, the cost of fuel in the case of a diesel engine amounts approximately to 30 per cent of that needed for the petrol engine. It is also found that a diesel engine converts its fuel up to 30 per cent into useful work as against the percentage of about 20 for a petrol engine. Again, diesel oil is not as inflammable as petrol, and hence there is greater safety in transport and handling of it.

In the case of petrol engine the mixture of gas and air is ignited inside the cylinder by an electric spark, whereas in the case of a diesel engine the air drawn into the cylinder is compressed to a very high pressure raising its temperature to a sufficiently high degree so as to ignite the oil when injected at the end of the compression stroke. Consequently, no independent electric ignition is required in the case of a diesel engine. A diesel engine, however, is more costly compared to the petrol engine on account of the all-round heavier and stronger components needed for its construction, and the higher

PLATE IV



Half-track Tractor

precision injectors and pumps, which have not so far admitted of cheap mass production. Similarly, the high compression pressure of diesel rules out direct hand starting at full compression, and the designers and manufacturers of diesel engines have to provide an independent or auxiliary motive power for starting these engines.

A normal tractor has usually 3 to 4 speed ranges, varying from about ½ mile to about 15 miles per hour with one or two very low reverse gears. The crawler-type tractors have often a greater range of speed. An extra low gear is not only desirable but also necessary for certain operations. The clutch gear box on the wheeled tractors is the same in principle as on the road vehicles. An ideal transmission system for any tractor would require some sort of indefinitely variable gear that could allow maximum output to be reached at all times by using the highest speed permitted by the load. Using a tractor in low gear results in less work per day than the maximum which the engine is capable of. It also consumes more fuel per acre. The practical way to solve this difficulty is to have a tractor with as many forward speeds as possible, which should be fairly close together covering the range of about 1½ miles to 5 miles per hour. Normally, the highest gear for tractors of the crawler-type should be about five miles per hour. On tractors with pneumatic tyres a higher gear, giving a speed of 15 miles per hour, would be useful for rapid transport work.

Experiments with tractors have shown that there is no inherent difficulty in ploughing at 4½ miles per hour even with the existing plough designs, and that the increase in draught at higher speeds is justified by better pulverization of the soil. Increased speed might be even more economical with pneumatic-wheeled tractors, in spite of the higher draught, because they have a better overall efficiency at the low drawbar pull, and have to be geared to higher speeds for full load. In some cases where the tractor was originally running on a light load, its efficiency was increased by raising the speeed. The time and labour saved at higher speeds have more than justified the hopes of the experimenters. These conclusions have, of course, not been universally accepted; and though it is agreed that speed is an important aid in getting through as much work as possible in the shortest time, it is not necessarily an advantage if it involves an increased horse power requirement. Mere generation of large horse power at a lower fuel-consumption rate, and achieving comparatively lower maintenance costs, are not helpful if the power generated cannot be made available for useful work.

A tractor has to be judged by its capacity to transmit a high percentage of the power developed by the engine to the drawbar. In practice, the losses in transmission itself are not very great compared to those taking place on the driving wheels or tracks. A farm tractor differs from a road vehicle in that its forward propulsion mechanism has not only to move the tractor over the land but has also to exert a tractive effort sufficient to pull an implement or machine. This effort is known as " drawbar pull ".

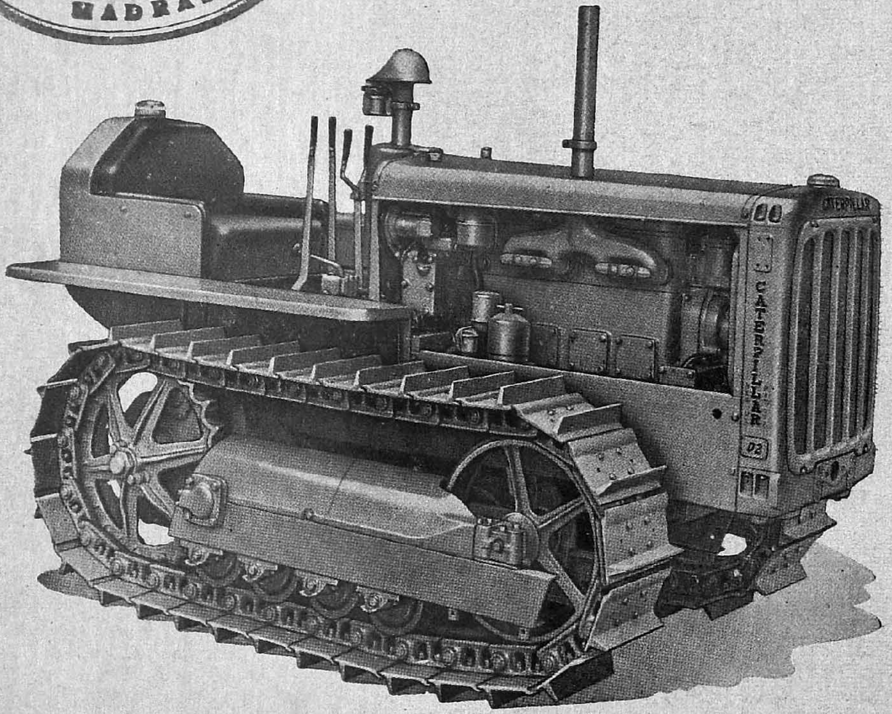
It is greater at lower speeds; and, therefore, the speed at which a tractor delivers it in full measure should be found out.

The amount of ' grip ' obtained by tractors on agricultural land depends mainly on three factors:— (i) the area of driving-surface in contact with land; (ii) the amount of weight on that surface; and (iii) the condition of the soil. It may appear that the larger the teeth on the driving wheels and the greater the weight on them, the more they will penetrate the ground, and, therefore, the less will be the wheel-slip. Though this is true to a point, it has to be remembered that some horse-power has to be used to pull wheels out of the holes thus made and, consequently it has to be ensured that the soil does not get consolidated to a high degree. Generally, tracks give the best grip on all normal agricultural lands. This is mainly due to the large driving surface in contact with the land made possible by the lugs or grousers fitted to the tracks. The relative high weight of the crawler tractors is also a help and not a handicap, for it is spread over a large area and does not result in a very great consolidating effect on the soil. Heavier soils, especially when they have a high moisture content, are more prone to be damaged than the light sandy ones. The disadvantage of tracks lies in their high initial and subsequent maintenance costs.

The wheel-type tractor has the advantage of easy manœuvring over the crawler-type. Wheels, however, slip; and this is often the limiting factor in the performance of the wheel tractor. The wheel-slip reduces the speed but does not correspondingly reduce the fuel consumption. To avoid wheel-slips, chains similar to the snow-chains are sometimes used. The driving wheels are fitted with teeth which cut into the soil. The larger the diameter of the wheel (other things beirg equal), the greater will be the ease with which it will travel over rough surfaces. There is, however, a limit to which the size of the wheel can be increased usefully; and this is four to five feet of diameter. The width of tread is also limited, the average being 12 to 14 inches. We have to find out a compromise as regards the size of the lug and the diameter of the wheel. In case we have too few lugs which do not sufficiently penetrate into the ground, there will be excessive wheel-slip. On the other hand, if the lugs are deep, there will be heavy soil packing and greater rolling resistance.

It may be mentioned that tractors with iron lugs are not allowed on public roads since they damage the road surface. Arrangements to provide " shoes" over the projections have been made but this contrivance has not proved very satisfactory, especially under muddy conditions. Pneumatic tyres were consequently introduced. In view of their propensity to slip, and unsuitability for heavy work, these did not find favour in the beginning. However, in view of the reduced vibration achieved through them and the resulting increase in life of the axle-bearings and other related parts, as well as the greater comfort for the driver and the facility of putting the machine on the road, these are now improving in popularity. Generally, the grip of the pneumatic wheels

PLATE V



Crawler Tractor

on the soil depends on the area of the driving surface in contact with the land, the amount of weight on that surface, and the condition, of the soil. It is, therefore, apparent that to get the maximum power at the drawbar sufficient weight should be applied to the driving wheels. This is done by adding iron weights on the driving axle or by filling the tube with water. Many farmers prefer to have two sets of wheels: spade-lugged wheels for heavy work, and pneumatic wheels for lighter and faster type of work.

A new type of tractor which has tracks instead of the rear wheels, and pneumatic front wheels has been designed. This modification makes for increased area of driving surface in contact with the soil and availability of full power of the engine for use at the drawbar. A tractor fitted with these half-tracks can be turned quite easily which is a great advantage. The results given by the half-tracks under soil conditions favourable to the operation of a wheeled tractor, are approximately 50 per cent better than those achieved by the wheeled tractor. If surface conditions are not so favourable to the wheel, but are still such as would make the operation of a wheeled tractor feasible then the additional results obtained are at least 100 per cent. Further, under conditions when no wheeled tractor could operate at all, the half-track equipment would enable satisfactory work to be done with hardly any reduction in performance and drawbar pull.

Crawler Tractors

Crawler tractors are designed mainly for heavy drawbar work at low speeds. The weight of the tractor is carried on the two large endless chains, each wrapped around two wheels, the driving one being toothed. This tractor has a larger surface which greatly decreases soil consolidation and has a lower rolling resistance. The track presents rigid surface to the ground, and is, at the same time, flexible enough to cope with the irregularities of the field. Constant track repairs are, however, required, and often complete renewal becomes necessary. Another difficulty with the crawler-type tractors is with regard to their steering. On account of the absence of front wheels, the machine cannot be steered in the same way as the wheeled tractors are steered. Recourse is, therefore, had to differential steering, the engine's power being withheld from one of the driving axles. This is done by having a brake or a separate clutch on each half axle, or by combining the brakes and the clutches.

Crawler tractors are found useful for deep ploughing of *hariali*-affected fields and sugarcane areas, and also for bulldozing work. In spite of their advantages, such as very low soil consolidation effect, ability to ride easily on loose surfaces, higher drawbar pull per horse-power, etc., their higher price and greater maintenance costs rule them out unless enough heavy work could be found for them. It may be added that such tractors should preferably not be used in sandy soils, as such soils wear out the track quickly and make the use of crawler tractors uneconomic.

Standard Tractors

These are wheeled tractors, usually of a medium horse power—15 to about 40 horse-power. They can be used for carrying out most of the farm operations. However, since they have small ground clearance, they are not very useful for rowcrop work. They are particularly useful for heavy road haulage work. These tractors have in addition a centrally placed power take-off and a pulley, which is useful for working other agricultural machinery.

General-purpose Tractors

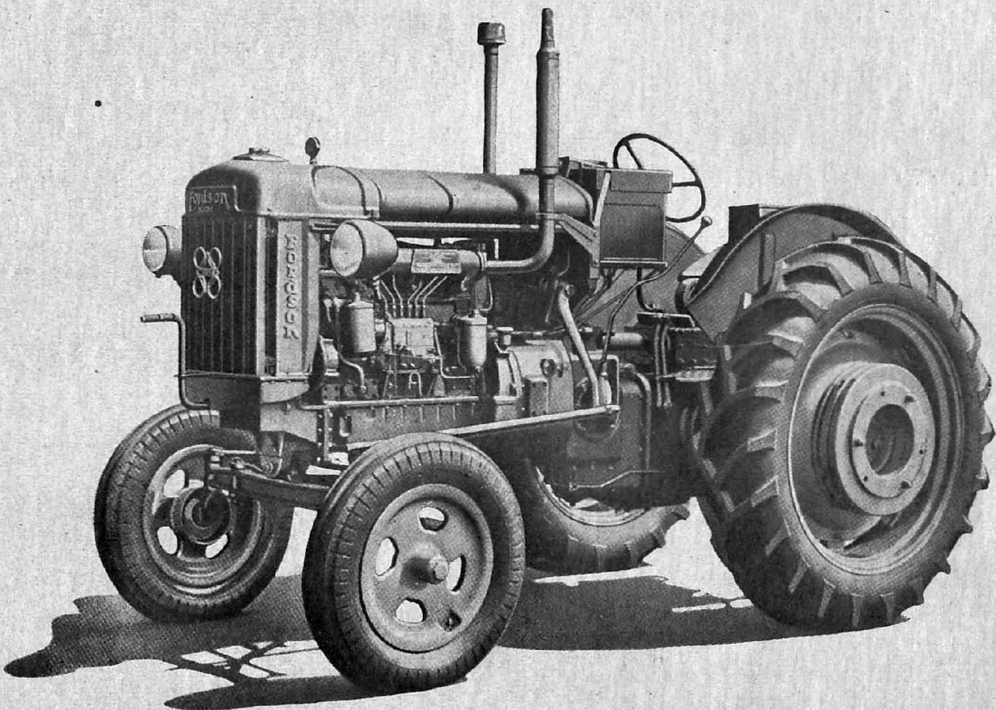
This type of tractors furnishes power for practically all farm work, and is useful for many jobs on which the track-type and standard tractors cannot be employed. These tractors have usually four wheels, though a true rowcrop tractor has one single front wheel or two wheels placed together. The main function of this machine is to facilitate working in crops grown in rows. It is, therefore, necessary that the wheels should be easily adjustable to suit the row-widths of the various crops in which the tractor is to be used. They usually have high clearance and hence do not damage the crops.

Generally speaking, the four-wheeled rowcrop tractor is more suitable for general purposes than the three-wheeled model. A general-purpose tractor must be heavy enough to give good traction efficiency in ploughing, yet not heavier than what is necessary. Its weight must be properly distributed to achieve efficient traction and to maintain stability. The engine must have enough power for the heavier drawbar jobs, yet be efficient at lighter loads. The machine should have sufficient clearance, without being top-heavy.

Modern general-purpose tractors have means for changing quickly the rear-wheel tread to suit the distance between different types of rowcrops. These wheels are adjustable over a range varying from 56 to 88 inches. The tractor usually has a brake for each rear wheel. This helps in swinging it round sharply. The capacity and efficiency of a general-purpose tractor depends to a great extent on flexibility of speed. Most of the tractors of this type are provided with several forward speeds, so that the machine can be operated at full throttle at all times, thereby ensuring maximum engine efficiency. These tractors have also suitable power take-offs, which are very useful for working other farm machines.

Market Garden Tractors

This class of tractors is designed mainly for market garden work. Originally it included two-wheeled tractors controlled by handles by an operator walking behind. In view of the fact that such tractors cannot do deep ploughing and are tiring to handle for a full day, very small three or four-wheeled tractors have been designed recently for horticultural work.



Wheel Tractor

Ploughs

Ploughing is the basic tillage operation carried out for preparing seed beds for crops. The purposes of ploughing are numerous, some of which are enumerated below:

(1) to put the soil surface in condition to receive moisture rapidly;

(2) to increase the moisture-holding capacity of the soil;

(3) to obtain a deep seed bed of good texture;

(4) to destroy and prevent weeds;

(5) to add more fertility to the soil by covering vegetation and manure;

(6) to prevent erosion from wind and water;

(7) to improve soil aeration;

(8) to destroy insect pests, and prevent insect damage;

(9) to change the soil texture;

(10) to increase the crop yielding capacity of soil by permitting greater root development.

Ploughing depth depends on the nature of the soil and the type of crop to be grown. Under average soil conditions, shallow ploughing of six inches to eight inches depth is recommended. Deep ploughing, 10 to 14 inches, is adopted for sugarcane crop and also for eradication of deep-rooted weeds like *hariali*. It is advisable that ploughing to the same depth should not be adopted every year, as it tends to consolidate the sub-soil and form it into a hard pan, which makes penetration of the crop roots as well as moisture into the sub-soil difficult.

The two main types of ploughs used in India are the mouldboard plough and the disc plough. The ploughs used with tractors can also be divided into two general classes: the trail-behind ploughs and the direct-connected or mounted ploughs.

Mouldboard Plough

This plough, when drawn across a field, cuts the soil horizontally and vertically and lifts and turns it over. Tractor mouldboard ploughs are available with one to five bottoms to suit the power of the tractor, the ploughing conditions, and the area of the farm. Tractor ploughs for being trailed behind a tractor have two or three wheels. The three-wheeled tractor plough is designed to be pulled behind the power unit and has a hitch enabling it to be used behind any kind of tractor. For turning on the head lands and moving from place to place, the plough bottoms must be raised out of the ground, for which the necessary mechanism is provided. The plough lifts on all the three wheels by means of a clutch, located on the land wheel, which is operated by a trip rope from the tractor seat. Hydraulic-operated mechanism is also available in place of the cable-operated mechanism. Recently, the lifting of the plough, previously done by levers, is being accomplished by self-lifting mechanism, which derives its power from one of the plough wheels and is engaged or disengaged by a remote control bar by the tractor driver. The two-wheel tractor ploughs do not have rear wheels, and the lift is on the land wheel, although a third wheel is available as the rolling landside to absorb side draft and relieve landside pressure. On some of the three-wheel ploughs the customary land and furrow levers are replaced by cranks and screws for adjusting the depth and levelling of the plough. A spring release hitch is a desirable safety feature for trail-behind ploughs when solid objects are likely to be encountered in the soil. Two-wheel tractor ploughs are available with one or two bottoms. These ploughs are compact and turn easily.

Direct-connected tractor ploughs are invariably manufactured by the same manufacturers who make the tractors. They are consequently available in sizes that suit the power of the tractor. These are mounted on the tractor and are carried as well as pulled by the machine. Tractor-mounted ploughs can be manœuvred in place, being lifted by the tractor. There are special mouldboard ploughs for specific works but these are not being described here. Considerations that should weigh while selecting a tractor plough are described in the Chapter on "Selection and Maintenance of Equipment".

Disc Ploughs

The disc plough was brought out in an effort to reduce friction by providing a rolling bottom instead of a flat one that would slide along the furrow. It was supposed to require less draft than the mouldboard type. The results of the working of the disc plough show that it can be employed with advantage under conditions where the mouldboard type will not work. The disc plough can be used on ground that is to hard for the mouldboard, and particularly on the one full of stones. It will scour most soils if a scraper is used; it does not form hard pan and the angle of the disc can be adjusted for work on hard or loose land. The disc plough bottom is a perfectly round concave disc of steel, sharpened on the edge to aid in the penetration of the soil. When the plough is pulled forward, the disc will be turned as a result of the action of the furrow slice upon it. The furrow slice is pulverized to a certain extent when carried over to the concave surface of the disc. All disc ploughs should be equipped with an adjustable scraper. With its aid it is possible to get greater pulverization of the furrow slice and also to invert it much better. The disc plough can be made to penetrate more easily by setting the disc in a more vertical position. The flatter it sits the less is its tendency to penetrate. To enable the disc plough to come in contact with the soil properly, weight is added to the frame and the wheels to force the plough into the ground. The size of the disc plough varies from 24 to 30 inches in diameter.

There is one important difference between the mouldboard plough and the disc plough. The former is pulled through the ground by suction of the plough, while

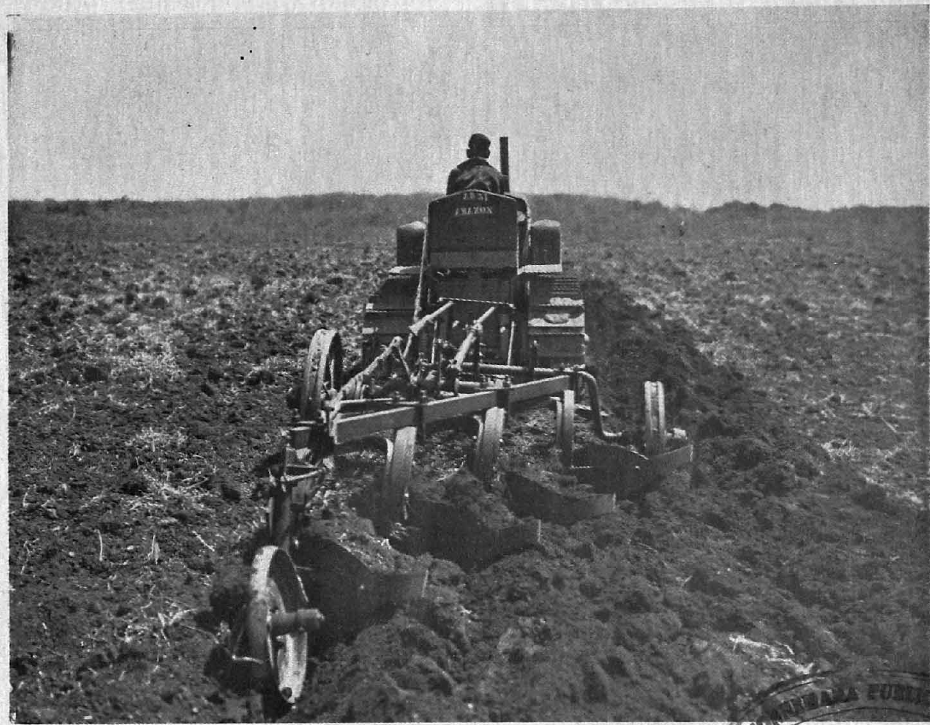


FIG. 1—Mouldboard Plough

FIG. 2—Disc Plough

the latter is forced into the ground with the aid of weight, and by the suction of the disc due to the angle given to it. Track-operated disc ploughs are constructed in many sizes both in regard to the number of diggers and the diameter of the disc. The diggers can be adjusted to give the required depth. This adjustment can be secured either by changing the position of the discs on the tool-bar or by changing the angle of the discs. The wheel depths are adjusted either by levers or cranks or screws. A heavy weight bar, generally of the gear-type, operated by cable, raises and lowers the plough at the end of the field. A disc plough should provide means for adding weights to the frame if required. Ploughs are available in different length-types ranging from 1 to 7 furrow sizes.

Directly connected ploughs are usually of two or three furrow sizes. These are usually used with row-type tractors being coupled with tractors. At the tractor end the operator could readily control the depth of penetration with the help of levers.

Rotary Ploughs

In addition to the above mentioned two ploughs, there is a third type called the ' rotary plough ', which is entirely different from the mouldboard and the disc ploughs in design. It has cutting knives, mounted on a horizontal power driven shaft, which operate at about 300 R.P.M. The knives on some machines are provided with a shock-cushioned friction clutch which prevents them from breaking when they come in contact with a rock or solid obstacle. These ' rotary ploughs ' are not yet in vogue in India.

Cultivators

The plough cuts the furrow, and the plough-breast inverts it. Cultivators and harrows are then used, principally to pulverize the soil and to comb out the weeds. Destruction of weeds is the primary purpose of cultivation. Cultivators perform functions intermediate between those of the plough and the harrow. They are used mainly to break down the furrow slice so that the harrow may work and further refine the soil, and to bring up the runners of weeds to the surface layers from which the harrow may extract and collect them. Weeds draw moisture and plant food from the soil, thereby robbing the growing crop. Cultivation serves two other purposes as well. It creates moisture-saving surface-mulch and admits air and light to the soil. If the soil becomes crusted after rain, it should be broken into mulch to prevent escape of moisture through capillary attraction. Air and light are essential to plant growth, and are admitted to the soil more readily when the surface is loose and rich. The " Cultivator " is an important class of tillage-tool, operated by the action of a number of tines which break up the soil but perform no inversion. Tines produce different effects according to their shape and the angle at which they come in contact with the soil. A straight perpendicular tooth or tine tears a track, the depth of which depends on the firmness of the soil, the position and sharpness of the point, and the weight upon it. Ordinarily, the forward motion of the tine does not cause it to penetrate into the ground. The straight vertical tine is more a pulverizing than a weed-lifting device, and although it loosens the surface layers it compresses those underneath. Its wedging action may injure the texture of heavy soil in damp conditions. A tine inclined backwards is useful for breaking the surface clods. A tine inclined forward, that is with inclination in the direction of its motion, tends to penetrate more deeply into the ground than a vertical tine of similar weight and sharpness. Weeds lying across the path of the tine slide upwards to the surface. This type of inclined tine is, therefore, more of a loosening and weed-combing device than a pulverizing one. The curved tine is a modification of the straight tine with forward inclination. Owing to the upper part of the curve making a greater angle with the soil than the lower, this shape has a greater pulverizing effect than the simple straight tine. The spring tine has a certain amount of elasticity which allows it to vibrate in the soil, thus enabling it to free itself of weeds and increase its pulverizing action. The first requirment of a cultivator is that it should be quickly and easily adjustable to varying field conditions. The operator will find it impossible to cut out all weeds and stir the ground evenly unless his cultivator is adjusted properly. To be easily adaptable to all conditions is the most valuable attribute of a cultivator.

Cultivators are usually classified by the design of their tines, which are of three types: (1) spring, (2) spring loaded and (3) rigid. Those with spring tines are suitable for light work only. Cultivators with spring loaded tines are also made for use by tractors on the lighter soils and where cultivations are shallow. Normally, tractor cultivators have rigid tines clamped firmly to the frame. As stated above, a certain degree of rigidity is essential for breaking the surface of hard stubble, but a spring setting assists the tine to penetrate by means of the digging or chopping action. Owing to this action the flexible spring tine can cope with harder soil than what may normally be expected. This pattern does not, however, rip up hard land to a depth of several inches at one turn—depth can be secured with it, but only gradually.

For an average farm, the tines should be of such a length that, when set in their deepest position, the measurement from the tips to the underside of the cultivator frame should be at least 18 inches and preferably 20 inches. This ensures plenty of clearance for weeds and other rubbish to pass under the frame when cultivating dirty land. The rows of tines should also be so spaced that there is plenty of room to allow rubbish to pass freely between them. This distance should not be less than about 20 inches when tines are arranged in two rows, and should be greater when they are arranged in three or more. Where the land is very heavy, or deeper work including subsoiling has to be done, a heavier type of cultivator will be required. The length of the tine in such type of cultivation should not be less than 24 inches from the point to the underside of the cultivator frame, and can with advantage be increased for deep subsoiling. The choice of a cultivator depends on the type of soil, the maximum depth required and the tractor power available. For average conditions a cultivator weighing from 80 to 100 lb. per tine, with a maximum effective tine length of about 18 inches is usually adequate. If the land is very heavy or the work of the cultivator is likely to be arduous for other reasons, a stronger cultivator weighing about 150 lb. per tine with the same tine length should be chosen.

In adapting the cultivator for tractor draught, certain special requirements have to be met. These are briefly mentioned below:

1. The frame and the tines must prove equal to the stresses to which they will be subjected, since the tractor implement is expected to work the land deeper and also under harder conditions than the bullock-drawn cultivator.

2. Owing to the greater force in action and the higher speed, the wheel-bearings must be larger, dust-proof, oil-tight and renewable.

3. As one man is expected to operate both the tractor and the cultivator, it must have a self-lift device.

4. For the same reason, the tines must be capable of working without much liability to choke.

There are different types of tine and shovel cultivators, but the principle on which they work is the same. Under certain conditions, disc cultivators are used to better advantage than shovel cultivators. They are used in unusually weedy fields where shovel or surface cultivators have tendency to clog. In stony or rooty fields and for hill-side crops, the disc type of cultivator is favoured.

Each tine should be square with the axle, so that the share works strictly 'point first'. Omission to raise the tines when turning on or near a hard headland is one of the chief causes of their distortion. Each tine in a row should have the same depth and pitch. The swivel wheel is one of the first parts of the cultivator to wear out. A single broad-tyred swivel wheel appears to serve satisfactorily, and is, therefore, preferred. Careful adjustment and thorough oiling of cultivation equipment will increase the efficiency and lengthen the life of the cultivator.

Harrows

The harrow completes the work of the plough and the cultivator in further refining, shaking down and levelling the soil for sowing, and in drawing out perennial weeds and other "rubbish". It performs a number of other functions also, such as covering seed or fertilizer, aerating the soil, promoting tillering, breaking crusts and forming soil-mulch. It also destroys annual weeds, aerates the surface of grassland, draws out moss, spreads worm castings, and breaks down and spreads clods of manure.

The tines of the cultivator being six to nine inches apart, this implement is not adapted for the complete refinement of soils that have a tendency to cohere in lumps. The teeth of the harrow, however, cut tracks that are only from one and a half to three inches apart. Lumps and clods of larger diameters have, therefore, no chance of passing under the harrow without being struck by one or more teeth.

Soils that form clods will pulverize only when they are in right condition with regard to moisture. When such land is too wet, harrowing will " puddle " the clay particles, setting the soil hard on drying. On the other hand, if lumps are permitted to dry through rapidly, they will form clods and these will have to wait till rain softens them, or they must be attacked with implements other than the harrow. Heavy land will pulverize when half-dry. Harrowing dry hard clods is futile.

Drag Harrows

The ' Drag ' is a heavy harrow with long curved teeth. The points are either round, or chisel or duck-foot shaped; the first having the best penetration and the lightest draught, the last having the greatest effect but requiring heavy construction and great draught. The teeth vary in length from five to ten inches, set $2\frac{1}{2}$ to $3\frac{1}{4}$ inches apart, and ranging in weight (including the frame) from 6 to 10 lb. The function of the drag is to comb the weeds from the lower layers of the soil to the surface; the weeds would be shaken and collected by the lighter harrows. In functions, and in the order of operations the drag comes between the cultivator and the seed harrow. If ' dragging ' is omitted, the land may not be thoroughly cleaned to the proper depth.

Seed Harrows

Seed harrows have generally a lighter frame and vertical straight teeth which are shorter than the drags. Their working tracks are spaced about $1\frac{1}{2}$ inches in the lighter types, and two inches in the heavier ones; the weight per tooth may be as low as $1\frac{3}{4}$ lb. or as high as $4\frac{1}{2}$ lb. Seed harrows are employed to refine the soil for drilling; to draw out and shake weeds free from the soil, to cover seed after drilling, and to aerate and mulch the surface of the land bearing growing crops.

Disc Harrows

There are other types of harrows with tines and spring teeth but the one most commonly used is the disc harrow. It pulverizes and packs the soil leaving a surface mulch and a compact subsurface. It is used for breaking the surface and mixing the trash with the top soil before ploughing and thereafter for pulverizing lumps and closing air spaces in the turned furrows. Under certain conditions, the disc harrow is the only implement used in preparing fields for planting small grains.

Disc harrows are made in single-action and double-action types. Most of the double-action harrows and some of the single-action harrows are designed for use with the tractor only. The disc harrow has a very different effect from that of tined implements on the soil. Apart from the definite cutting action of the discs, which differs from the shattering and stirring action of the tines, the soil is broken down without bringing any quantity of buried plant material to the surface. This is of advantage in the preparation of a seed bed on land that has been ploughed clear of grass or hay or where a green crop has been ploughed in. To do a good job of discing, the disc harrow must penetrate well and evenly over its entire width. In the case of the two-section machines, both the sections must meet these requirements, the discs of the rear one cutting the ridges left by the front discs instead of trailing in their furrows. Penetration of a disc harrow is obtained by angling the discs, the angle necessary for good work depending on the condition of the soil and the amount of trash to be cut. The maximum penetration is usually obtained at an angle of approximately 20 degrees. In using a disc harrow, it is often found that the discs on the front gang wear out faster than those on the rear one. When any difference in size becomes apparent, either the complete sections or the discs themselves should be changed over from one gang to the other to equalize the rate of wear so that all the discs need replacement simultaneously. After a fair amount of use, the two gangs of a disc harrow may get out of line and allow the discs on the rear gang to follow exactly in the track of those on the front one. This will greatly reduce the rate of effectiveness of the implement.

The efficiency and length of service of a disc harrow depends upon the care given to it. The main precaution to be taken when using it is to make sure that the bearings receive adequate lubrication. Many of the modern disc harrows are equipped with fittings for pressure lubrication, making it easy to keep the bearings well oiled. A good cutting edge on all the discs is desirable. Discs should be greased with a good hard oil when the harrow is not in use.

Rollers

The principal effect of the roller is to consolidate the soil. Its other direct effects are to crush clods and smooth the surface. Smoothing is desirable to facilitate the work of the drill or the harvester. Clod crushing is concerned with the refinement of the soil for sowing or with the eradication of perennial weeds. Consolidation of the soil is, however, desired for a number of purposes, such as anticipating the natural settling of the soil after sowing, encouraging tillering, averting lodging, causing moisture to rise from the lower into the upper layers of the soil, etc.

There are certain considerations which matter while making choice of the rollers. These relate to their weight, length and diameter. A roller with a large diameter is usually recommended. A high wheel with the broad tyre requires less draught on soft land than a small wheel with the narrow tyre, because it does not sink so deep. A roller with a large diameter would sink less into the ground. The smaller the diameter, the deeper the cylinder will sink, and the more will it consolidate the soil.

The draught of a roller of small diameter is greater. On the other hand, a clod crushing roller of small diameter is more effective. One has, therefore, to weight the advantages against the disadvantages and select a suitable type. Most of the modern tractor rollers are about 20 inches in diameter. Their weight also varies widely, and is anything from 1 to 4 cwt. per foot of width. It is fairly certain that all ordinary rollers are capable of consolidating only the top two or three inches of the soil, and that tined or disc implements have to be used to make the land firm to greater depths.

Fertilizer Distributors

The first requirement of a good fertilizer distributor is that it should be resistant to the corrosive effect of artificial manures. Ordinary steel, brass, copper and cast iron are all attacked. Wood is not so liable to attack; but it may become distorted, warped and eventually rot because of the moisture, for many fertilizers are to some extent deliquescent. Most of the fertilizers if left for any length of time tend to set hard in the machine, thereby clogging the feed. Highly resistant metals like stainless steel and other material such as hard rubber or enamels, which are used mostly for protective coatings, are relatively expensive and hence not much used. The second requirement, closely related to resistance to corrosion, is that fertilizer distributors should be easy to clean. This cleaning takes up a great deal of labour and time and makes the fertilizer distributor one of the most expensive farm implements to maintain. The third requirement of a fertilizer distributor is that it should be able to handle a wide range of materials, since artificial manures vary widely in texture and size of grain. The fourth requirement is that it should not be much affected by wind. This means that the fertilizer in most cases should leave the machine as near to the ground as possible. The fifth requirement is that the feed mechanism should shut off cleanly, and not drop fertilizer when the distributor is turning on the headlands. Various types of feed-mechanism are used to eject the fertilizer in more or less measured quantities and to ensure uniformity of distribution. It is found that machines with the least number of moving parts in contact with the fertilizer are the best. Rollers, reciprocating plates, plates and flickers and various modifications used in the mechanism, all work well under good conditions but spread unevenly when the fertilizer is in an unsatisfactory state. Bumps in the field also adversely affect uniformity of application.

The usual type of distributor covers a width from six to nine feet. Special models, however, up to 16 feet or 17 feet width are made for tractor-use and usually have some means of reducing the width for transport. They can be pulled from one end to enable them to go through farm gates and along narrow roads.

Artificial manure should be in good condition if it is to be distributed evenly and without trouble from blockages. If it has become caked in storage, it should be passed through a $\frac{1}{4}$ inch mesh sieve after lumps have been broken. Most fertilizer distributors can be used for lime but the high rate of application common in the case of this material and the small capacity of the hopper necessitate frequent filling of the machine. It is often found convenient to spread the lime by shovel direct from the lorry. Farmyard manure spreaders are also getting popular. It is important that a spreader receives careful maintenance to reduce the corrosive and rotting effects of the farmyard manure.

Seed Drills

It is necessary to plant all crops at proper depth and at planted distances. If seed is planted too deep or too shallow, or if it is planted too thin or too thick, the yield is bound to be affected. The utility of a seed drill depends considerably on its capacity to distribute the seed uniformly over the whole area sown. Uniform seeding is essential to regular growth and ripening. Drills are often far from being perfect as regards sowing at uniform rate. Wide variations have been observed in actual practice. The speed of the tractor, the slope of the land and the incidence of shocks should have no influence on the rate of delivery.

Similarly, the drill should be able to lay the seed at the desired depth. A seed drill should also ensure uniform width between the rows. Proper distance would depend on a number of factors, such as rainfall, quality of land, type of crop to be grown, etc. There are four types of feed in use: (i) cup feed; (ii) disc feed; (iii) external-force feed; and (iv) internal-force feed.

Cup feed: This is the commonest feed and probably the most useful one generally. Each cup chamber communicates with the main seed reservoir by a pigeon-hole fitted with a slide. The series of slides may be connected together so as to be regulated by one lever. To ensure even flow of seed through the pigeon-holes, it is necessary to have a device or keeping the box level when the machine is going up and down. It is used for sowing all kinds of seeds in any way, and when the work is finished the seed box is quickly emptied and cleaned. Its chief drawback is that it requires more care in operation to ensure regular sowing than the forced-drill, especially on rough or uneven land.

Disc feed: Opposite each seed spout there is a disc in the circumference of which there are pockets having the same functions as the cups in the cup drill. Discs with different numbers and sizes of pockets are required for sowing different kinds of seed, and the rate of sowing is modified by the use of change-pinions.

External-force feed: The seed box has only one compartment. Over each spout there is a small hopper. There are drills in which the drive is fitted with change pinions for varying the rate of revolution of the seed shaft. The top of each hopper should be provided with a sliding shutter so that any spout may be cut out. The special virtue of the force feed lies in its ability to sow evenly on hilly land. The slope of the box has no effect on the rate of sowing, and shocks do not affect the delivery. The force-feed drill is less expensive to make owing to the fewer number of parts. Its drawback is that it is less adaptable than the cup drill.

Internal-force feed: In this type, the distributor consists of a disc with flanged rims, the insides of which are ribbed or slightly fluted. Each feed disc is housed in a small metal hopper in the bottom of the seed box. The rate of sowing is controlled by varying the speed of the feed disc. The points in favour of this feed are that it gives continuous delivery and is able to sow trashy or damp seed better. It lacks, however, the adaptability of the cup feed, and it is difficult to empty any surplus seed out on completion of the work.

There are two principal types of drills manufactured at present—(i) the fluted force-feed and (ii) the double-run-feed. The first one is used generally. A third type called the 'lister type drill' has been recently finding favour, as with this type the seed is placed deep enough to take advantage of the soil moisture. Press wheels squeeze air spaces out of the seedbed and pack the soil over the seed. There is just enough compactness to permit the young plants to break through easily.

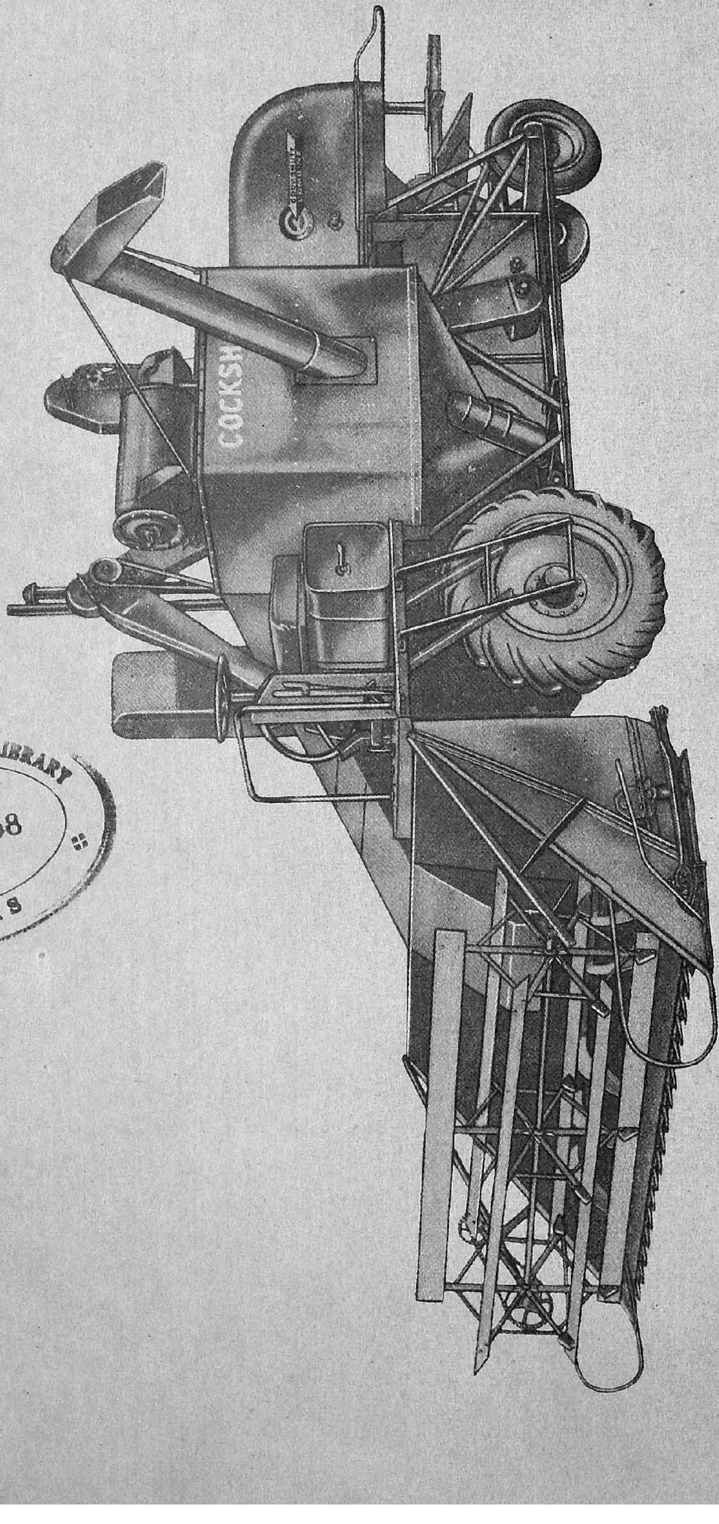
The farmers in foreign countries are using a combined grain and fertilizer drill, which pulverizes the soil, plants seed, distributes fertilizer, and covers both with soil. The fertilizer is prevented from coming in contact with the seed. It is released through separate tube and deposited in rows; but there is always a layer of soil between the fertilizer and the seed.

Hoes

Good cultivation results in destruction of weeds. Normally perennial weeds should be eradicated by cultivators before the land is sown. Thorough cleaning before sowing is not always possible, and the surviving perennials may be checked by tillage between the rows, if the crop is sown in drill rows, and by hand work between the plants. These inter-cultivations with hoeings are necessarily superficial and are not very effective in eradicating weeds possessing perennial roots. Hoeing proper is a superficial form of tillage, and is very effective in the destruction of annual weeds. The effect of the hoe is greatest when the soil and atmosphere are rather dry but the work must not be done when the soil is so dry that it will come up only in clods.

The surface of land tends to harden and encrust after sowing, especially in dry weather. In this condition the soil is unfavourable to crop growth. A loose surface admits rain, prevents excessive drying, probably encourages deeper rooting, and assures erosion. Repeated hoeings confer the above benefits on the crop plants. Hoeing to produce a tilth is more necessary in dry than in wet districts. Deep hoeing of roots should be avoided when the crop is half-bulbed—the crop is often injured by the

PLATE VIII



Self-propelled Harvester Combine

destruction of the root fibres, which spread across the inter-spaces. The implement used for hoeing cereal crops is made in several forms, and different shapes and sizes of shares are used. When the drill rows may be clearly seen, and provided the soil is not too dry, the crop can be quickly and closely side-hoed with a multiple hoe. To allow the closest and best work among young roots, the hoe should take the same number of rows as the drill that sowed the crop. At the first hoeing the soil should not be disturbed deeply in the region of seedlings; otherwise their root-lets, shallow at this stage, will be broken or dried out. It is also necessary that the blade must have a point in front. The rotary hoe is made up of two series of hoe wheels, the second series working the soil left between the first series. The hoe wheels have teeth shaped like fingers. The wheels rotate these teeth or fingers and penetrate and stir the soil. It results in a thoroughly pulverized surface. Weeds are uprooted and the soil is left in good condition for plant growth. The work of a rotary hoe is most satisfactory when the crops are just coming out through the ground. The rotary hoe is used to the best advantage after heavy rains have packed the ground and created unsatisfactory surface tilth.

Harvesters

A combined harvester-thresher heads the standing grain, threshes it and cleans it as it moves over the field. It takes the place of and dispenses with the grain binder, the header and the stationary thresher, obviating the task of shocking or stacking the grain and hauling the bundles. There are two general types of combines: the pull or tractor-drawn combine and the self-propelled type. The pull-type combine is drawn by a tractor. The smaller combines are driven from the power take-off of the tractor, while the larger sizes have an auxilliary engine mounted on the combine to drive them. The pull-type combines range in size from 4 feet to 8 feet cut for the smaller sizes, and from a 10 feet to 20 feet cut for the larger sizes. A combine has cutting and feeding mechanism, threshing mechanism, separating and cleaning mechanism, and straw winding attachment.

The self-propelled combine has many advantages not possessed either by engine-driven or power take-off operated combines. The great advantage of getting the grain straight from the standing crop into sacks or bins appeals to corn growers and farmers. The straw is not cut, the grain being rubbed out of the ears by a series of high speed discs. Combined grain has to be stored in sacks or bins and the moisture content must not exceed certain limits if deterioration is to be avoided. This necessitates artificial drying.

In comparison with other methods of harvesting and threshing, the advantages are:

(1) Saving in harvesting and threshing costs.

(2) Decreased labour.

(3) Elimination of hired help.

(4) Earlier cleaning of the field for tillage operations.

(5) Distribution of the straw on the land.

(6) Earlier marketing of the crop.

The disadvantages of the combines are:

(1) Large investment necessary.

(2) Large amount of power required.

(3) Likelihood of the grain being damp.

CHAPTER III

SELECTION AND MAINTENANCE OF EQUIPMENT

A GOOD farmer must be able to pick the right kind of implement for every farming operation, and to achieve functional coordination between different machines.

As a general rule, multi-purpose machines are to be preferred to those limited to single-line jobs; but where separate operations have to be carried out simultaneously, separate machines would be desirable. Where certain operations, such as deep ploughing, sub-soiling, mole-draining, baling, threshing, spraying, lime spreading, etc., are carried out only occasionally, it is usually not worthwhile for the average farmer to purchase special equipment for these, or to expend the high power required by some of the machines. Similarly, there are farm operations which can be done as efficiently by manual and bullock labour as by machinery, and at much less cost. The objective of farm policies should, therefore, be to secure an optimum combination of the existing human and animal resources with agricultural machinery.

It is important that in selecting either tractors or implements for a farm the whole mechanical equipment should be regarded as one unit, all the components of which have to have a functional unity. The first thing to do is to prepare estimates of the acreage for which each of the field implements has to cater in an average year, of the number of work-hours required for carrying out different operations, and of the transport arrangement. The number and types of the tractors and the implements required could be determined after this is done. It is usually assumed that, on an average farm, the tractor could be worked for certain definite hours in a year. The larger the size of the farm, the smaller is the amount of capital required for machinery per acre, for a basic minimum of machinery is required to run any farm, whatever be its size. Mechanical cultivation is not economical from a capital investment point of view if a holding is small. The only way this could be offset is by carrying out certain operations on a community basis.

Selection of one particular machine in preference to another depends on many factors, some of which are: (1) reliability of the manufacturer, (2) design and workmanship, (3) adaptability, (4) safety feature, (5) ease of operation and (6) ease of service and adjustment.

Tractors

Farming conditions vary considerably from place to place, and it would,therefore, be advisable to study individual farm requirements before selecting a tractor. A general-purpose tractor would ordinarily be found suitable for normal row crops. A far larger number of implements have been designed for use with the general-purpose tractor than with any other type. The track-laying tractor is useful for extremely hilly country on account of its low centre of gravity, as well as for the swampy, sandy, and other loose-type soils and large irrigated fields. The long tracks exert small pressure on the soil, and are, therefore, suitable for loose-type soils also.

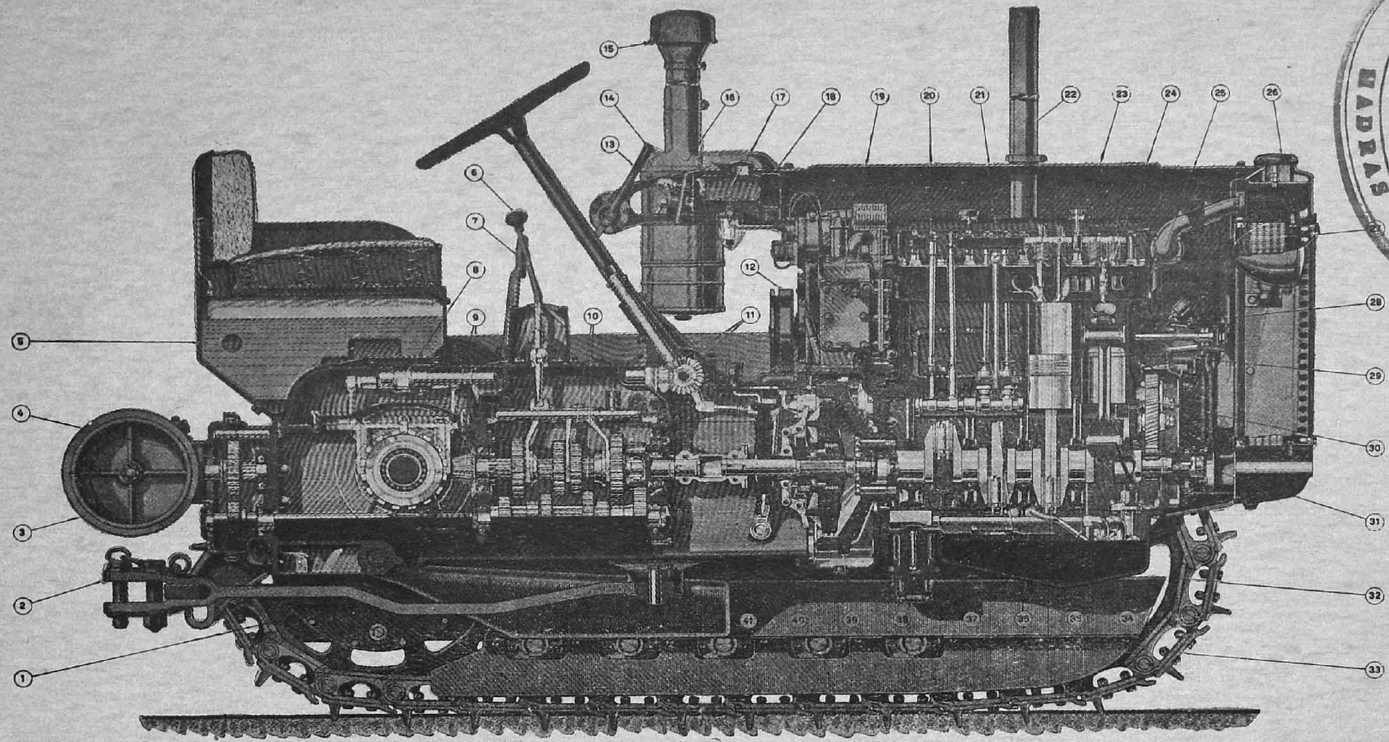
The size of the tractor is an important factor in planning proper mechanized farming. The following points deserve consideration in determining the size:

(1) Acreage and shape of fields
(2) Type of soil
(3) Acreage of major crops
(4) Size of available operating implements

It is desirable to select a tractor that will do the necessary work in good time and be approrpriate to the soil. A tractor that is too heavy may dig in. It is also not desirable to select a tractor too small to cope with the implements meant to be used with it. The shape and size of the field also determine to a certain extent the size of the tractor. Small irregular fields require a small flexible tractor—preferably one with mounted implements. It is better to select a tractor that is slightly overpowered than under-powered to work the implements. A tractor must be adaptable in its operation as it is required to work in heat and cold, dust and rain, on firm and loose footing, at fast or slow speeds, etc. It should be simple in construction, so that the operator can understand it. It is desirable to select first the implements that will be worked with the tractor and then select the tractor rather than *vice versa*. The type of fuel to be used and its cost are further considerations. The selection has often to be based on convenience of utilizing the tractor power for working the farm machinery.

The main requirement as already stated is that the tractor should have enough power at the drawbar to handle the full range of implements under all conditions. The best method to ensure this would be to use a drawbar autometer for finding out the draught of the various implements over a wide range of soil conditions on the farm. It is desirable to scrutinize the test results of the tractor. Testing standards have been set up in various countries, the best known being perhaps those conducted by the Agricultural Experimental Station, University of Nebraska, in the U.S.A., and by the National Institute of Agricultural Engineering of Britain. The conditions under which the tests were conducted by these and many other stations vary considerably. The difference between the University of Nebraska and the National Institute of Agricultural Engineering tests is an important example; the former being obtained under prepared ideal conditions and the latter under practical agricultural conditions. In the absence of the results of an initial tractor-test carried out under the average farm conditions, it is desirable to assume 85 per cent of the tractor's maximum performance

PLATE IX



Sectional View of Fiat Mod. 50 and 52 Tractor

1. Driving wheel. 2. Drawbar. 3. Belt pully. 4. Gears driving belt pulley. 5. Main fuel tank. 6. Gear lever. 7. Brake hand lever. 8. Shaft driving steering clutches. 9. Bevel gears transmitting power to driving wheels. 10. 5 speed reverse gearbox. 11. Bevel pinions driving steering clutches. 12. Flywheel of auxiliary starting engine. 13. Instrument board. 14. Accelerator hand lever. 15. Diesel engine air intake. 16. Oil operated air filter. 17. Petrol tank for auxiliary starting engine. 18. Bowl filter, with tap. 19. Auxiliary petrol driven starting engine, with 2 opposed cylinders. 20. Valve rocker push rods. 21. Valve rocker spindle. 22. Diesel engine exhaust pipe. 23. Inlet valve with deflector. 24. Fuel oil injector. 25. Thermostat on cooling water circuit. 26. Radiator filler cap, with filter. 27. Vertical tube radiator. 28. Cooling water circulating pump. 29. Lighting dynamo. 30. Camshaft driving gears. 31. Dog clutch for starting handle. 32. Track idlers. 33. Track link. 34. Oil pump. 35. Oil suction filter in sump. 36. Camshaft. 37. Transverse suspension spring, with small buffer spring. 38. Bearing rollers. 39. Toothed crown for starting Diesel engine. 40. Clutch plates. 41. Clutch lever.

under ideal test conditions as available. Yet another important consideration in the selection of a tractor is the availability of spare parts and the local service facilities.

A machine to warrant its purchase must be reasonable in price, and not expensive to run. In the U.S.A. and Western countries now-a-days, a tractor does not have a limited seasonal use, and is hence found economical. It is difficult to say categorically that mechanisation under Indian conditions can be extended to the same extent as has been done in the West, for among other things the wages of agricultural labour and the price of the produce have a far-reaching implication in deciding whether wholesale mechanisation would be economical. Moreover, each farmer or a group of farmers will have to work out the needs in regard to mechanization, for while in one case it might be an extravagance to possess a particular type of tractor or other agricultural machinery, it may definitely lead to saving in agricultural costs in the other.

Care and Maintenance

A tractor consists of three basic units, namely, (i) the engine which is the source of power, (ii) the transmission system which makes this power available at the drawbar, power take-off, power lift and belt pulley, and provides means for varying the traction speed, and (iii) the clutch which acts as a coupling to connect the engine to the transmission mechanism and belt pulley.

There are two general types of internal-combustion engines—two-stroke cycle and four-stroke cycle engines. Practically, all the farm engines and tractors are of four-stroke cycle type whether of the spark ignition kind or of the diesel type. For proper operation of the engine, attention must be paid to the four fundamental systems, namely, the fuel supply, ignition, lubrication and water circulation systems.

Fuel Supply

The fuels commonly used for working the tractor engines are: (a) kerosene, (b) petrol or power kerosene, and (c) high speed diesel oil. In the case of the ordinary petrol or power kerosene engine, the fuel is delivered into the cylinder by a carburetor. The function of a carburetor is to supply a mixture of fuel and air to the engine in the proper proportion for all loads and speeds. This is a difficult task, since the torque developed by an engine, though proportionate to the amount of air-fuel mixture taken into the cylinder, is not necessarily proportional to the speed. The flow of fuel through the carburetor jet does not increase directly in the wake of the flow of air to the throat of the carburetor. If maximum power is desired, the fuel must be supplied in excess, so that all the oxygen available is consumed. On the other hand, if economy is desired, an excess of oxygen must be present, so that all the fuel will be burned. An ideal mixture would be within these two limits. In order to start an engine at low temperature, it is necessary to supply relatively large quantities of fuel. A 12 to 1 air-fuel ratio is usually considered to be the leanest and the 8 to 1 ratio the richest. An engine is said to be flooded when the mixture is richer than the latter. The jets in a carburetor are usually very small, and it is necessary that all the fuel should be carefully filtered before being put into the tank. There should preferably be a filter between the tank and the carburetor. Piping back into the carburetor indicates a weak mixture and is the first symptom of the fuel supply trouble. Stoppages are frequently caused by small particles of the scale from the tanks, pieces of waste, or drops of water. It is, therefore, necessary to clean the pipe and the filter regularly. A leaking joint in inlet may cause trouble by weakening the mixture. All joints should, therefore, be kept tight and leakages stopped as far as possible.

Fuel supply lines include everything from the storage tanks to the engine cylinders, and the air system from the air cleaner to the carburetor. As stated, the fuel should be filtered when it is being poured into the tank. The air cleaner functions in two ways. A centrifugal cleaner on the top of the air-entrance pipe is designed to separate or screen out trash, fuzz and chaff from grain-combining and hay operations and corn husks in corn picking. If these accumulate on the screen, they will clog the intake air. The lower air cleaner, which is usually of an oil-bath type, is meant to remove dirt particles from the air. The air is first made to pick up a small quantity of oil by the air-velocity, sufficient to automize some of the oil. The automized oil and air mixtures then pass through a series of baffles and metal mesh where the excess oil and dirt collected on the mesh drains back into the reservoir below. This washing down of excess oil keeps the strainer mesh fairly clean at all times. The accumulated dust and dirt settle in the oil reservoir. The bottom of the reservoir should be lowered periodically to clean it of the accumulated deposit and then refilled with clean oil.

Dirt exclusion is equally necessary in the case of the diesel oils. As the fuel injection nozzles are precision parts, diesel oil requires special handling because of the extremely small cleaners of the injection units. Fuel filters are always placed on the diesel engines, but the mesh in the filters is greater than the clearances in the fuel injections pump. An air filter must not offer too much resistance to the passage of air. The necessity of having proper air clearance and maintaining them in order cannot be overstressed. It has been stated that a tractor can be expected to run 3,000 hours under full load in dusty conditions with no adjustments, provided it has a satisfactory cleaner; but, without an air cleaner the engine would be ruined after 15 hours' use. Air cleaners have developed from the dry centrifugal type, through the water-bath cleaner, the oil-wetted filter, and finally to the present oil-bath filter. It is generally assumed that under severe dusty conditions a good oil-bath air filter reduces the rate of tractor engine wear to about ½ to ¼ per cent of that which would occur without filters.

The ideal air cleaner would possess the following characteristics: efficiency in dust removal from the air, small air restriction, small size, infrequent need for servicing, simplicity in design, ability to muffle carburetor noises, durability, low cost and the ability to act as a back-fire flame suppressor. The modern oil-bath air cleaner approaches the ideal cleaner in several of these points.

A typical oil-bath air cleaner is of the centre tube inlet type and has deep filters to assure proper preformance of the cleaner and to prevent carry-over into the intake, even under conditions of rough vehicle movement. This type of cleaner is suitable for severe dust conditions because the air inlet can be extended above the engine, thereby obtaining cleaner and cooler air.

Air enters at the top and passes through a duct to the surface of the liquid sump where it is deflected upwards. Much of the dust and sand is rejected to the sump at this point. The air then passes upward through the filter, carrying oil droplets with it. In the filter, most of the remaining dirt gets attached to the oil-wetted surfaces and drains back into the sump, primarily by way of the wall surface. The air outlet is on the side and a removable cup fitted to the bottom permits convenient cleaning and servicing.

The air cleaner must be of a size suited to the engine. In an undersized cleaner, the restricting or choking effect on the engine will be very large. What is even more serious, the dirty oil will be drawn from the cleaner into the engine. If the cleaner is too big, it will not operate at maximum efficiency, especially at low loads, since the cleaning efficiency of oil-bath air cleaners depends on sufficient air-velocity for blowing the oil into the filter screen. The cleaner selected should be as small as possible but still capable of preventing the oil from passing through its filter and into the engine at the highest load and greatest tilting to which it will be subjected.

Ignition System

There are two common types of ignition systems; the battery distributor, and the magneto.

The battery distributor type ignition system consists of a battery, a coil which transforms low voltage current to high voltage, a distributor which carries the high voltage current to the proper plug, and the spark plugs which release the spark in the cylinder. In this system, a generator is required to keep the battery charged. The spark released within the cylinder causes explosion of the fuel gases. Without a strong spark, timed to occur at the proper instant, the engine is difficult to start and will not operate efficiently. Engine ignition requirements are affected by the spark-plug location, spark-plug gap, the compression ratio, manifolding operation, carburetion, throttle opening, engine temperature, and the arrangement of the high voltage leads.

The location of the spark plug is very important in securing proper burning of the fuel and air mixture so as to obtain best use of the fuel and also to avoid detonation. No doubt, its location near the intake valve secures high performance but it leads to detonation, since, as the last part of the charge to be burned is compressed, it is also heated by the hot exhaust valve. Generally the plug is so located as to give minimum *flame travel. A compromise position between the intake and exhaust valve is*, therefore, selected. Leaner mixes burn more slowly than rich mixes, and require a large spark advance.

Spark-plugs must operate at the correct temperature. Operation at too low a temperature results in 'fouling' by carbon ; operation at too high a temperature results in the pre-ignition of the mixture and burning of the plugs. Spark-plug gap-widths affect the performance of an engine, particularly at light loads. Under conditions of part-throttle operation, when the mixture is lean and stratified, the wide gap provides a margin of safety.

The best way to trace ignition faults is to tackle the job systematically so that each test either finds the fault or eliminates certain parts of the system that are unsatisfactory. It should also be seen that fuel supply is in good order, as ignition trouble is not the only thing that will prevent an engine from starting. Begin your ignition tests by checking the ignition switch and cable. Examine all connections, clean the magnets case and around the spark-plug. If the cable and switch are found in order, the next thing to see is whether any spark at all reaches the plug. Then test the plugs. The spark plugs should be removed, cleaned, and their gaps adjusted. If there is no spark on any of these tests it may mean: (a) a plug is sooty and the gap between the points is bridged by carbon; or (b) too large a gap or no gap at all; or (c) the insulator is wet; or (d) the high tension cable is broken or disconnected or the insulation has perished.

The next thing to be checked is the contact-breaker. The magneto breaker-points must be kept clean and adjusted. The distributor contacts and brushes should be cleaned at regular intervals. Wipe the inside and outside of the magneto cap. Clean the distributor. Remove carefully the corrosion from all terminal points inside and outside the distributor cap. A poor contact in the distributor will cause starting trouble, loss of power, and other difficulties. It is essential that all ignition parts should be kept clean and free from dirt and excess of oil.

The battery should also be periodically looked after. Check the condition of the battery with a hydrometer, add distilled water according to the need, and clean the battery terminals and cover them with grease. During charging, water in the electrolyte may be driven off, thus increasing the intensity of the solution. Never permit the electrolyte level to go lower than the top of the plates. Distilled water should be added, as already stated, for taking up the level which should normally be ¼ inch above the top of the plates. The cells should never be filled completely as this does not allow sufficient room for gasing or expansion. The specific gravity of the electrolyte (before adding water) should not go below 1·225, which is nearly half charge. When fully charged, the specific gravity would normally be 1·240 to 1·255 approximately. It is important to keep the top of the battery perfectly dry, as the presence of moisture, especially if it is slightly acid, will set up terminal corrosion and may also permit current leakage between the cells. The stoppers of the filling orifice should always be screwed down tightly on their rubber gaskets. It should be seen that vent holes in the stoppers are open. The terminal should be coated with petroleum jelly or with anti-corrosive grease. The actual terminal lugs and bushbars will not corrode, as they are made of lead, but the connectors and their clamp bolts are sometimes attacked by the acid. An effective and safe way of removing the corrosion is to soak the parts in a strong alkaline solution made by dissolving washing soda in the warm water.

In the case of a diesel engine, air is compressed until the resulting high temperature is sufficient to ignite the fuel injected after the compression is practically completed; and as such no ignition devices or spark plugs are required.

Lubrication

The object of lubrication is to reduce friction and wear between the surfaces. Lubrication accomplishes this by interposing a film of oil or grease between the sliding surfaces. The other functions of lubricating oils in the internal combustion engines are the cooling of surfaces, such as the pistons, by picking up heat and dissipating it through the crankcase, and the reducing of compression losses by acting as a seal between the cylinder walls and the piston rings. A lubricant must be able to perform certain tasks in order to accomplish its purpose satisfactorily. It must possess sufficient viscosity and oiliness to protect the mechanical devices at different speeds, pressures and temperatures. It must be of such a nature that it can be handled satisfactorily by the lubrication system. Finally, it must be able to stand up to all conditions of service.

The lubricating oil in an internal combustion engine does not get depleted but becomes unfit for further use through contamination. Oil contamination may consist of solid particles such as dirt, grit, and other abrasives. This may be caused by water or by a chemical action. Water gains entry into the engine in several ways. It is formed during the combustion of the fuel, and some of this enters the crankcase by flowing past the pistons. The pressence of water in the lubricating oil may cause emulsions and sludge. Tractor engines are normally operated at high temperatures but they are not always running under load, for when a change of implements or an adjustment has to be made, the engine is shut down to idling speed and consequently cools down somewhat. This results in fuel droplets forming on the cylinder walls and (particularly in an old engine), getting past the pistons and into the crankcase, thus diluting the oil in the sump. Excessive crankcase dilution makes the oil thin, reduces its viscosity. It may happen that there is not sufficient reserve of film strength to maintain the bearing in a properly lubricated condition. The action of oxygen on very hot oil is another trouble often encountered. The oil in a crankcase is constantly being churned up so that the oxygen in the air is "kneaded" into it. This action, added to the effect of particles, dirt and carbon, results in the decomposition of the oil which forms a thick mass known as sludge. The oil in the crankcase should be reinforced with fresh oil up to the mark indicated on the oil gauge. The crankcase should be completely drained, washed with kerosene and filled with fresh high-grade oil according to the recommendations of the makers. When the engine is started, the oil indicator will rise, indicating pressure if the oil system is working properly. If it does not rise, the operator should check the supply of oil in the crankcase or the oil strainer screen.

For proper lubrication, as stated above, the oil should not be permitted to go below the proper level recommended by the manufacturers of the tractor. It should be clearly understood that "clear" oil is not necessarily "clean" oil, nor is dark or black oil necessarily "dirty" oil. It is, therefore, essential to follow strictly the manufacturer's instructions for periodic changes of oil and filter elements. Of all the farm machines, the tractor requires most carefull oiling, since no other factor affects the life of a tractor so greatly as does inadequate oiling. This deserves utmost attention. A thoroughly lubricated tractor will last longer and give greater service.

Cooling System

The purpose of the cooling system, regardless of whether the engine is diesel or spark ignition type, is to dissipate the heat of combustion and friction and to maintain proper engine temperature for efficient engine performance. The proper design and maintenance of a cooling system is, accordingly, extremely important since the amount of heat to be dissipated is great. The engine must be cooled in order to maintain proper lubrication, to prevent overheating of the engine parts, and to ensure proper combustion. On the other hand, the engine temperature must be high enough to ensure vaporization of the fuel and prevent dilution of the lubricating oil.

Direct cooling by air is used on some small farm engines but the majority are cooled by liquid. The wall temperature of air-cooled engines is generally higher than that of the water-cooled type because of the low value of the heat-transfer co-efficient between metal and air. The control of cylinder temperature in air-cooled engines is difficult for stationary applications. The hottest points in a cylinder head are the exhaust valve and the exhaust port, and, therefore, special attention must be given to them—whether it be by air or liquid cooling. Air cooling has the advantage of eliminating water jackets, pumps, radiators and water connections, but it requires fans and, in stationary engines, blowers for moving the air.

The commonest liquid used for cooling is water. It is made to circulate round the cylinder heads and through a radiator with an air driven fan. The circulation of water is sometimes thermosiphoned or temperature controlled. When the cylinders warm up after starting the engine, the warm water rises due to decrease in its specific gravity and is displaced by cooler water. The suddenly rising warm water from the cylinder causes circulation through the radiator where the water is cooled by a blast of air drawn through the radiator by the fan. In this manner, the engine is kept at an even temperature.

The radiator consists mainly of a core of vertical copper tubes, attached to which are the sheet-copper fins that form extra cooling area. A screen on the top of the radiator tubes is designed to prevent foreign matter from entering and clogging the tubes. The water to be used should be clean and its level in the radiator kept above the radiator tubes. Water should never be poured into an empty cooling system when the engine is hot. Because of the slow speed of tractors, a large-sized syphon is required, and the water pump speeds up water circulation. Without the pump, the water is likely to boil away quickly and over-heat the engine. A thermostat is generally provided to maintain the liquid at the desired temperature. Thermostat control eliminates the necessity for the operator to close the radiator blind in cold weather. Tractor engine should be made to work at a temperature of 160°F. to 180°F., since at lower temperatures there is a risk of the water boiling away. As stated, the task of the radiator is to dissipate heat from the water to the air, and in order to accomplish this, the air must come in contact with the heated surface of the radiator. The radiating surface has, therefore, to be kept sufficiently large, resulting in decrease of space for passage of air and increase of resistance to the flow of air. On the other hand, the resistance to the flow of air must be kept relatively small in order that sufficient volume of air may be moved by the fan through the radiator.

The functional features of different types of liquid cooling systems are as under:

(a) Thermostat :

- (i) Simplicity and lower cost
- (ii) Quick engine warm-up
- (iii) Circulation in proportion to load or head and not in proportion to speed
- (iv) Large passages and water spaces required
- (v) Circulation not positive

(b) Pump without thermostat:

(i) Slow engine warm-up

(ii) Circulation in proportion to the speed of the engine and not related to load

(iii) Small passages and places required

(iv) Circulation is positive

(v) Difficulty to maintain engine temperatures and part-loads

(c) Pump and thermostat:

(i) More complicated and costly

(ii) Quick engine warm-up

(iii) Circulation proportional to speed and temperature

(iv) Compact and small passages permitted

(v) Engine temperatures maintained irrespective of load or speed

Water is used as a cooling medium because of its relatively high heat-transfer property and abundant availability. The principal disadvantage of this method is that it may cause corrosive action on the radiator and the engine. In areas where temperatures are very low, water has another disadvantage as it has a high freezing-point.

It may be mentioned here that a boiling radiator is not necessarily a sign that the water is not circulating properly, for it may be that the fuel mixture is over rich, or even too weak. Other causes of heating-up are a retarded ignition, low level of engine oil in the sump, unsuitable oil, dragging brakes, overloading, low level of water in the radiator, or slackness in the fan belt. A common cause of overheating is the furring-up of the radiator due to the use of hard water or the accumulation of muck in the water. It may also be caused by the accumulation of dust and dirt in the radiator grill, particularly after the tractor has been used for threshing. The grill should, therefore, be periodically cleaned by compressed air or by water pressure directed from the engine side of the radiator.

The best way to avoid trouble in the engine or furring-up of the radiator is to fill up the radiator with soft water. Otherwise, periodical cleaning should be resorted to. The scale can be removed by filling water jackets and the radiator with strong hot solution of common soda, then after leaving it to stand through the night it should be drained off, and the water jackets and radiator throughly washed with clean water. Soda should not be used if the radiator or pipes are made of aluminium, because soda is injurious to this metal.

Transmission System

The transmission system delivers the power from the engine to (a) the drive wheels where it is used to pull loads, (b) the power take-off where it is available to operate equipment requiring power in addition to that necessary for forward travel, and (c) the power lift, where it is used in raising and lowering integral equipment. Power is also transmitted with a remote cylinder for raising or lowering trailed implements.

Power is transmitted from the engine to the drawbar through the clutch and transmission gears. Sliding pinions of varying sizes in the transmission are shifted to mesh with corresponding gears to provide for various forward speeds and one speed in reverse. A differential is provided in the axle of the driving wheels to permit each of them to turn independently. This helps working in rough conditions and particularly in turning or taking a sharp curve.

The sole purpose of the clutch is to link or connect the power of the engine to the load. To function properly, the clutch should operate smoothly and without a jerk. A power take-off is usually provided to make power available from the tractor engine for driving farm machinery. The power take-off consists mainly of a shaft which is driven by the regular transmission. Its operation is controlled by a shift-lever, suitably placed for the convenience of the tractor operator. Hitch and power take-off locations on all tractors are now-a-days standardized so that tractor-drawn equipment, powered through the take-off, is readily interchangeable. It may be added that power take-off provides continuous running power for the machines as long as the tractor engine is running. Its power is completely independent of the transmission clutch. The operator can stop the forward travel of the tractor at any time and start it again while the machine continues to operate at full speed without interruption.

The hydraulic power-control, when provided on a tractor, supplies power for raising and lowering the equipment. In the case of the drawn implements, this is done through a remote cylinder attached to the implement and connected to the tractor by flexible oil lines.

Hour Meter

Since tractor manufacturers insist on oil-changing and running adjustments being carried out strictly according to the number of working hours given in their instruction books, it is necessary to have an hour meter fitted to the tractor, as it provides an automatic means of registering the number of hours the tractor has been working. An hour meter would, in the future, be considered as a standard tractor-fitting.

Traction Energy

Of the three principal ways of converting tractor engine energy into useful work, the least efficient and yet the most-used means is the drawbar. For this reason the subject of traction efficiency has been the subject of considerable research. Traction is the term applied to the driving force developd by a wheel or other means as it acts upon a surface. Tractive efficienry is defined as the ratio of drawbar horse-power to the horse-power input of the rear axle. It is the measure of the efficiency with which the driving wheels transform the torque of the rear axle into linear drawbar pull. A number of factors operate to lower tractive efficiency. The more important of these are rolling resistance, energy losses in obtaining adhesion, and losses due to steering. Some of the factors affecting the coefficient of traction are: tyre inflation pressures, soil types, tyre or lug equipment, soil moisture content, and wheel sizes. One of the advantages of rubber tyres over steel wheels and lugs is the decreased rolling resistance of the tractor on rubber tyres. Other factors being equal, the greater the diameter of the wheel, the greater will be the area in contact with the ground, and the lesser will the wheel sink. The effect of wheel-diameter is marked on loose-track surfaces. When rubber tyres were first adopted for tractors, one of the major problems was securing of traction for heavy jobs liked ploughing. Traction gear-ridges were generally designed for the slow speed. Steel-luged wheels are generally permitted for the maximum drawbar pull. At first the possible solution was thought to be in loading the rubber-tyre wheels until sufficient traction was secured. The other and more logical solution lies in increasing the speed and reducing the maximum drawbar pull of the tractor, thus utilizing nearly the full horse-power. It may be added that a tractor with larger horse-power requires approximately twice the normal speed to utilize its available horse-power to the full.

Inflation pressure is one of the most important factors affecting the rolling resistance of pneumatic tyres. Reducing the inflation pressure increases the work of flexing the tyre but decreases the energy expended in dispalcing the soil. On a hard smooth surface, where there is no surface displacement, reducing the pressure increases the rolling resistance. On loose sand it greatly decreases the rolling resistance. Some interest was manifested in dual pneumatic tyres to increase traction. Tests carried out, however, indicate that the traction, expressed in pounds drawbar pull, is greater for the single than for the dual tyres.

Practical experience on farms has demonstrated that it is necessary to add extra weight on the driving wheels of most tractors with pneumatic tyres to secure adequate traction for heavy field work. There has been discussion as to the relative effectiveness from the stand-points of coefficient of traction and tractive efficiency, and iron wheel weights and liquid ballast. Air-filled tractor tyres operate more efficiently and economically in sand and loam than tyres filled either partially or fully with water. Tests on sandy soil showed that at 1,000 lb. drawbar pull there was little difference in the performance of the tyres filled partially or fully with water. Both were considerably less effective than the air-filled tyre. Similarly in the loamy soil, the air-filled tyres again proved to be superior. A number of studies seem to indicate inferior performance for liquid-fill on sand and other low traction soil conditions.

A tyre that is under-inflated develops cracks all round the casing at a point midway between the tread and the bead; and although this cracking is not visible from the outside, it will, if allowed to continue, mean a burst cover which cannot be repaired. Too low an air pressure will also cause the cover to creep round the rim, and this frequently tears out the valve stem. The rear tyres are generally run at 12 lb. pressure, except for ploughing, when the tyre running in the furrow should be at 16 lb. pressure. The pressure should be increased still further when the tractor is used for road work.

Tracks

Tracks have been used to reduce ground pressure and rolling resistance and to increase cohesion on soft loose soil surfaces which have low supporting capacity. On some surfaces the gripping power of the track may actually be sufficient for the tractor to exert a drawbar pull greater than the weight of the tractor itself. These advantages are in part counterbalanced by internal track friction and greater initial cost. Special provisions must be made if steel tracks are to be operated on or across hard-surface roads.

Because of high internal track-friction and low bearing pressure, tracks give best relative overall drawbar efficiency when the tractor is operating at nearly maximum drawbar pull on soft loose surface. Also, the high initial cost of track construction is lowest per drawbar horse power for larger tractors, and is more readily made good by the greater tractive efficiency when tractors can be used for a sufficiently large number of hours.

Tractor Ploughs

The first thing to be decided in choosing a tractor plough is the size that will be adequate for the work it will be called upon to do. There is no simple and practical way of defining the size of a plough. Probably the best way is to take the pitch measurement—that is, the distance from the share point to the beam. On a light plough it will usually be in the region of 20 to 22 inches, on a medium one about 24 inches, and on a heavy one 27 inches or more.

The maximum depth of ploughing to be secured decides, more than anything else, the size of the plough that is required—for a maximum of six to seven inches, a light plough will be adequate; for 10 or 11 inches a medium one; but for anything above 12 inches, it is better to choose a heavy plough. On very heavy or hard soil, or on land with boulders roots or other obstructions, it is usually better to have a plough one size heavier than is indicated by the maximum ploughing depth, in order to ensure sufficient strength for the rough employment. When dung or surface rubbish has to be ploughed in, a pitch measurement of at least 20 inches is essential if blockages are to be avoided.

Once the size of the plough has been fixed, the next step is to decide on the number of furrows necessary to provide a load for the tractor. The most efficient drawbar pull of the tractor in ploughing-gear on firm land is found from the results of tractor tests. It is advisable to take 80 per cent of the maximum drawbar—pull given in the instruction book as the expected performance. The draught of the largest furrow normally used can be found from the resistance of the land—that is, the number of pounds-pull required by the plough for every square inch of the cross-section of the furrow-slice. Figures for land resistance should only be taken as a guide, because they can vary a great deal from one part of a field to another, and may change from day to day, depending on the condition of the land, the setting of the plough, the depth of ploughing and a host of other factors. It is possible, however, to classify land broadly according to the anticipated resistance, for which the following figures may be taken as a rough guide:

	lb. per sq. inch
Light land	4 to 6
Medium land	6 to 9
Heavy land	9 to 13
Very heavy land	13 to 18

Quite often it is found that the tractor will pull a four-furrow plough over the greater part of a farm but in one or two fields three furrows are all that it can manage to pull. In such cases, and whenever the tractor can pull four furrows over as much as half of the total area of the farm, a four-furrow plough should be chosen, which can easily be converted to a three-furrow one when required. It should also be remembered that while most of the three-furrow ploughs can be converted to two-furrow ones, and *vice versa*, the three-furrow ploughs can rarely be converted to four-furrow ones, unless they have been specially ordered for this purpose.

The choice of plough bodies will have an effect not only on the efficiency of the work that the plough does, but also on the whole system of cultivations carried out on the farm. As with plough size, the over-riding factor is again the maximum depth of ploughing to be achieved. If it is to be greater than about 7 inches, general-purpose bodies should not be used; if it is over about ten inches, it will be necessary to have digger bodies. The neat, well set-up and unbroken furrow slices made by the general-purpose body often need far more after-cultivations to produce a firm seedbed, and under many conditions, clearly defined hollows are left under the furrow slices. Quite a number of crop failures have been traced to neglect in filling up these spaces. There are, however, times when hollows under the unbroken furrows are a definite advantage: the spaces under the furrow slices help in surface drainage of heavy land, and it is often possible to get on to such land earlier after rain. It must be remembered, however, that the hollows are still there, and the scheme of cultivation must be planned so that they are eliminated before the crop is planted.

The choice of body depends mainly on the soil and the system of farming. There must be a definite relationship between the width and the depth of the furrow slice for good ploughing. For general purposes, at least three inches of width are needed for every two inches of depth. Thus, in selecting a plough, a model capable of taking the necessary width of furrow to suit the depth of ploughing must be chosen. It is extremely important that the main frame of a tractor-plough—consisting of the beams, brackets and braces—should retain its shape as long as possible. A great deal of ploughing troubles is due to ploughs getting out of alignment after a period of use. A common fault is sagging in the middle.

A farmer must also consider whether he will be served best by a trailer plough or a mounted plough. The trailer plough is not restricted in size or weight, and can, therefore, be built in a very wide range of models to suit almost any tractor, any type of land, and most systems of farming. The only changes that are likely to be needed are in regard to the layout of the controls and the hitch in order to accommodate difference in seating position. A part from such minor changes, which are usually made once for all when the plough is purchased, it is necessary only to pull out the drawbar pin and untie the trip rope to free the tractor for other work.

The disadvantages of a trailer plough are, first, that together with the tractor, it may easily form a rather long and unwieldy unit which is not easily handled; and secondly, it is not always easy for the operator to control it, because the control levers are behind him, and it often needs a good deal of effort to move them quickly. This latter disadvantage is being overcome to some extent by the development of hydraulic control mechanisms for trailed implement, including ploughs. This arrangement will reduce the physical effort involved but necessitates connecting and disconnecting the line every time the plough is hitched to or unhitched from the tractor, and requires that there must be little or no loss of oil or risk of contamination by grit or dust while this is being done.

The mounted plough is the ideal type for work in small fields and confined spaces. It is always fitted close up to the rear of the tractor and lifted by the power lift, so that very sharp turns can be made using the independent steering brakes on the rear wheels of the tractor if necessary. The controls are always close at hand, and as they need little effort for operation, it is usually less tiring for the driver to work a mounted plough than a trailing one. The initial cost of a mounted plough will usually be substantially lower than that of the corresponding trailing model. The compactness of a tractor and mounted plough allows a narrow headland to be used. The adoption of a mounted plough, however, imposes certain limitations. It cannot be too heavy, for it will, when lifted, remove so much weight from the front wheels that the tractor would become unstable. Further, it cannot be used conveniently with a crawler or a tractor on half-tracks. The tractor too must be designed specially to take a mounted plough. Besides, the farmer would have little freedom in selecting the type of plough, best suited to his farm condition. In fact, the selection of a mounted plough cannot be considered separately, but must be regarded as being part of the much larger question of whether it is desirable to adopt the principle of mounted implements for a large part of the machinery on the farm.

With a disc plough the land is merely cut up and moved sideways without being inverted to any great extent as is the case with a mouldboard plough. Disc ploughs are accordingly not suitable for ploughing grasslands or where crop residue is to be buried. Their main use, however, is for preparing a clean field for another crop and when the ploughs have to work in extremely hard land or in very loose ground. Hence for tough conditions and where the top material is not required to be buried down, such a plough would be found useful. When selecting this plough, one with an "overhead frame" should be preferred to one with a "side frame" as the former would give better clearance.

Assuming that the farmer has made up his mind to have a mouldboard plough and also about the type of mouldboard plough he desires to purchase, he should pay attention to necessary details. The following points deserve consideration:

(i) *Lift:* The ideal lift is one that gives a constant ground clearance when the plough is lifted, irrespective of the depth at which it is set to work. Such is the case with a mounted plough. But it is impossible to design the linkage on the lift of a trailing model.

(ii) *Controls:* Plough controls should be simple to operate, and placed within easy reach of the driver. Though adjustment of screws is a rather slow process, screw-control had a decided advantage in as much as the screws are easily moved and the handles remain in position at all settings. Levers, on the other hand, give a rapid adjustment but are rarely within the dirver's reach over the whole length of travel.

(iii) *Wheels:* The land wheels should be large and wide enough to carry the plough under all soil conditions. The land wheel of any plough should be placed, as far as possible, where it does not follow the wheel of the tractor. If it does, and the going is heavy, the land wheel will have to run into a rut and the plough will go deeper. This would produce an increase of the draught of the plough causing more frequent wheel-slip and deeper rut which would ultimately lead to the tractor getting bogged.

(iv) *Disc coulters:* Single-arm disc coulters are less likely to cause blockages than the double-arm type, but they cannot easily be made as strong, and the rate of wear is likely to be higher. Disc bearings should be well sealed against the entry of dust and grit.

(v) *Skim coulters:* A well-designed and well-set skim coulter will cut a clean skimming from the furrow slice, placing it in the bottom of the open furrow. Skimmings should on no account remain attached to or resting on the furrow slice, as otherwise the ploughing will be hollow.

(vi) *Shares:* Chilled cast iron shares are easy to replace, need no maintenance, and have a fairly long life in non-abrasive soils. For rocky conditions, steel shares are much superior to cast-iron ones. When the underside of the nose of a steel share wears out, so that most of the suck is lost, and when the edge of the wing becomes rounded, the share should be removed for sharpening. If this is not done soon enough, the plough will not penetrate properly and the share may be worn beyond repair.

Cultivators

Points to be taken into consideration in selecting a suitable cultivator have already been mentioned in Chapter II. To recapitulate briefly, these are: (i) weight of the cultivator per tine in keeping with the nature of the work and type of the farm land, (ii) effective tine length, (iii) the number of tines on the cultivator suitable for the tractor possessed by the farm owner, and (iv) type of the 'cultivator', e.g., rigid or spring-loaded cultivator.

Harrows

The harrow is an implement used for levelling the ground, crushing the clods, stirring the soil, preventing and eradicating weeds, and covering the seed. Harrows can be divided into three main categories, namely, Disc harrows, Drag harrows, and Seed harrows.

The disc-harrow should preferably be a tandem disc harrow rather than a single-gang machine. The latter does not leave a level soil surface unless the field is covered twice by the implement. In the case of a tandem disc harrow, which has two gangs of discs, one behind the other, the soil receives the maximum effect, particularly as the discs in the rear gang run midway between those on the front gang. Disc harrows are very suitable for breaking down the soil without bringing the buried plant material up. This is a very useful implement for the preparation of a seedbed. Arrangements to have "transport trucks" which are nothing more than travelling wheels to hold the discs off the ground and to transport them, should be insisted upon, as transporting discs over long distances on hard surfaces is likely to result in injury to the sharp edges of the discs. In deciding upon the size of a disc harrow, its average draught per foot of width should be ascertained, and the width and number of discs in each gang determined taking into consideration the drawbar-pull of the tractor in use. It is always desirable to assume about 2/3rd of the maximum drawbar pull as available for dragging a disc harrow.

The drag harrow is not usually necessary on an average mechanized farm. It will if weighted stir the soil to a depth of about two inches. As a general rule it is not considered a very good clod-crusher.

What would probably suit the farmers' need best is the seed-harrow having spring teeth or fixed teeth. The choice is dependent on the type of soil and crops to be grown. It may be mentioned that different types of teeth could be had for different purposes but those alone should be purchased which would mainly suit the cropping pattern to be adopted.

Rollers

The selection of rollers should not normally present any difficulty. For farms of average size, a roller about 18 inches in diameter and weighing about 3 cwt. per foot of width should suffice. If instead of a plain roller one having rings is used, better breaking of clods in the preparation of seedbed can be obtained. On lands which are liable to form hard clods, it is usually better to choose a narrower and heavier type of roller.

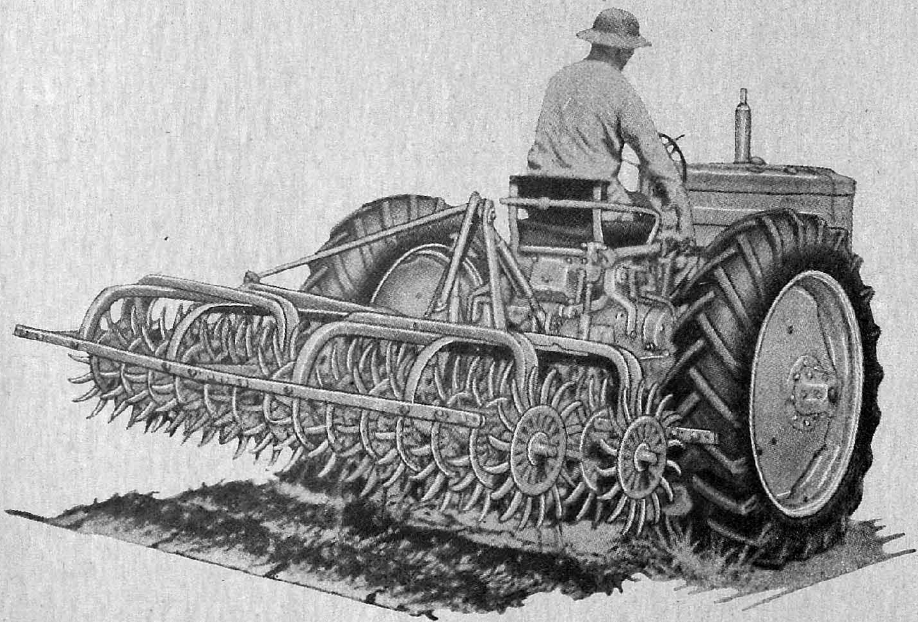
Manure and Fertilizer Distributors

When selecting a manure and fertilizer distributor, it should be seen that it is resistant to corrosion, can be easily cleaned, and is capable of spreading various types of fertilizers and manures evenly and at the desired rates. The size of the farm and the extent of power available should also be taken into consideration. Manure spreaders are usually of trailer type, having conveyor-drive with beaters. The size of the distributor should be determined in relation to the size of the farm, the type of the manure mixture or fertilizer required to be spread, and the time during which it has to be spread. If the mixture has to be spread after the crop is grown, it is necessary that the distributor should have spouts to suit the rows of crops. The normal practice, however, is to deposit the fertilizer along with the sowing of seed.

Seed Drills

When choosing a seed drill, the various types of cereal crops that are likely to be grown on the farm have to be taken into consideration. It is possible to have one seed drill only for a mixed farm, provided it is of the right type. One can now-a-days get a seed drill which can plant cotton seed, maize or sorghum. The seed-drill should have an external force-feed-mechanism with a simple agitator in the seed box. The choice of the coulters is dependent on the type of the farm land. Whichever be the type of coulters, they should be so mounted as to give different spacings, starting from four inches for sowing seed mixtures. Very often a large number of coulters are required to be removed when changing from seed mixtures to cereals or to crops sown in wide rows. It would be better if each feed unit could be provided with an independent means of shutting it off when the corresponding coulter is out of use. Normally, as stated above, a farm should not require more than one seed-drill. In case it is desired to have a combined grain and fertilizer drill, it is useful to have an independent fertilizer box with separate spouts for dropping the fertilizer.

PLATE X



Two-row Rotary Hoe

Hoes

Hoeing is one of the lightest farm operations. The rate of working depends very much on how close the hoes are set to the rows, and how easy it is to see the plants. With a tractor, rear tool bars are not suitable for accurate working unless they are steered by a person other than the driver of the tractor. As most of the fields are far from being level, the best type of hoe-blade mounting is one which allows single-blade or even a group of blades, to move up and down in relation to each other. The other alternative to the independent mounting of hoes is to prepare the seedbeds first, so that they are level enough for rigidly mounted hoes to be worked efficiently. Tractor hoes can be had as a single-row, two-row, four-row, and even six-row implements. The number of row-hoes must be equal to the number on the drill. Normally a four-row tool bar is found to be most suitable.

There are rotary hoeing machines also which consist of a large number of light wheels mounted horizontally with erect spokes all round the periphery. These are very effective where the climate is hot and dry enough to kill the weeds in a few hours after the operation. It is necessary to see that the plants are not very large when hoeing is done, for otherwise the spokes may catch and pull out some of these. The hoe is very akin to a 'cultivator', as the work it does is nearly of the same type as that of the latter. The considerations mentioned for the selection of a 'cultivator' apply, therefore, to this implement as well.

Combine Harvester

It should be understood that small hilly fields are not suitable for the use of combine harvester, as it cannot always work well on steep slopes. Similarly, where the land is cut up, it is extremely difficult to work a combine without incurring heavy losses. A combine would not be economic if the climatic conditions do not necessitate harvesting to be done in a specific period. The types of crops normally grown are a further consideration in this behalf. The same combine may not be suited for different types of crops and, therefore, unless the area under a particular crop is sufficiently large to justify purchase of a combine, it may not be advisable to go in for this costly machine.

CHAPTER IV

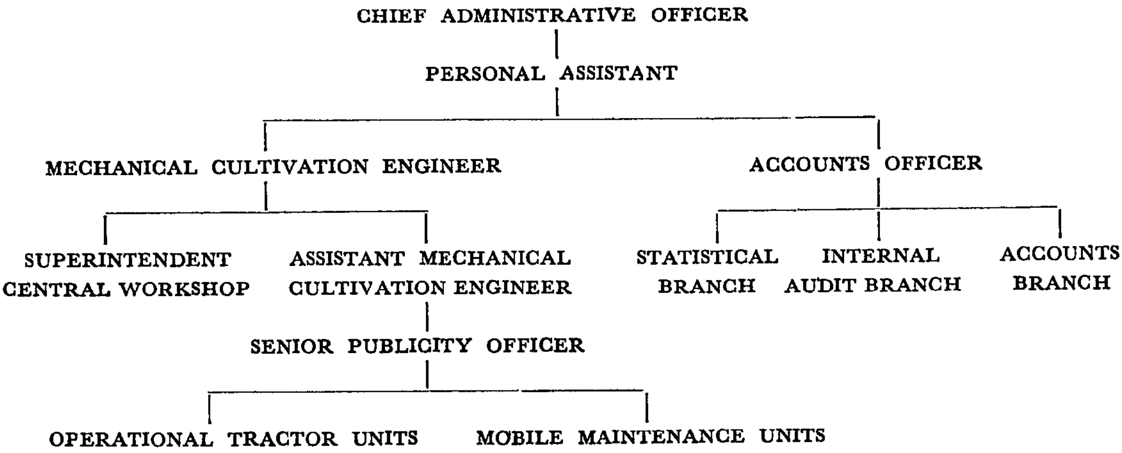
ORGANIZATIONAL ASPECTS

ALONGSIDE the selection of appropriate farm machinery the question of planning a suitable organization for running the scheme on economic lines needs to be studied carefully. The mechanical equipment has to be grouped into units of proper size and located at suitable centres offering adequate concentrated demand. With a view to keeping the tractors and implements in complete working order throughout the working season, it is necessary to have mobile maintenance units located at suitable points. The number of such units and their location would depend on (i) the number of machines on the strength of the Section and (ii) the extent of dispersal of these machines over the area of operations.

The work of the organization has three different aspects, viz., (i) mechanical and operational, (ii) publicity and cultivation of demand, and (iii) financial control and statistics. Each of these functions will have to be assigned to a distinct section. Thus, the Mechanical Cultivation Engineer will be in charge of the maintenance, upkeep and running of the tractors and other machinery. He will also be responsible for the maintenance of the stores and the workshop in order to ensure that the tractors are properly serviced, repaired and overhauled with the minimum of delay. He would be the head of all the operational staff in the organization. Publicity of fostering of demand would be the responsibility of another branch which may be called the Works Section. A propaganda organization is necessary to secure a constant and adequate flow of demand for ploughing and bulldozing services. Although the benefits which accrue to the cultivators from these services are unquestionable, the demand for these services is seldom secured without persuation because of the conservative nature of the cultivators. This Section may also arrange for the provision of credit facilities in the form of *taccavi* loans etc. wherever necessary. Financial control and maintenance of accounts and statistics will be the charge of the Accounts Section. This Section will maintain detailed accounts of the organization on commercial lines, and compile statistical information on the working of the different operational units as well as for the organization as a whole. The Mechanical and Accounts Sections should be manned by properly qualified personnel. The work of the Publicity (or Works) Section should be looked after directly by the officer who will be in charge of the whole organization.

The Chief Administrative Officer of the Organization should be responsible for laying down general lines of policy, co-ordinating the working of all the Sections and ensuring overall efficiency.

The actual strength of the staff in the three Sections, and the status of the different officers would, of course, depend on the size of the Organization. A chart showing the general set-up of an organization intended to serve the requirements of a State, and having a large fleet of tractors is given.



Where the organization is to be restricted in its scope to a small local area with comparatively smaller needs, the strength and the status of the staff should correspond to the requirements. In the case of a concern owning only a few tractors, all the functions of creating demand, keeping accounts, and exercising general control may be combined and assigned to a single person.

A Central Workshop sufficiently equipped for all repair and overhauling work, should be provided for in the scheme. It should be placed under the immediate control of the Mechanical Cultivation Engineer.

If the organization is State-wide in scope, comprising a large number of units spread over an extensive area, it would be necessary to devise a scheme of zonal grouping of the units, each zone being controlled by a Divisional Officer. This would enable proper supervision to be exercised. Besides, the Divisional Officer would serve as a connecting link between the zonal sub-units and the Central office, and thus help to achieve effective control and co-ordination.

The organizational machinery will consist of a regular hierarchy of administrative centres, with the operational units forming the base, the Maintenance Units and the Divisional offices occupying the intermediate stage, and the Central office (together with the Central Workshop) constituting the apex. The constitution, the functions, and the equipment and establishment requirements of each class are dealt with in some detail below.

Tractor Units

The number of tractor units to be formed in a State or any other area of operation depends mostly on the number of tractors in employment, which in the case of different State organizations in the Indian Union varies from 50 to 300. The other factors to be taken into consideration in determining the number of tractor units are: (a) extent of the area of operation and (b) the demand for tractor ploughing and other mechanical cultivaton work in concentrated blocks.

Generally, if sufficient area is available for tractor ploughing in concentrated blocks (within a radius of say about ten miles), and if it would thus be possible to provide full employment to the machines, a tractor unit should comprise 16 machines, viz., 12 tractors of 60 to 80 H.P. and 4 bulldozers of 60 to 80 H.P. Such a unit of 16 machines can be divided suitably into two sub-units, each having 8 machines–6 tractors and 2 bulldozers. The sub-unit should generally have the following implements, accessories, transport facilities, and establishment:

Implements

(i) One plough per tractor and one extra plough, i.e., 7 ploughs in all.

(ii) Two disc harrows (for 6 tractors).

Accessories

(i) Spares: Each tractor unit should necessarily have in stock fast-moving spares, such as bolts, nuts, filters, fan belts, injectors, mould boards, plough shares, etc., sufficient for replacement of their proto types in at least 25 per cent of the machines in the unit.

(ii) Fuel oil: There should be stock of fuel oil sufficient at least for fifteen days' requirements so that no machine remains idle for want of fuel.

Transport Facilities

It is necessary to provide each tractor unit with a jeep for the use of the Foreman Supervisor in charge of the unit, and the Publicity Officer, with a view to enabling the former to visit the sites for supervising the work of various machines in the sub-unit and the latter for canvassing work and collecting advances.

It is also essential for each tractor unit to have its own transport arrangements for moving fuel oil, spares, etc., from the nearest railway station, oil depots, workshops and stores, to the sites where the unit operates. For this purpose, it is necessary to provide each unit with one motor-lorry or two wheel-type tractors operated on highspeed diesel oil, with trailers. It is advisable to use wheel-type tractors worked on highspeed diesel oil, with trailors, for the purpose, as it is more economical.

Establishment

The following staff is considered essential for each tractor unit. The pay scales given against the various posts are those obtaining in Bombay State and may vary according to the conditions and rules prevailing in different States:

S. No.	Nature of the post with pay scale	No. of posts	Remarks
1	Foreman Supervisor (Rs. 150-10-270)	1	One Foreman Supervisor should be in charge of one tractor unit.
2	Mechanic (Rs. 150-10-200)	2	One Mechanic can look after eight machines.
3	Assistant Publicity Officer (Rs. 80-5-100-8-140-E.B.-10-200)	1	For securing custom for the unit and doing necessary convassing.
4*a*	Tractor Driver (Rs. 70-5-100)	18	
b	Bulldozer Operator (Rs. 80-5-120)	6	
5	Motor Driver (Rs. 55-3-85)	1	One for the jeep.
		1	One for the lorry (or if two wheel-type tractors are provided instead of the lorry, two Tractor Drivers in the scale of Rs. 70-5-100).
6	Cleaner (Rs. 45 p.m. each) (Fixed)	4	One Cleaner is necessary for four machines.
7	Clerk (Rs. 46-3-85-E.B.-4-125-5-130)	1	One Clerk is necessary for each unit for maintaining accounts, preparing returns and for other clerical work.
8	Technical Storekeeper (Rs. 46-3-85-E.B.-4-125-5-130)	1	One Technical Storekeeper is necessary for each unit for maintaining the stores, keeping the records pertaining to stores and generally assisting the clerk in preparing the various returns.

Procurement of Custom

The procurement of custom for the tractors is a special job; and in order to enable the Foreman Supervisor to devote himself principally to the mechanical side of his duties, it is necessary that there should be a special officer, who may be designated as Assistant Publicity Officer, attached to each operational unit. He should be of the rank of a grade II Agricultural Officer of the Upper Subordinate Service. His duty would be to tour the area served by the unit, and canvass and secure adequate custom for the tractors and other machines and collect the necessary deposits for the work in consultation with the officers of the Agricultural and Revenue Departments concerned. He will be under the control of the Unit Foreman Supervisor.

Mobile Maintenance Units

A Mobile Maintenance Unit is necessary for attending to the repairs of the machines on site. The unit should be equipped with the necessary accessories and tools. Generally, one Mobile Maintenance Unit can look after 64 machines or 4 tractor units. Such a unit should be stationed at a suitable place within easy reach of the units to be catered for by it. The equipment and establishment requirements of the unit are indicated below:

Equipment, Tools and Machines

Each Mobile Maintenance Unit should be provided with one jeep for the Foreman Supervisor in charge of the unit, one mobile workshop lorry and one motor-lorry for transporting machine parts, tools, etc. As the maintenace of tractors and bulldozers in complete working order throughout the working season is a matter of vital importance, it is essential that the repairs and servicing of the machines should be carried out with the least delay. It is, therefore, desirable that the repairs of such machines should be attended to on the spot instead of shifting them to the headquarters of the Mobile Maintenance Unit; and hence the need for a moblie workshop lorry.

Each Mobile Workshop lorry should possess the following equipment and tools:

(1) Chassis Diamond T, 10 wheeler, front and back well drive with petrol engine.

(2) Body, with adequate floor area complete with two flat sides, rear doors, inclusive of battery box, tripod pipe stand box, working table, cupboards, luggage carrier, etc.

(3) Power Plant about 15 K.V.A. complete with switch board.

(4) Precision Lathe 3" to 5" centre, motorised.

(5) Air Compressor about 10 cft. capacity motorised.

(6) Welding Plant motorised.

(7) Flexible Shaft—motorised.

(8) Drilling Machine ¾" capacity, motorised.

(9) Battery Charger suitable for 4-6 V, 2-12.

(10) Twin Tool Grinder 6"×8" grinding stone motorised.

(11) Hydraulic or Screw Press.

(12) Special Tool Kit for tractor work.

(13) Blacksmith's forge with tools.

(14) Carpenter's tools.

(15) Fitter's tools.

(16) Lifting tools.

(17) Storing tins, etc.

In addition, each Mobile Maintenance Unit should have the following main tools and machines:

(1) Tripod with 5 ton chain block.

(2) Mechanic's tool kits—two kits.

(3) Screw jacks—10 tons—4 numbers.
(4) Valve seat and face cutter.
(5) Wheel pullers and sleeve pulls.
(6) Testing equipment of injectors.
(7) Taps and dies sets of all types.
(8) Table drill up to 1″.
(9) Table vice—6″ jaws.
(10) Oxygen welding set.

Establishment

The staff considered necessary for the proper working of a Mobile Maintenance Unit together with their pay scales (as prevalent in Bombay State) is given below:

S. No.	Nature of the post with pay scale	No. of posts
1	Foreman Supervisor (Rs. 150-10-270)	1
2	Technical Storekeeper (Rs. 46-3-85-E.B.-4-125-5-130)	1
3	Mechanic (Rs. 150-10-200)	1
4	Welder (Rs. 100-4-120-5-160)	1
5	Turner-cum-Fitter (Rs. 100-4-120-5-160)	1
6	Blacksmith (Rs. 72-4-120)	1
7	Motor Driver (Rs. 55-3-85)	3
8	Hammerman (Rs. 40-1-50-2-60)	1
9	Cleaner (Rs. 45 p.m. fixed)	2

Divisional Set-up

It is not possible for a single centralized authority to do full justice to the work of exercising effective primary control and supervision over the activities of the units spread over the entire area of the State. It is necessary, therefore, to divide the area of operation into Divisions, each Division being controlled by an Assistant Mechanical Cultivation Engineer. The Assistant Mechanical Cultivation Engineer should be able to supervise the work of about four tractor-units, or about 64 machines. Thus, each Division would comprise 4 tractor-units and one Mobile Maintenance Unit. It is the primary duty of the Assistant Mechanical Cultivation Engineer to see that all the tractors and implements in his Division are kept in full working order, that proper arrangements are made to supply the necessary stores, fuel oil, etc. to all the units, and that repairs to machines are undertaken expeditiously.

The headquarters of the Assistant Mechanical Cultivation Engineer should be at a suitable central place so that he can conveniently look after the work of all the units in his division. He would exercise primary control over the administrative and organizational matters. It is necessary that adequate administrative and financial powers should be delegated to him.

The organization of propaganda, and procurement of custom for all the operational units is another important item to be attended to at the Divisional level. There should be one senior Publicity Officer of the rank of a grade I Agricultural Officer of the Upper Subordinate Service, attached to the Divisional office for assisting the Divisional Officer for this purpose.

Establishment

It is necessary to provide each office of the Assistant Mechanical Cultivation Engineer with the following staff (the pay scales mentioned are those prevalent in Bombay State):

S. No.	Nature of the post and pay scale	No. of posts	Remarks
1	Assistant Mechanical Cultivation Engineer in Class II (Rs. 220-15-400-E.B.-20-500-E.B.-25-650)	1	
2	Class III		
1	Propaganda Officer (Rs. 210-10-300) ...	1	
2	Head Clerk-cum-Accountant (Rs. 100-8-140-10-150)	1	
3	Junior Clerk (Rs. 46-3-85-E.B.-4-125-5-130) ...	3	One for establishment, one for accounts and one for propaganda and procurement.
4	Technical Storekeeper (Rs. 46-3-85-E.B.-4-125-5-130)	2	One for general store work and and one for preparing various working returns (including statistics).
	Class IV		
1	Peon (Rs. 30-½-35)	3	Includes one for propaganda and Works Officer.
2	Night Watchman (Rs. 30-½-35) ...	1	
3	Store Mazdoor (Rs. 30-½-35)	1	

Regional Workshops

Maintenance of regional workshops at suitable centres is absolutely necessary for all major repair jobs which cannot be undertaken by the Mobile Maintenance Units. It is advisable to have one workshop for about 128 tractors or 8 tractor units. On this basis, workshops should be established at suitable central places in a big tractor organization. In the case of organizations having a smaller number of tractors, it would suffice if there is only one workshop at the central headquarters.

Equipment

Each workshop should be provided with the following equipment:

(1) One electric welding set—30 AMP capacity.

(2) One blacksmith's electrically drawn forge.

(3) Two lathes—16″—deep gap.

(4) One spacing machine.

(5) One hack saw motor drawn.

(6) One oxyacetylene welding plant (high pressure).

(7) One set of fitter's tools.

(8) One set of blacksmith's tools.

(9) One set of mechanic's tools.

Establishment

Each workshop should have the following staff (pay scales mentioned are those prevalent in Bombay State):

S. No.	Nature of the post and pay scale	No. of posts
1	Superintendent (Foreman Supervisor) (Rs. 150-10-270)	1
2	Mechanic (Rs. 150-10-200)	1
3	Fitters (Rs. 100-4-120-5-160)	2
4	Turner (Rs. 100-4-120-5-160)	2
5	Machinist (Rs. 100-4-120-5-160)	1
6	Welder (Rs. 100-4-120-5-160)	1
7	Blacksmith (Rs. 72-4-120)	1
8	Hammerman (Rs. 40-1-50-2-60)	1
9	Painter (Rs. 72-4-120)	1
10	Carpenter (Rs. 72-4-120	1
11	Cleaner (Rs. 45 p.m. fixed)	2

Tractor Training Centres

It is often difficult to secure an adequate number of tractor and bulldozer operators on account of the fact that mechanized agriculture is comparatively new in this country. It is, therefore, necessary that a tractor organization which intends to undertake activities on a large scale should organize the training of an adequate number of tractor operators. The training centres should be set up at suitable places, so as to have one centre in each Division. The syllabus for the training course should be comprehensive and proper facilities of practical training in ploughing and bulldozing operations afforded to the trainees. Such facilities of practical training can be easily arranged if the centres are located in the vicinity of an operational unit.

Central Office

The mechanical cultivation work spread over the whole State should be headed by a Chief Administrative Officer of rank higher than that of a Class I Officer. He should be selected from among senior officers in Class I Service having considerable experience of administrative work, or recruited by promoting an experienced Mechanical Cultivation Engineer with sufficient administrative experience. The central office should consist of the Chief Administrative Officer, and the Heads of the two principal sections of the organization, viz., the Mechanical Section and the Accounts and Statistical Section, together with their respective office staff.

The Chief Administrative Officer would, in addition to exercising general control over the functioning of the Mechanical and the Accounts and Audit Sections, look after the work of the Publicity and Procurement of Demand (or Works) Section, which would be his special responsibility. He would guide and control the work of the Unit and Divisional Publicity Officers through the Divisional Officers and see that adequate demand for ploughing work is secured for all the operational units. This constitutes a very important part of his duties, as in fact the economic working of the organization depends mostly on the extent to which the tractors are kept employed, which in turn depends on how efficiently the propaganda for securing ploughing and bull-dozing custom is organized. The existence of large areas in need of mechanical cultivation services is in fact the very *sine qua non* of a tractor organization. In view, however, of the conservative nature of the cultivators, the problem is how to convert this potential demand into actual custom, and hence the need for well-planned publicity.

The Chief Administrative Officer should be assisted by a Personal Assistant of the rank of a Class II Officer for the administrative and propaganda work.

The Accounts and Statistical Section should be under the control of an Accounts Officer of the rank of a Class I Officer in an organization having extensive area of operation, or of the rank of a Class II Officer in the case of a smaller organization. He should be an officer with wide experience.

The Mechanical Cultivation Engineer, who would be in charge of the Mechanical Section, should be an engineer with considerable experience of tractors and tractor-drawn implements. He would be responsible for the proper upkeep, repairs and maintenance of the tractor fleet and machinery, and administer the stores. He would control the whole of the operational and supervisory staff through the Divisional Officers.

The details of the staff required for the central office and the pay scales suggested (on the lines of those prevalent in Bombay State) are given on the next page.

As already explained, the work in a large tractor organization will have to be functionally divided at different administrative levels. This division may be considered under two main heads: (i) Technical control and supervision, and (ii) Accounts organization and audit control.

Technical Control and Supervision

The success of mechanized agriculture will depend to a large extent on the technical control and supervision of the agricultural machinery put into service. This control can be split into two distinct spheres: (i) Preventive Maintenance and (ii) Periodic Maintenance.

S. No.	Name of the post with pay scale	No. of posts	Remarks
1	Chief Administrative Officer	1	
	Class I		
1	Mechanical Cultivation Engineer (Rs. 350-30-650-E.B.-45-1,100)	1	
2	Accounts Officer (Rs. 350-30-650-E.B.-45-1,100)	1	
	Class II		
1	Personal Assistant to the Chief Administrative Officer Officer (Rs. 220-15-400-E.B.-20-500-E.B.-25-650)	1	
	Class III		
	(i) For the Chief Administrative Officer		
1	Office Superintendent (Rs. 200-10-300) ...	1	
2	Senior Clerk (Rs. 100-8-140)	1	One for establishmet, etc., and one for propaganda work.
3	Stenographer (Rs. 100-5-125-6-155-E.B.-6-185-8-225)	1	
4	Junior Clerk (Rs. 46-3-85-E.B.-4-125-5-130) ...	5	Three for establishment, administration, etc., one for propaganda and one for typing.
5	Peon (Rs. 30-½-35)	4	Includes one for the Personal Assistant.
	(ii) For the Mechanical Cultivation Engineer		
1	Technical Assistant (Rs. 200-10-300) ...	1	
2	Technical Storekeeper (Rs. 46-3-85-E.B.-4-125-5-130)	4	
3	Steno-typist (Rs. 100-8-140- with Shorthand allowance)	1	
4	Peon (Rs. 30-½-35)	3	
5	Store Mazdoor (Rs. 30-½-35)	2	
	(iii) For the Accounts Officer		
1	Accountant (Rs. 140-10-200)	1	
2	Senior Clerk (Rs. 100-8-140)	1	
3	Senior Auditor (Rs. 140-10-200)	1	
4	Junior Auditor (Rs. 100-8-140-10-150) ...	3	
5	Senior Statistical Assistant (Rs. 210-10-300) ...	1	
6	Junior Statistical Assistant (Rs. 80-5-100-8-140-10-200)	2	
7	Junior Clerk (Rs. 46-3-85-E.B.-4-125-5-130) ...	4	One for audit, two for accounts and one for statistics.
8	Peon (Rs. 30-½-35)	2	

As the machines are to be used intensively during the short agricultural season, it is essential that preventive maintenance should be recognized as very important by the operational and maintenance staff. Preventive maintenance consists in a routine check up to find out defects, if any, in the machinery and to take prompt action to avoid damage. The lubricating, fuel and cooling systems of the agricultural machinery need daily checking by the operational staff. They should be trained to regard this as part of their operational duties. Negligence on the part of the operators in attending to this important work will result in damage to the machinery and the consequent enforced idleness of the machines.

The operational staff should also be trained to maintain clean stocks of fuel and lubricating oils. The fuel system, though provided with adequate filtering arrangements, should not be over-taxed by allowing suspended impurities into the system.

With these fundamental duties assigned to the operational staff, it would be necessary to have supervisory staff to keep proper check on the work done. Normally, a mechanic in charge of the tractors should carry out these supervisory duties. He should also employ test checks on the fuel filters and lubricating oil filters. He should pay surprise visits to operation areas and check whether routine duties allotted to the tractor drivers are done by them satisfactorily.

The supervision up to this stage is of routine nature. There should be another technical officer of higher rank, possessing more knowledge of preventive maintenance. It will be his duty to check the more intricate technical processes, such as the working of the fuel pumps, injectors and the governors of the machinery, and to carry out necessary repairs in time. The operators and the mechanic in charge of the unit should not be allowed to handle the precision equipment as they possess neither the required equipment nor the necessary experience.

The higher stage of supervision will consist in periodical overhauling of the machines after they have operated for specified number of hours. These duties should be allotted to the senior technical personnel of the organization, and will include:

(i) Decarbonizing of the engine after specific hours of working of the machinery.

(ii) Changing of pistons and liners after specified hours of working of the machinery.

(iii) Checking and calibrating of the fuel system.

(iv) Checking the transmission and trackgroups of the equipment.

Periodic checking should normally be confined to periods during which the machines remain idle.

Adequate check and control should be exercised on the spares and consumable stores too. There is a tendency on the part of the operational staff to overstock the spares. This practice should not be over-indulged as some of the replacement may be unjustified. Only those spares which are likely to be needed should be allotted to the operational staff. Other spares requiring special technical knowledge should be in charge of experienced technical personnel. The oils and lubricants should be in charge of a responsible officer who will issue the required quantities after checking the quantities issued previously. This would also provide correct data about the consumption of the oils and lubricants for the required quota of work. If any machine is showing higher consumption, the matter should be investigated and set right by competent technical staff.

The Foreman Supervisor should regularly send his inspection reports on tractors and implements to the Divisional Officer. The proforma suggested for these reports is given in Appendix (Form 1).

The duties of the technical personnel of the tractor organization are summarized in the following chart:

ENGINEER-IN-CHARGE

(General supervision of the staff, upkeep and maintenance of the agricultural machinery and looking after the store)

SUPERVISOR in charge of heavy repairs and maintenance of the fleet (overhauling and major repairs)

SUPERVISOR in charge of the tractor unit (Daily maintenance and first line repairs)

Operators (Daily maintenance of the machinery)

Accounts Organization and Audit Control

Having discussed the general administrative set-up of the organization with a detailed description of the hierarchy of working centres at different organizational levels and also the main features of the work of technical control and supervision, it is now necessary to describe the principal features of the accounts and audit control unit which constitutes the other major section of the organization.

It is essential that the system of accounts be organized on commercial lines at different administrative levels so as to make it yield a complete running picture of the trading and profit and loss account. Whether the organization is actually running on economic lines can only be ascertained if the financial results of its working are assessed at regular periodical intervals.

The first thing to be ensured is that the rate-structure for the different types of ploughing and bulldozing operations is constructed on the principle of self-sufficiency. This in its turn calls for the introduction of a scientific system of cost accounting. A tractor organization will have on its strength machines of different manufactures and also of varying capacities. These machines would be required to undertake different types of ploughing and bulldozing operations. Again, these machines will be grouped in different formations, such as the operational units. The accounting procedure will have to be organized with a view to (i) working out economic rates for different types of services, (ii) ascertaining which of the machines are working economically, and which of them prove to be wasteful and, therefore, need to be weeded out, (iii) judging the economic aspect of the various operational units, and finally (iv) collecting particulars of the expenditure and income in respect of each type of operation for ascertaining their economic success and feasibility.

As the financial transactions of the organization would be taking place over a widely spread out area and would be of a very voluminous nature, it is essential that the Accounts and other Departments like the Stores Purchase Section, Works Section, etc., of the organization should be so organized as to secure an effective system of internal checks. The fundamental principle of internal checks is that every transaction should pass through several hands in a well-defined manner and that there should be a written record of the part played by each employee. The duties of each employee should be clearly defined in order to entrust fixed responsibility to him. The system of internal check will ensure speedy detection of errors as well as fraud on the part of the employees, and secure harmonious working of the entire organization.

The internal check will have to be supplemented by a regular audit of the accounts. It is necessary that the accounts organization should be equipped with an efficient Audit Branch which should be responsible for carrying out prompt and detailed audit check over the accounts transactions of the entire organization.

Statistics play an important part in the formulation of policies of any business undertaking. In the case of a state-wide Tractor Organization with hundreds of machines on its strength and operating in tracts where soil conditions, the length of the ploughing season, and the availability of demand vary very widely the employment of statistical methods for determining the tendencies in the nature and volume of custom in different regions will be of very great use. It is, therefore, advisable to have a separate Statistical Branch as an adjunct to the Accounts organization, charged with the function of collecting and analysing the statistical data so that correct inferences regarding the relative efficiency of different machines and the nature of demand for the ploughing and bulldozing operations in different regions and months of the year can be drawn.

Procedure of Maintaining Financial Accounts (including Stores Accounts)

The following paragraphs describe the procedure recommended for the maintenance of financial accounts (including Stores accounts) at the levels of the operational units, the Mobile Maintenance Units, the Divisional Offices, and the Central Office of the organization.

(a) *Tractor Units*

The operational unit will be required to maintain basic records and accounts concerning (i) the operational work, and (ii) the financial transactions.

(i) *Operational records:* On receipt of an application for ploughing or bulldozing work, it should be immediately registered in an appropriate 'Application Register' to be maintained in respct of each separate operation. The Application Register suggested for the purpose may be of the type of Form No. 2 of the Appendix.

After the application is sanctioned, the necessary Agreement Bond should be got executed by the party (Form No. 3 of the Appendix).

As soon as the work against any contract is taken up, necessary entries in regard to the work done on each day should be made in the relative Tractor Operation Daily Register (Form No. 4). Separate Registers in this form should be maintained for (i) ploughing, (ii) bulldozing and (iii) other operations. Weekly abstracts from this Register should be submitted by the Unit Foreman to the Divisional office and also to the Central office. These weekly returns will show the details of work done by each machine on each day. On completion of the contracted work, necessary entries should be made in the Works Registers (Form No. 5) to be separately maintained for (i) ploughing, (ii) bulldozing and (iii) other works. These Works Registers are intended to serve the purpose of ledgers for the above types of works.

(ii) *Financial accounts:* Each unit will be required to maintain the 'unit' accounts and for this purpose the following records will have to be maintained:

(a) Cash Books
(b) Receipt Books
(c) Challans and Vouchers

It will be convenient if two separate cash books are maintained—one exclusively meant for recording receipts for mechanical cultivation work and remittances, and the other for recording all other cash transactions such as receipts of funds for the 'unit' expenditure and disbursement thereof on account of payment of salaries and wages, purchase of stores, repairs and incidental expenses.

The following returns should be submitted by the unit to the controlling office:

(a) Weekly statement of all receipts (showing the ploughing revenue) (Form No. 6)
(b) Weekly statements of remittances (with challans) (Form No. 7)
(c) Monthly statement of expenditure including disbursement on account of salaries, wages, contingencies, etc. (Form No. 8)
(d) Six-monthly returns for the preparation of the periodical proforma accounts:
    (i) Statement 'A' of earnings (Form No. 9)
    (ii) Statement 'B' showing financial data (Form No. 10)
    (iii) Statement 'C' of stores (Form No. 11)
(e) Statement showing monthly expenditure under stores (Form No. 12)

(iii) *Store accounts:* Maintenance of stores and spare parts of machinery on proper lines is one of the important features in the working of a tractor organization. There will be various types of machines, viz., tractors, bulldozers, implements, etc., on the strength of the organization. So far as the supply of the spares for each different type of machine is concerned, the position is not very simple since special types of spares are available only from the manufacturers of the particular type of machine or their accredited agents. If the spare parts of the various machines are purchased in bulk quantities, it is possible to get from the dealers some discount and to ensure supplies in time and at the approved rates. It is, therefore, desirable to prepare annual consolidated indents after ascertaining the requirements of the various machines. Each tractor unit should, therefore, submit its consolidated annual indent of spare parts to the controlling office.

Maintenance of accounts pertaining to the stores transactions requires special care, and as such it is necessary that it should be dealt with in some detail.

Requirements of stores are to be obtained by the Unit either from the Central office or the Divisional office, or from outside suppliers direct under orders from the Central office. The Unit Officer should communicate his requirements of the spares by means of a requisition in a prescribed form (Form No. 13) to his immediate controlling office. In the case of spare parts this requisition should be accompanied by the necessary damage report (Form No. 14). The Unit should also be required to return all the damaged and unserviceable parts at periodical intervals to the main stores. In the case of supply from the Divisional or Central Stores, the Unit should check the same with the Receipt and Issue Vouchers (Form No. 15), which it will receive in duplicate, and on being satisfied that the supply actually conforms to the particulars in the voucher, one copy of the same should be returned to the officer concerned duly receipted. The other copy of the Receipt and Issue Voucher will be retained by the Unit for its office record. In the case of supply from outside agencies, the articles will be checked against the delivery note received from the suppliers. The same will be acknowledged to the office concerned (i.e. the office placing the order) in the prescribed form (Form No. 16).

The receipt of the stores should be duly entered in the Store Receipt Journal (Form No. 17). This receipt Journal will be sub-divided into the following four parts:

(1) Spare parts

(2) Oils and lubricants

(3) Consumable stores, and

(4) Machinery and implements.

Entries relating to the receipt of each of the first three types of stores will be made in the respective sub-divisions of the Receipt Journal. The receipt of capital items such as tractors, implements, vehicles, deadstock articles, etc., will be entered in the fourth sub-division of the Journal. Repairs to tractors etc., will be entered in a separate register to be maintained for the purpose (Form No. 18).

The issue of stores should be made only under the authority of the Unit Officer, who should be responsible for ascertaining the actual requirement. The spare parts should be issued only after obtaining the necessary damage report from the mechanic concerned. The issues should then be duly entered in the Store Issue Journal (Form No. 19). This journal should be sub-divided into the following four parts:

(1) Spare parts
(2) Oils and lubricants
(3) Consumable stores, and
(4) Machinery and implements

Each of these parts will be further sub-divided into as many parts as there are tractors and vehicles in the unit. In the case of petrol, oils and lubricants, the issues will generally be made in bulk representing the requirements of different machines for a certain period. Such bulk issues should be initially entered in a separate register (Form No. 20), and receipt acknowledged in this register by the drivers concerned. The drivers should be required to render accounts of such bulk issues periodically, and the final issues thus reported should be posted from the said register to the Issue Journal. The issues of spare parts and consumable stores should be initially entered in a register to be called General Acknowledgement Register in which the mechanic or any other person receiving the issues will sign in token of receipt. The issues will then be entered in the appropriate part of the Issue Journal.

Stores Ledger: (Form No. 21) All the entries in the Receipt and Issue Journals should be duly posted to the appropriate accounts in the Store Ledger.

Periodical compilation of the stores data: The Unit should compile, preferably once a month, the data relating to the stores transactions (Form No. 12) and submit the same to the immediate controlling office.

Where large quantities of stores and spare parts of various types are stocked, it is necessary to attach a Bin Card (Form No. 22) to each cupboard, shelf or box earmarked for each category. This will facilitate the verification of stores, and enable the stock position to be known at any time.

(iv) *Operational returns:* In order that the controlling offices get all necessary information and data as promptly as possible it is necessary that the Units should be required to submit the operational returns periodically. The suggested returns are as follows:

(1) Mechanical Cultivation Operation Report Register (Form No. 23)

(2) Lorry Working Report (Form No. 24)
(In this form a report regarding the running of the vehicles during a week is to be submitted to the Divisional as well as Central Office)

(3) Weekly Fuel Stock Statement (Form No. 25)
(To be submitted to the Divisional as well as Central Office)

(4) Weekly Mechanical Cultivation Works Accounts Statement (Form No. 26)
(Report showing details of the work done and the earnings during a week is to be submitted to the Divisional as well as Central Office)

(5) Monthly Progress Report on Mechanical Cultivation (Form No. 27)
(To be submitted to the Divisional as well as the Central Office)

(6) Tractor/Bulldozer Log Book (Form No. 28).
(To be submitted monthly to the Divisional as well as the Central Office)

The above forms are self-explanatory, and contain all the data of which the controlling offices should be in possession with a view to exercising proper control over the activities of the Units.

(b) *Mobile Maintenance Units*

The Mobile Maintenance Units which carry out ' on-the-site ' repairs, overhauling and servicing of the tractors, must maintain proper accounts. For this purpose the maintenance of proper job cards is necessary. All the expenditure incurred in connection with any job should be debited to the relevant job account. Such expenditure would include the cost of spare parts used as well as the labour charges, including the overhead expenses. Suitable job cards should be devised for maintaining the job accounts (Form No. 29). In order to decide whether the Mobile Maintenance Units are economically justified, it is necessary to ascertain periodically whether the expenditure incurred on their maintenance (including the cost of staff, overhead charges such as rent, etc.,) depreciation of machinery and interest on capital investment) is made good by the savings resulting from the repair and overhauling jobs carried out by them. Financial and stores accounts should be maintained by these Units, and the necessary periodical returns submitted in the same way as recommended in the case of operational Units.

(c) *Divisional Offices*

The Divisional offices are expected to exercise effective local control over the working of the Operational and Mobile Maintenance Units within their jurisdiction. In order to enable the Divisional Officer to exercise this control properly, necessary financial powers should be delegated to him. Generally speaking, he should be empowered to draw funds for meeting the routine expenditure of the Units under his control as well as of his own office within the limits of the grants allotted to him. His purchasing powers in respect of machinery, spare parts, etc., should be restricted within well-defined limits. The Divisional Officer will exercise strict control over the financial dealings of the Units in his charge. He will see that the cash collections of the Units are promptly and regularly credited into the treasury and that the ploughing work undertaken by the Units is fully covered by adequate advances or suitable security. He should ensure by frequent visits to the Unis that the basic accounts are maintained by the Units. He should also personally check a certain percentage (which may be prescribed) of different types of transactions in the Units. Thus, a certain percentage of the area ploughed by the tractors should be actually inspected and measured by the Divisional Officer in order to verify the correctness of the periodical reports of operational work submitted by the Units. He should also periodically check the stocks of oils and lubricants with the Units. As regards the stock of spare parts, physical verification of the same should be carried out every year by the Divisional Officer.

The financial and other returns received from the Units should be compiled in the Divisional office and forwarded to the Central office. It should be the responsibility of the Divisional Officer to find out as to which Units are running on sound lines and which are not. In the case of the latter, he should try to discover the reasons for or circumstances leading to defective working, and also devise and report the necessary remedial measures for the consideration of the Central office.

Divisional accounts: The Divisional office will maintain regular accounts of all the income and expenditure pertaining to that office and those of the Units coming within its jurisdiction. Thus, whatever expenditure is actually incurred by the Divisional office itself will be duly recorded in the Divisional Cash Book and posted to the Divisional Ledger. So far as expenditure at the Units' level is concerned, the funds required will have to be supplied by the Divisional office. The expenditure incurred by the Units out of the funds supplied should be reported at the end of each month to the Divisional office (*vide* Form No. 8). On receipt of these monthly returns the Divisional office will incorporate the Unit expenditure in its own books through the Journal and the Ledger. The Divisional office should also incorporate the revenue earned by the Units from month to month. The Units will furnish the necessary data regarding the work done as well as the particulars of the collections made (Form No. 26). These should also be entered in the Divisional Journal and Ledger. The Divisional Ledger will contain separate accounts for the consumption of each type of stores, such as petrol, oils and lubricants, spare parts, consumable stores, etc. The Units should furnish the necessary data about the actual consumption of the stores in a form prescribed for the purpose (Form No. 12). This information should be incorporated in the Divisional Ledger through the Journal. Thus, the Divisional Ledger will contain all the accounts from which the financial results of the working of the Units under its control can be ascertained. A list of the different accounts which will appear in the Divisional Ledger is given in the Appendix.

Store accounts: The accounts of the Divisional Stores should be maintained on the same lines as recommended for the store accounts of the Units.

Periodical returns: All the operational returns furnished by the Units will be checked by the Divisional office and then forwarded to the Central office duly endorsed. The Divisional office will scrutinize these, particularly with a view to finding out whether the consumption of oils and spares is commensurate with the out-turn of the work. In the case of consumption of spare parts, commensurability with the output of the work will have to be judged over a sufficiently long period, say a year, in view of the fact that the replacement of parts on a large scale takes place generally at the time of overhauling the machines, which is done mostly during the off-season. The benefit of this replacement is derived only during the working season that follows; and, therefore, its economic justification can be gauged only with reference to the out-turn of work during the relevant working season or seasons.

The Divisional office will forward to the Central Office every month its monthly Trial Balance so as to furnish all the necessary data regarding the income and expenditure of the Division during the particular month.

(d) *Central Office*

The financial control of the Mechanical Cultivation Organization will be exercised by the Chief Administrative Officer at the Central office through the Accounts Section. In the case of a Government organization, the Chief Administrative Officer will have to work within the budgetary provisions made for the organization. In the case of a corporate body, the sanctioning of finances will be the responsiblity of the Board of Directors. It will be the duty of the Chief Administrative Officer to see that the expenditure is strictly confined within the limits prescribed in the budget. The organization must necessarily run on commercial lines; and it is, therefore, necessary that the financial results of the working of the organization should be made available to the management at periodical intervals. The Accounts Section should devise a suitable system of accounting on commercial lines which, among other things, must ensure the collection of the necessary accounts data from the Units at fixed periodical intervals, generally not exceeding a month. These basic accounts data compiled by the Divisional office would be received by the Central office, and incorporated in the Central Ledgers. Steps should then be taken to compile the proforma accounts (i.e. the Trading and Profit and Loss Account and Balance Sheet) for the period, which should be a month if possible, or a quarter or half-year, but never exceed six months. It is only when the working results are known to the management that they can expeditiously take steps to devise such policy adaptations as may be warranted by the circumstances.

The accounts should be maintained according to the double-entry system of accounting, which alone can yield a true picture of the financial results of the working of the organization at the Central office. The following set of accounts books should be maintained:

(1) Cash Book
(2) Accounts Journal
(3) Accounts Ledger
(4) Stores Receipt Journal (Form No. 17)
(5) Stores Issue Journal (Form No. 19)
(6) Stores Ledger (Form No. 21)

All the transactions taking place at the Central office will be duly entered in the books of the original entry, viz., the Cash Book and the Journal. The stores transactions, i.e., the receipt and issue of stores, will have to be entered in a different set of books, viz., the Stores Receipt and issue Journals, and then posted to the Stores Ledger. On receipt of the monthly Trial Balance from each Divisional office, the figures thereof will be incorporated in the Central Ledger through the Journal. A list of accounts items in the Central Ledger is given in the Appendix. At periodical intervals, preferably a month, the financial books should be balanced, the Trial Balance agreed and the Trading and Profit and Loss Account and the Balance Sheet compiled in prescribed forms (Forms No. 30 and 31).

Depreciation on Tractors and Other Machinery

A State-wide organization necessarily involves a huge capital outlay on the purchase of a large number of tractors, implements and other heavy machinery. Proper appraisal of the financial results depends largely on making correct assessment of the periodical depreciation of the assets and adjusting the same against the earnings in the Revenue Account for the relative period. The question of devising a correct method for calculating depreciation, therefore, assumes special importance. The generally accepted method for charging depreciation is to calculate it in relation to the working hours of each particular machine. The capital cost of the machine is divided by the number of working hours representing its estimated life, and this gives the rate of depreciation per working hour. It is also necessary to take into account the factor of obsolescence in calculating the final annual depreciation. Thus, it may be that the usefulness of a tractor will not last beyond a certain period of time, even though it may not have run the full length of its working life. Obsolescence is calculated in relation to the estimated length of time within which the machine does not get 'out-of-date'. The annual depreciation charge will have to be calculated both on the basis of working hours and obsolescence and the higher one of the two adopted. Depreciation in the case of implements, vehicles and other machinery may be calculated according to the same principles. For the purpose of working out depreciation and charging the same to the periodical Profit and Loss Account, a record in the form of a Register of Assets should be kept in which particulars of the machine, its original landed cost, subsequent additions thereto, etc., should be shown. Columns for showing the annual charge of depreciation should be provided in this register.

Interest on Capital

Interest is to be charged on the capital cost of each tractor, bulldozer, implement, vehicle and workshop machine. If any amount is credited to the depreciation fund in respect of such assets, and if such fund is invested, it will, of course, earn interest; and this should be credited to the Profit and Loss Account. It will also be necessary to charge interest on the working capital of the organization, obtained by way of an advance from Government. The expenditure on account of interest charges on working capital should be allocated to the different tractors, vehicles and other pieces of machinery, on the basis of their respective book values.

The accounts of the Central Stores will be maintained on the same lines as the Stores accounts at the Units, procedure in respect of which has already been explained.

Personal Ledger Account

The accounts requirements in relation to the transactions of a large State organization will be served better if a Personal Ledger Account is opened in the name of the Chief Administrative Officer. The organization, essentially an undertaking of a commercial nature, calls for an expeditious and simple financial procedure. The ordinary Government accounting procedure, involving as it does too many checks, is rather rigid and, therefore, not properly adapted to the requirements of a commercial undertaking. For example, the procedure relating to the withdrawal of money from the Treasury for current expenses by submitting detailed contingent bills is rather cumbersome and entails delay, besides involving clerical labour which can well be avoided. The funds can be operated under a Personal Ledger Account and there would be no occasion for any delay in the disposal of work.

Cost Accounts

The importance of maintaining cost accounts with a view to ascertaining the working costs of tractors and bulldozers in an organization which is meant to run on economic lines can hardly be over-emphasized. The final working cost is made up of the following several factors:

I. Petrol, oils and lubricants:
   - (i) Fuel oil
   - (ii) Engine oil and other lubricants

II. Maintenance and repairs:

(i) Spare parts

(ii) Repairs

III. Staff:

(i) Operational and maintenance staff

(ii) Field supervisory staff

(iii) Administrative staff

IV. Transport and Miscellaneous:

(i) Transport charges

(ii) Office expenses

(iii) Other miscellaneous expenses

V. (i) Depreciation of wasting assets

(ii) Interest on capital

The system of cost accounts should ensure the recording of expenditure under each of these several heads, so that with an analytical sifting of these particulars the working cost of (i) each individual machine, (ii) each operational unit and (iii) each of the different operations (such as deep ploughing, shallow ploughing, levelling, etc.) is accurately determined. It is only when the total expenditure is thus analysed into its various constituent elements that the management can be in a position to know which machines and Units are economical and which are wasteful.

The basic requirement in such a system of cost accounting is the collection of full statistics pertaining to the receipts and expenditure of each machine separately. The basic form which is recommended for this purpose is Form A (Tractor Log Sheet), which would furnish primary data regarding the working of each tractor and implement including the day-to-day consumption of oils and lubricants. This form will be filled in by the Tractor Operator himself and submitted to the Unit Foreman each week. The particulars to be supplied will be originally recorded in the Tractor Operator's diary and then copied out in this form. It is necessary that the notings in the Diary are made daily, as these diaries would constitute the original records showing the daily operations of the tractor.

On receipt of the weekly statements in Form A from all the operators, the Unit Foreman should consolidate the data for the whole month in Form B. This return would contain, besides columns summarizing the data furnished by the operators in Form A, separate columns for showing the expenditure incurred on spares and repairs. The Foreman will be submitting as many monthly returns in Form B as there may be machines, i.e., tractors and implements, in his Unit. This return will thus furnish all the necessary particulars relating to the working, repairs and oil consumption of the tractors and implements during the particular month.

The Unit Foreman will also furnish another monthly return in Form C which would show the particulars regarding the working of the Unit transport vehicles during the month, including the mileage covered, the quantity and cost of fuel oils, the lubricants consumed, and the expenditure on spares and repairs.

Mobile Maintenance Units

The return in Form C will be submitted by the Mobile Maintenance Units in respect of the transport vehicles attached to them. These Units will prepare Job Cards showing the expenditure incurred on each repair job handled by them. The cost of the stores and spare parts consumed as well as the cost of labour and other establishment employed will be charged to the job in the card. Thus, all the expenditure incurred by the Mobile Maintenance Units, so far as is referable directly or indirectly to the different repair jobs, is analyzed and collected in the different Job Cards, for being debited to the respective accounts of the tractors and implements in the Cost Ledger. The Job Cards will not, however, cover the entire expenditure of the Mobile Maintenance Units, as certain workshop expenses, such as the expenditure incurred on Unit vehicles and the cost of establishment in respect of the idle period, will not be chargeable to any specific jobs. The Mobile Maintenance Units should, therefore, sumbit a monthly return in Form D showing the particulars of such residuary expenditure as does not stand already included in the Job Cards pertaining to the particular repair jobs.

Divisional Office

The returns in Forms B, C and D will be submitted by the operational and Mobile Maintenance Units to their respective Divisional offices. The latter after scrutinizing these will forward them to the Central office. The Divisional office should itself furnish two returns in addition to those submitted by the Units. Firstly, it should submit a return in Form C in respect of the transport vehicles attached to the Division itself. Secondly, it should also submit a return in Form E showing the particulars of the expenditure pertaining to (i) the establishment—operational, supervisory and administrative, direct or indirect, (ii) depreciation on different tractors, implements and other machinery, (iii) interest on the capital cost of the same, and (iv) miscellaneous expenditure.

Central Workshop

The Central Workshop should prepare Job Cards in respect of the repair jobs handled by it. These Job Cards will analyse the expenditure incurred on the Central workshop with a view to allocating as far as possible to the different tractors, implements, etc., serviced by the workshop. The residuary expenditure, i.e., the expenditure not referable either directly or indirectly to particular repair jobs, will be dealt with in the return in Form D, which the workshop will furnish directly to the Central office. The workshop will also furnish the return in respect of the transport vehicles on its strength in Form C.

Compilation in the Central Office

With the receipt of the Returns in Forms B, C, D and E from the Divisional offices and the Central workshop, the Central office will be in possession of the necessary expenditure data (up to the Divisional level) duly analysed for purposes of allocation to different individual machines. The Central office will have to post the data to the permanent Cost Registers, analyse the overhead expenditure incurred at the centre and allocate the same to appropriate accounts in the Cost Registers, and work out the costing results. Separate cost registers may be maintained for different categories of machines. Thus, the cost register for ploughing the bulldozing tractors may be in Form F-1, that for implements (including bulldozer attachments) in Form F-2, that for transport vehicles in Form F-3, and that for workshop and other machinery in Form F-4.

I. *Register F-1:* This register will incorporate the particulars furnished in Forms B and E pertaining to tractors and bulldozers. Separate pages will be allotted to each individual tractor in this register, care being taken to see that tractors of the same capacity and doing the same type of work are allotted consecutive pages to facilitate further consolidation and classification of the data. Similar procedure will be followed in the case of bulldozing tractors. The pages allotted to each machine, i.e., a tractor or a bulldozer will be sub-divided into as many parts as the types of operations on which the machine will be employed, such as deep ploughing, shallow ploughing and harrowing in the case of a ploughing tractor, and levelling, clearing, bunding, etc. in the case of a bulldozing tractor. Each of these sub-divisions will get the postings of the relative particulars from Return B, except in the case of (i) consumption for idle run, and (ii) cost of spares and repairs. The expenditure on these two items will be allocated to the different sub-divisions in the proportion of working hours for which the machine was employed on the different types of operations.

Besides these sub-divisions meant for collecting the data referable to the different operations, there will be an additional sub-division to be called a ' General ' sub-division, opened in the account of each machine in this ledger. In this sub-division, the particulars relating to the aforesaid two items from Form B, namely, consumption in respect of idle run, and cost of spares and repairs, and all the particulars from Form E will be posted. Particulars in all the columns in Forms B and E, with the exception of columns " Miscellaneous expenditure ", and " Establishment—direct and indirect ", will be posted to the corresponding columns in this register. The miscellaneous expenditure up to and including the Divisional level will be collected in the relevant column in Form E. Miscellaneous expenditure incurred at the Central office will be collected from the relevant accounts in the Central ledger (financial) and the figures added to these reported in Form E. The total miscellaneous expenditure thus arrived at will be divided by the total number of machines (tractors and bulldozers) on the strength of the Section to find out the average monthly expenditure per machine which will be posted in the relevant column in the ledger.

In the case of particulars in column 'Establishment—direct' in Form E, the figures of all the Divisions will be totalled under two categories: (i) Tractor Drivers, and (ii) Bulldozer Operators. The figures debitable as direct establishment charge per tractor and per bulldozer will be worked out by dividing the respective figures of direct establishment charges (comprising of expenditure on operational personnel) by the number of tractors or bulldozers, as the case may be. So far as indirect establishment charges are concerned, the figures reported in the relevant column in Form E by all the Divisions will be totalled up, and this total divided by the number of machines (tractors and bulldozers) to find out the indirect establishment charge per machine up to the Divisional level. This figure of average indirect establishment charge will be the first debit to this column in the Register. The column will get another debit in respect of the Central Office establishment, equal to the amount arrived at by taking the monthly total of expenditure from the Central Office establishment account in the Central Ledger and dividing the same by the total number of machines (tractors and bulldozers) on the strength of the Section.

Repairs: The column 'Repairs' in the General sub-division in this Register will get a direct debit of the amount reported in the column 'Cost of spares and repairs' in Form B. In addition to this direct debit, the column 'Repairs' will have two more debits in respect of expenditure not directly referable to specific repair jobs. These two additional debits will be as detailed below:

(1) *Indirect repairs cost:* The figures of expenditure reported in the columns 'Cost of Establishment', and "Other Workshop Expenses" in Form D by the Mobile Maintenance Units and by the Central Workshop will be totalled, and the figure split under two main heads: (i) cost referable to ploughing and bulldozing tractors and (ii) cost referable to implements including bulldozing attachments. This allocation will be made on the basis of the ratio of the direct repairs expenditure (as found out from the Job Cards) on tractors to that on implements. Each figure under (i) and (ii) above thus obtained will be further divided under the following sub-heads:

- (i) (a) Cost referable to ploughing tractors
  - (b) Cost referable to bulldozing tractors
- (ii) (a) Cost referable to bulldozing attachments
  - (b) Cost referable to other implements

This splitting of the expenditure into the above two sub-divisions will also be effected in the ratio of the direct repairs expenditure (as disclosed by the Job Cards) on ploughing tractors to that on bulldozing tractors, and the ratio of direct repairs expenditure similarly disclosed on bulldozing attachments to that on other implements.

(2) The other item of indirect repairs cost is in respect of the expenditure incurred on the vehicles of the Mobile Maintenance Units and the Central Workshop, as reported by them in Form C. This expenditure will be totalled and split up on the same lines as in the case of the allocation of the first item of indirect repairs cost.

The figures of indirect repairs cost thus worked out in respect of tractors and bulldozers will then be posted to the 'Repairs' column in the General sub-division in this Register, as addtional debits to the tractors and bulldozers.

Transport charges: The column 'Transport charges' in the General sub-division will get the postings from the data recorded in Register F-3. The latter will collect the expenditure incurred on the transport vehicles attached to operational Units, Mobile Maintenance Units, Divisional offices, Central Workshop and the Central office. The accounting procedure regarding expenditure on the vehicles attached to the Mobile Maintenance Units and the Central Workshop has already been dealt with. The expenditure on vehicles attached to the operational Units, Divisional offices and the Central office as recorded in the Register F-3 will have to be posted under 'Transport Charges' in the Register F-1 as detailed below.

The expenditure as recorded in Register F-3 will be posted in respect of (i) vehicles attached to each operational Unit, (ii) vehicles allotted to each Division separately, and (iii) vehicles allotted to the Central office. The pooled figure for each operational Unit will be divided by the number of machines (i.e. tractors and bulldozers) in the particular Unit to find out the average expenditure on direct transport. This average expenditure will be different for different operational Units. The average expenditure thus worked out for each operational Unit will go as the first debit to each individual tractor and bulldozer in the particular unit. Besides this debit on account of direct transport charges, the column 'Transport Charges' will get two additional debits on account of indirect transport charges: (i) the pooled expenditure in respect of the Divisional vehicles will be divided by the number of tractors and bulldozers in the particular Division to find out the average expenditure per machine which will go as debit in respect of the particular Division; (ii) the pooled expenditure pertaining to the Central office vehicles will be divided by the total number of tractors and bulldozers in the whole organization and the figure of average expenditure thus obtained will go as the second debit.

Thus, all the cost data furnished in Forms B, C, D and E (so far as pertaining to tractors and bulldozers) will have been posted in the four sub-divisions of the account of each individual machine in the Register F-1. The fourth sub-division, i.e., the General sub-division in each account will contain particulars in respect of the expenditure incurred during the year on spares and repairs, establishment, transport charges, depreciation, and interest. Each of these items of expenditure will have to be allocated to different types of operations (covered under the first three sub-divisions) on which the machine was employed during the year. This allocation will be made on the basis of the respective working hours for which the machine was employed. The expenditure thus allocated will be reposted to the corresponding columns in the respective sub-divisions. This allocation and reposting will be carried out only at the end of the financial year.

After all the postings and repostings are made for the whole year, each of the columns in the three sub-divisions should be totalled and the average of consumption for different oils and lubricants as well as the average expenditure on spares and repairs per working hour in respect of different types of operations on which the machine was employed should be found out. These averages will serve as criteria for judging the mechanical efficiency of each machine.

II. *Register F-2:* This Register will incorporate the particulars from Forms B and E relating to implements (including the bulldozer attachments). Separate pages will be allotted to each individual implement, care being taken to see that proto-type implements are allotted consecutive pages to facilitate further consolidation and classification of the data.

Besides the postings from Forms B and E, this Register will get additional postings from Forms C and D in respect of indirect transport charges, as already explained under the heading 'Repairs'.

After the postings for the whole year are made, each of the columns in this Register will be totalled, and the relative efficiency of each implement judged in relation to the average expenditure on spares and repairs per working hour. The average working cost of each implement per working hour can also be found out by totalling the yearly expenditure under the several heads and dividing the same by the total number of working hours.

III. *Register F-3:* This Register will incorporate the particulars from Forms C and E, which pertain to transport vehicles. Separate pages will be allotted to each individual vehicle, care being taken to see that vehicles of the same type and capacity are allotted consecutive pages to facilitate further consolidation and classification of the data. The particulars furnished in Forms C and E will be directly posted to the corresponding columns in the Register. The yearly total of each of the columns will be taken and the working efficiency of each vehicle judged on the basis of the average expenditure per working hour under the heads ' P.O.L.' and ' Spares and Repairs '.

The expenditure recorded in this Register in respect of (i) vehicles attached to operational Units, Divisional offices and Central office, and (ii) vehicles attached to Mobile Maintenance Units and Central Workshop, will ultimately go as a debit to the heads ' Transport Charges ' and ' Repairs ' respectively in Register F-1.

IV. *Register F-4:* This Register will incorporate the particulars pertaining to machinery from the returns in Forms D and E. Each piece of machinery will be given a separate page in the Register. This Register will give an analysis of expenditure incurred on each piece of machinery under the several heads provided in the Register.

Assessment of Costing Results

The analytical data recorded in the Register F-1, as explained above, furnish the necessary criteria for judging the mechanical efficiency of each individual machine with reference to each type of operation on which it is employed. Again, on the basis of these data, group costing for working out the average cost per working hour of each different type of operation (such as deep ploughing, shallow ploughing, levelling, etc.) will be undertaken with a view to ascertaining the extent to which the provisions under the different heads of expenditure in the break-up of the different ploughing and bulldozing rates were actually adhered to and proved adequate or otherwise. Data will also be compiled to find out the costing results of each of the different operational Units in the organization. Finally, the entire data will be consolidated with a view to determining the working results of the organization as a whole for the year. The final figures (worked out from the costing set of books) should be tallied with the figures of expenditure under the corresponding heads in the annual Trading and Profit and Loss Account as compiled from the financial set of books. In fact, it is necessary that the total of each of the different heads of expenditure as reported in the monthly costing returns should be reconciled each month with the figures of expenditure in the corresponding ledger account in the financial Ledger.

For carrying out the compilations mentioned at (ii) and (iii) above, two separate Registers, G-1 and G-2 in the forms given in the Appendix, will be maintained. The Register G-1 will collect at one place the particulars of the expenditure and income in respect of each different type of operation undertaken by the organization. In this Register, separate sections or groups of pages will be allotted to each type of operation, viz., deep ploughing, shallow ploughing, harrowing, levelling, etc. In each of these sub-divisions, the tractors employed on the particular type of work during the year will be consecutively entered and the yearly totals of columns from the relative sub-divisions from the Register F-1 will be posted to the corresponding columns in this Register. After all such postings from the F-1 Register to this Register are completed, the totals for the different columns will be taken. These would show the consolidated expenditure and income under various heads for each particular type of operation. It can thus be found out how the expenditure actually incurred under the different heads for the particular type of operation compares with the provision made for that head in the break-up of the relative ploughing or bulldozing rate.

The nature of the working of different operational Units will be judged by collecting from the F-1 Register the yearly data pertaining to the tractors and bulldozers attached to the respective Units. A Register G-2 will be maintained for the purpose of carring out this compilation at the end of the year. Separate groups of pages will be allotted in this Register to the different operational Units, and the portion assigned to each Unit will be sub-divided into as many parts as the number of different operations on which the tractors and bulldozers are employed. All the tractors and bulldozers on the strength of each Unit will be entered consecutively in each of these sub-divisions under the particular Unit and the yearly totals of the various columns of each sub-division from the Register F-1 will be transferred to the corresponding columns, pertaining to the same machine, in this Register. The Registers F-1 and G-2 will contain cross references to the pages in the respective registers.

The sub-divisional totals of the various columns under each unit will give an analysis of the yearly expenditure incurred on the particular unit for the particular type of operation during the year, as well as the income earned by the Unit on account of this work. This will bring out the nature of the working of the Unit with reference to the particular type of operation. By taking the final totals of the columns under each Unit, consolidated figures of expenditure and income (under different heads) of the particular Unit in respect of all the types of operations carried out by it during the year will be obtained; and these will indicate how far the particular Unit has been working economically.

Finally, all the Unit totals under the different heads of expenditure and income will be added up, which would show the consolidated income and expenditure (under different heads) of the organization as a whole for the particular year. As stated above, these figures of income and expenditure as compiled from the statistical set of books should be tallied with the corresponding figures of income and expenditure in the Trading and Profit and Loss Account compiled from the financial set of books.

APPENDICES

List of accounts which will appear in the Divisional Ledger

1. Accounts to be opened
   - (a) Pay of officers
   - (b) Pay of establishment
   - (c) Pay of operational staff
   - (d) Pay of workshop staff
   - (e) Travelling allowance of officers
   - (f) Travelling allowance of establishment
   - (g) Travelling allowance of operational staff
   - (h) Travelling allowance of workshop staff
   - (i) Contingencies

2. Establishment charges
   - (a) Pay of officers
   - (b) Pay of office establishment
   - (c) Pay of operational staff
   - (d) Pay of workshop staff
   - (e) Travelling allowance of officers
   - (f) Travelling allowance of establishment
   - (g) Travelling Allowance of Operational staff
   - (h) Travelling Allowance of Workshop staff

3. Contingent expenditure
   - (I) Capital expenditure
     - (a) Deadstock and furniture
     - (b) Purchase of tools
   - (II) Revenue expenditure
     - (a) Purchase of spare parts
     - (b) Purchase of consumable stores
     - (c) Purchase of oil and lubricants
     - (d) Repairs
     - (e) Rent, rates and taxes
     - (f) Wages of watchmen and mazdoors
     - (g) Service postage and telegrams
     - (h) Railway freight and transport charges
     - (i) Miscellaneous charges

4. Receipts
   - (a) Deep ploughing account
   - (b) Shallow ploughing account

(c) Harrowing
(d) Levelling, etc.
(e) Vehicle hire charges
(f) Haulage charges
(g) Sale of capital assets
(h) Treasury remittances:
  (i) Credits to regular account
  (ii) Credits to deposit account
(i) Sundry debtors for ploughing charges
(j) Sundry debtors for other charges
(k) Sundry creditors for ploughing charges
(l) Sundry creditors for other charges
(m) Sundry creditors for supplies made
(n) Sundry creditors for services

List of accounts which will appear in the Central Ledger

1. Treasury withdrawal account

Withdrawal in respect of

(a) Pay of officers
(b) Pay of establishment
(c) Pay of operational staff
(d) Pay of workshop staff (including M.M.S.)
(e) Travelling allowance of officers
(f) Travelling allowance of establishment
(g) Travelling allowance of operational staff
(h) Travelling allowance of workshop staff (including M.M.S.)
(i) Contingencies

2. Capital expenditure

(a) Purchase of tractors
(b) Purchase of implements
(c) Purchase of vehicles
(d) Purchase of plant and machinery
(e) Purchase of tools and other nonconsumable stores
(f) Purchase of deadstock articles
(g) Purchase of furniture

3. Revenue expenditure: Contingent

(a) Purchase of spare parts
  (i) For tractors

- (ii) For implements
- (iii) For vehicles

(b) Purchase of consumable stores

(c) Purchase of oils and lubricants

- (i) H.S.D.
- (ii) Petrol
- (iii) Engine oil
- (iv) Grease
- (v) Cotton waste
- (vi) Distilled water

(d) Repairs

(e) Rent, rates and taxes

(f) Wages of watchmen and mazdoors

(g) Service postage and telegrams

(h) Railway freight and transport charges

(i) Miscellaneous charges

4. Revenue expenditure: Establishment charges

(a) Pay of officers

(b) Pay of establishment

(c) Pay of operational staff

(d) Pay of workshop staff (including M.M.S.)

(e) Travelling allowance of officers

(f) Travelling allowance of establishment

(g) Travelling allowance of operational staff

(h) Travelling allowance of workshop staff (including N.M.S.)

5. Revenue expenditure: Financial charges

(a) Depreciation on tractors

(b) Depreciation on implements

(c) Depreciation on vehicles

(d) Depreciation on machinery

(e) Depreciation on deadstock and furniture

(f) Interest on capital outlay

(g) Audit cost

(h) Leave salary and pension fund contribution

6. Revenue receipts

(a) Ploughing charges

- (i) Deep
- (ii) Shallow
- (iii) Harrowing

- (b) Bulldozing charges
  - (i) Levelling
  - (ii) Bunding
  - (iii) Grading, etc.
- (c) Vehicle hire charges
- (d) Sale of empties
- (e) Miscellaneous receipts
- (f) Treasury remittances
  - (i) Credits to XXIX-agriculture
  - (ii) Credits to revenue deposits

7. Capital receipts
   - (a) Sale of capital assets

8. Personal accounts
   - (a) Sundry debtors for ploughing and bulldozing charges
     - (i) Deep
     - (ii) Shallow
     - (iii) Harrowing
     - (iv) Levelling, etc.
   - (b) Sundry debtors for vehicle hire charges
   - (c) Sundry debtors for haulage charges
   - (d) Sundry debtors (others)
   - (e) Individual accounts of each division
   - (f) Sundry creditors for ploughing advances
   - (g) Sundry creditors for supplies
   - (h) Sundry creditors for services rendered

9. General
   - (a) Government capital account
   - (b) Government suspense account

FORM No. 1

MECHANICAL CULTIVATION SECTION.................STATE.................

Inspection Report of Tractor

Tractor No. Engine No.

Make No. of hours worked till the report

Horse power

When was this tractor last overhauled?

Hours worked after complete overhauling till this report

Engine—General condition:
- Injectors—Are they working satisfactorily?
- Fuel pump—Working satisfactorily/Not working satisfactory
- Speed regulation—Good/Average/Poor
- Compression of the engine—Good/Average/Poor
- Lubricating oil system—
  - Condition at the time of checking
  - Working satisfactorily/Not working satisfactorily
- Working of oil pressure gauge—Satisfactory/Not satisfactory

Clutch
1. Does it require adjustment?
2. Is the clutch shaft bearing and operating sleeve bearing properly lubricated?

Clutch steering
- Does it require adjustment?
- Are the release bearing lubricated?
- Have you checked the oil level of final drive chamber?

Radiator
- Have you checked for leakage?
- Does the water get very hot?
- Is the circulation pump working satisfactorily?
- Is the thermostat working satisfactorily?

Fan
- Have you checked the tension of the fan belt?
- Is the fan bearing lubricated properly?

Track
- Have you checked the tension of the track?
- Are the rollers properly lubricated?
- Are the rollers, sprocket and front idler wheels, showing any excessive wear?

Remarks
- (1) Specify parts or spare required for immediate replacement of—
  - (a) Worn out parts
  - (b) Losses and damages not due to normal wear and tear
  - (c) In case of (b), name the person concerned

Technical Storekeeper *Foreman Supervisor,*
Unit No...............

FORM NO. 2

Mechanical Cultivation Contract Works (Applications) Register

S. No.	Name of applicant	Full address of the applicant	Date	Village	Taluka	Ploughing		Bull-dozing (level-ling) (hours)	Other opera-tions, such as (1) Road rolling (2) Haulage (3) Excavation on hire basis (4) Pumping etc.	Rate Rs.	Nature of soil	Survey No.	Remarks
						Deep (acres)	Shallow (acres)						

FORM NO. 3

MECHANICAL CULTIVATION SECTION..............STATE........

Form of application for mechanical cultivation of lands by Government tractors/bulldozers

To

The Chief Administrative Officer,

....

Sir,

I am to apply that the follwoing type of operation may be carried out on my marginally noted land by the machines of your Section:—

(1) Village:
(2) Taluka:
(3) District:
(4) Survey No.
(5) Total area:
(6) Nature of soil:

Nature of work to be done	Deep ploughing, Shallow ploughing, Harrowing, Ridging, Bunding, Grading, Haulage, Road Rolling
Depth of ploughing required	..............inches

I am prepared to abide by the terms and conditions specified in the attached Agreement Form.

I agree to pay rate of Rs............(in words Rs.........) per acre/hour (by................. H. P. machine in the case of bulldozing, etc.).

I will pay the amount of Rs.................(in words Rupees......................) as an advance to cover the full charges before the commencement of work mentioned above.

Name of the applicant in full.

Yours faithfully,

Signature of the applicant

Address:
Date:

Below application No...........dated.............from Shri............................ for.........................

Forwarded to the Foreman Supervisor, Unit No...............Camp.............. for inspection of land and report.

Chief Administrative Officer

Inspection Report

Inspected the land on......................Distance of the land from the Unit Headquarters/the location of working tractors............................miles.

Remarks:—

Foreman Supervisor

Unit No...................

No. of 19

Date

To

Shri..

....

Subject:— Application for........

....

Sir,

With reference to your application dated the........................I am to inform you that I am agreeable to undertake the work applied for subject to the conditions mentioned in the form of agreement bond enclosed. I am to request you to return the enclosed agreement duly executed by you, and pay the requisite advance of Rs............

Yours faithfully,

Chief Administrative Officer

Form of Agreement Bond to be executed by the cultivator or owner of the land for tractor/ploughing/bulldozing, etc.

THIS AGREEMENT made....................the day of....................one thousand nine hundred and fifty............................between............................ a cultivator/landowner/tenant inhabitant of......................in the...................... taluka.........................district......................(hereinafter referred to as "the Covenanter" which expression shall unless excluded by or repugnant to the context, include his heirs, executors, administrators and assignees) of the one part and the Governor of......................(hereinafter referred to as the "Government" which expression shall unless excluded by or repugnant to the context, include his successors in office and assignees) of the other part.

WHEREAS the Covenanter is the Cultivator/Owner/Tenant of Survey No....................of....................in....................taluka, district................. (hereinafter referred to as " the said land ").

AND WHEREAS the Covenanter being desirous of having the said land ploughed/levelled/graded/bunded/harrowed by Government tractors/bulldozers/ applied to Government that the said land may be ploughed/graded/bunded/harrowed by Government tractors/bulldozers.

AND WHEREAS the Government has agreed to plough/level/grade/bund/ harrow the said land on the terms and conditions hereinafter mentioned.

NOW it is hereby agreed between the parties hereto as follows:—

(1) The Covenanters said land shall be ploughed/levelled/graded/bunded/ harrowed and the Covenanter shall pay to the Government the cost of ploughing/ levelling/grading/bunding/harrowing calculated at the rate of Rs............(in words Rupees.................) per acre/per hour.

(2) The Covenanter shall pay in advance a sum equal to the full amount of the estimated charges.

(3) In case the land ploughed/harrowed/levelled/graded/bunded forms a complete survey number or numbers of pot hissa of such survey number, the measurement of such survey number or numbers or pot hissa as mentioned in the Records of the Revenue Department shall be taken as the measurement of the land ploughed/ levelled/graded/bunded/harrowed. In case, however, the land ploughed/levelled/graded/ bunded/harrowed is only a part of a complete survey number, the same shall be measured by the Foreman Supervisor appointed by the Chief Administrative Officer. In the event of dispute regarding such measurement the land ploughed/levelled/graded/ bunded/ harrowed shall be measured by the representative of the Mamlatdar of the taluka.

(4) The decision of the Chief Administrative Officer as to the measurement of the lands ploughed/levelled/graded/bunded/harrowed and as to any dispute arising out of this agreement shall be final and binding on the Covenanter.

(5) The Government shall not be responsible for any loss which may be incurred by the Covenanter due to any break down of machinery either before or during the work or due to any other cause beyond the control of Government. In such a case the Covenanter shall pay for the area ploughed/levelled/graded/bunded/ harrowed.

(6) If any part of the said land is found unfit for tractor ploughing/levelling/ grading/bunding/harrowing by reason of its containing trees, stumps, stones, nullahs, the Government shall not be bound to plough/level/grade/bund/harrow the same nor shall the Government be bound to plough/level/grade/bund/harrow any portion of the said land which is within 45 feet of any field which is bound by waterways, hedges, fencing, standing crops or any other landlord's fields.

(7) If as a result of shifting of the Government tractors/bulldozers from the locality in which the Covenanter's land is situated, it becomes in the opinion of Government uneconomic to plough/level/grade/bund/harrow the land of the Covenanter, it shall be open to Government not to plough/level/grade/bund/harrow

the said land and to terminate this agreement, provided that in such event the Chief Administrative Officer shall on behalf of Government notify to the Covenanter not later than.................its intention not to plough/level/grade/bund/harrow his land and to terminate this agreement, and provided further that Government shall refund to the Covenanter the amount which the Covenanter may have paid in advance in pursuance thereof.

(8) In the case of ploughing if for any reason any portion of the land agreed to be ploughed (such portion not exceeding six per cent of the total area agreed to be ploughed) is not ploughed to the stipulated depth, the same will be considered as ploughed to the said stipulated depth, for the purposes of this agreement.

(9) Any sum due to the Government by the Covenanter under this agreement shall be recovered by the Government with interest thereon at ten per cent per annum, as arrears of land revenue.

In witness whereof the Covenanter has set his hand and the Chief Administrative Officer has on behalf of the Governor.................State set his hand and the seal of his office hereto the day and year first above written.

Signed and delivered by the above named....................in the presence of

1.

2.

Authority to act

No.

Date

To

The Foreman Supervisor,

Camp.................District.................

Reference Ploughing Application No.......................of......................

With reference to your remarks on the application of Shri............................ of......................you are hereby authorised to take up the work. On completion of the work the necessary completion certificate signed by the applicant will be forwarded to this office within one week of the completion of this contract. The work will commence from.......................

Chief Administrative Officer

Completion Report and Indemnity Certificate

To

The Chief Administrative Officer,

..............................State

Sir,

With reference to your No..................of 19........... dated..................... authorising me to take up the work of Shri.. of.....................I have to report that the work was started on......................... and completed on........................ The work done is as follows:—

Survey No.	Acres-Gunthas	Hours-Minutes	Nature of work
Total ...			

Yours faithfully,

Foreman Supervisor,

Unit No...............

I am fully satisfied both as to the quality and quantity of the work done on my lands, detailed as above, and I indemnify the Mechanical Cultivation Section........... ....State, against any further claim.

Signature of Applicant

Date:

FORM NO. 4

MECHANICAL CULTIVATION SECTION..................STATE..................

Operation Daily Report Register

Tractor Driver's Name...........................

Date	Time		Hours	Total hours	Survey number	Nature of work	Petrol Gal.	H.S.D. Gal.	Shell Ardol Gal.	Std. Vac. Gal.	Shell Retinax Lb.	Transmission Gal.	C. Waste Lb.	Grease Lb.	Total acres ploughed levelled		Type of implement and No.	Name of party	Contract No.
	From	To													A.	G.			

FORM NO. 5

MECHANICAL CULTIVATION SECTION..................STATE..................

Mechanical Cultivation Works Register

Name of the party and address:.................. *Village*.............. *Taluka*.............. *District*...........

Contract No.	Work		Total Work Done						Bulldo-zing H. P. Grading etc.	Misce.	Rate	Total Amt. Due	Ad-vance Recd.	Balance due	Challan No.	Receipt No.	Bill No.	Remarks
	Start-ing	Com-pleted	Deep		Shallow		Harro-wing											
			A.	G.	A.	G.	A.	G.	H. M.			Rs.	Rs.	Rs.				

FORM NO. 6

MECHANICAL CULTIVATION SECTION................STATE.................

Weekly statement showing the earnings

Nature of work done					Amount due on account of the work done
Deep ploughing (acres)	Shallow ploughing (acres)	Harrowing (acres)	Grading	Other operations	Rs.

Foreman Supervisor,
Unit No...............

FORM NO. 7

MECHANICAL CULTIVATION SECTION...........STATE...........

Unit No.................

Weekly statement of remittances (with challans)

Date.......................

Place.....................

Treasury Voucher No.
Sub-Treasury No.
Bank (Name of Head Office, Branch, etc.)

Challan No.............

S. No.	Receipt No.	Contract No.	Name of party	Village	Amount credited	Work			Remarks
						Started	Completed		
					Rs.	Challan No.	Date	Name of treasury	

Technical Storekeeper

Foreman Supervisor,

Unit No............

FORM NO. 8

Monthly statement of expenditure including disbursements on accounts of salaries, wages, contingencies, etc.

S. No.	Amount drawn from the treasury/bank			Amounts disbursed—pay, dearness allowance and house rent allowance			Travelling allowance			Undisbursed balance
	Tr. Vr. No.	Date of the bill	Amount of the bill Rs.	Stores staff Rs.	Operational staff Rs.	Workshop staff Rs.	Stores staff Rs.	Operational staff Rs.	Workshop staff Rs.	Rs.

FORM NO. 9

MECHANICAL CULTIVATION SECTION..............STATE...........

SIX MONTHLY RETURN

Statement 'A' of earnings

Unit No.................. Month of..............19......

(i) Actual work done:

	A. G. or hours	Rate Rs.	Amount Rs.
(i) Deep ploughing ...			
(ii) Shallow ploughing ...			
(iii) Bulldozing by:			
80 H.P. ...			
60 H.P. ...			
40 H.P. ...			
25 H.P. ...			
(iv) Harrowing ...			
(v) Miscellaneous ...			
(vi) Idle running ...			
Total ...			
(ii) Transport charges due including jeep and truck ...			
Grand total ...			

Foreman Supervisor,

Technical Storekeeper Unit No..................

N.B.—The work done for any Government Department other than the Department of which the Mechanical Cultivation Section is a part should be included under cash work.

FORM No. 10

MECHANICAL CULTIVATION SECTION.................STATE..............

SIX MONTHLY RETURN

Statement 'B' showing financial data

Unit No.................. Period from.................to...................

(six months period)

		Rs.
1	Amounts credited to Treasury/Bank from receipts direct to (name of the Head in the case of Government Department):	
	(a) Against the recoveries for the period prior to (previous period of six months)	
	(b) Against the recoveries for the period from.............. to.................(previous period of six months) ...	
	(c) Against current term's work	
2	Amount adjusted to..................(Receipts Head) from the.................Deposit Account:	
	(a) From former year's deposits	
	(b) From current term's deposits	
3	Amount credited to deposit account during the term:	
	(a) Work done out of above	
	(b) Work yet to be executed, out of above... ...	
4	Amount of tagai loan adjusted (in the case of Government Department):	
	(a) Against the recoveries for the period prior to.........	
	(b) Against the recoveries for the period from............. to.................(previous six months period) ...	
	(c) Against current term's work	
5	Amount of advance for work as on..............(last date of the previous six months period) but work during the term	
6	Amount received during the current term but work yet to be done:	
	(a) Amount already credited to Treasury/Bank ...	
	(b) Cash on hand	
7	Outstanding dues for current term:	
	(a) Cash work (b) Tagai work (c) Departmental work } (in the case of Government Department)	

		Rs.
8	Outstanding dues for period prior to.................(beginning of the first six months period)	
9	Outstanding dues for period from..................to........... (previous six months period)	
	(a) Cash work (b) Tagai work (c) Departmental work } (in the case of Government Department)	
10	Refunds due for current term's work	
11	Refunds due for previous year's work	
12	Refunds made during the term:	
	(a) Against current term's work	
	(b) Against previous year's work	
13	Departmental adjustments during the year (in the case of Government Department):	
	(a) Against the recoveries for the period prior to...........	
	(b) Against the recoveries for the period from........... to..............	
	(c) Against current term's work	
14	Cash on hand on.................(beginning of the six months period)	
15	Cash on hand on...............(end of the six months period)	
	(a) Cash for work already done	
	(b) Cash for work yet to be done	

N. B.—Every item in this form must be supported by the detailed lists representing the figures noted.

FORM No. 11

MECHANICAL CULTIVATION SECTION..............STATE..............

Six Monthly Return

Statement 'C' of stores for the period ending.................for Units No..................

S. No.	Particulars (Nature of stores)	Opening balance (at the beginning) Rs.	Value of stores received during the period Rs.	Value of stores consumed during the period Rs.	Closing balance (at the end of the period) Rs.	Remarks
1	2	3	4	5	6	7
1.	Tractors					
2.	Implements					
3.	Deadstock articles					
4.	Spare parts					
	(i) Tractors					
	(ii) Vehicles					
	(iii) Implements ...					
5.	Consumable stores ...					
6.	Oils and lubricants ...					
	(i) Petrol					
	(ii) Oils					
	(iii) H.S.D.					
	(iv) Grease					
	(v) Cotton waste ...					
	(vi) Distilled water ...					
	Total ...					

Progressive total for year for column No. 5..

Technical Storekeeper

Foreman Supervisor, Unit No...............

FORM No. 12

MECHANICAL CULTIVATION SECTION..................STATE..................

Statement showing monthly expenditure under stores

Tractor and implementwise details of the value of stores consumed as shown in column 5 of Form No. 11

S. No.	Tractor and vehicle No.	P.O.L.	Spares	Consumable stores Rs.	Repairs Rs.	Remarks
Total						

Foreman Supervisor,

Technical Storekeeper

Unit No..................

FORM No. 13

MECHANICAL CULTIVATION SECTION..................STATE.................

Requisition Form

Requisition No...........................

Date.........................

To

The A. M. C. E./M. C. E.

Please supply the following material:—

Part No. or size	Particulars with make	For which machine	Quantity demanded	Quantity supplied	DIV/H.Q.R. & I. Vr. No. & date	Remarks

Foreman Supervisor,

Unit No...............

Duplicate of Form No. 13.

No.........................

Foreman Supervisor,

Unit No.............

FORM NO. 14

MECHANICAL CULTIVATION SECTION.................STATE.................

Damage Report

Damage/Defect to Tractor/Vehicle/Implement

Implement No............................Date....................Ref. No.....................

Tractor No.

Vehicle No. Type Unit No.

(2) Description of damage/defect

(3) Part No. of damaged/defective parts

(4) Do you require the above parts despatched to you? Yes/No

(5) Is the vehicle/implement.......................working/idle?

(6) Has the repairs been put in hand?

(7) Being repaired by

(8) Have the unserviceable parts been despatched to main store? Yes/No

(9) If despatched, issue receipt voucher No.

Remarks:—

Foreman Supervisor,

Technical Storekeeper Unit No.................

FORM No. 15

MECHANICAL CULTIVATION SECTION................STATE.................

Receipt and Issue Voucher

No.......................

Issued to................................Dated.................................19 .

As per your Demand No.........................date.......................19 .

Despatched per.......................................

S. No.	Part No. or size	Particulars	Quantity	Rate Rs.	Amount Rs.	Remarks

Please return one copy duly signed by you.

Despatcher's Signature.

Received the above in good order and condition and the same is entered in our Registers.

Stores Receipt Journal page No...................

Date Technical Storekeeper Receiver's Signature.

FORM No. 16

MECHANICAL CULTIVATION SECTION.................STATE.................

Acknowledgement Form

No........................

Place..

Date of receipt..

The following has been received from Messrs..

Quantity	Part No. or size	Particulars	Purpose

Entered Store Journal Page................................

Date................................

Foreman Supervisor,

Technical Storekeeper

Unit No...............

FORM No. 17

MECHANICAL CULTIVATION SECTION..................STATE..................

Stores Receipt Journal

Date	Inward No.	Received by or under	Received from	Debit or Despatch Memo	Particulars	Part No. or Size	For	Quantity	Bill or Cash Memo No.	Rate	Per	Amount	Other charges	Ledger Folio	Ack. No.	Remarks
												Rs.	Rs.			

FORM No. 18

MECHANICAL CULTIVATION SECTION....................STATE....................

Register showing the details of repairs to tractors and other machinery

S. No.	Tractor/ Bulldozer/ Implement/ Vehicle	Type	No.	Description of damage/ defect	Damage Report No.	Nature of repairs carried out	Parts used (with their numbers)	Cost of repairs			Remarks
								Repairing charges Rs.	Value of parts Rs.	Total Rs.	

Foreman Supervisor,
Unit No............

FORM NO 19

MECHANICAL CULTIVATION SECTION..................STATE..................

Stores Issues Journal

Date	Ref. No.	Issued to	Particulars	Part No. of size	For	Qty.	L.F.	Remarks

FORM No. 20

MECHANICAL CULTIVATION SECTION..................STATE..................

General Acknowledgment Register of fuel oils and lubricants

Unit No............ *Name of Driver*..............

S. No.	Issues in bulk			Weekly account of annual consumption			Remarks
	Date	Quantity issued	Signature of the receiver	Week ending ....date	Quantity consumed	Balance	

FORM NO. 21

MECHANICAL CULTIVATION SECTION..................STATE..................

Stores Ledger

Name..............................*Part No. or Size*........................ *For*..

Date	RECEIPT		ISSUES		BALANCE		Remarks
	Quantity	Value Rs.	Quantity	Value Rs.	Quantity	Value Rs.	

FORM NO. 22

MECHANICAL CULTIVATION SECTION..................STATE..................

Bin Card

Article

Maximum

Unit

Minimum

Date	Receipt	Issues	Balance	Remarks

FORM NO. 23

MECHANICAL CULTIVATION SECTION..................STATE..................

Mechanical Cultivation Operation Daily Report Return

Month..

Date	From	To	Hours	Total hours	Survey number	Nature of work	Petrol	H.S.D.	Shell Ardol	Std. Vac.	Shell Retinax	Trans-mission	C. Waste	Grease	Total acres plough-ed		Type of implement and No.	Name of party	Contract No.
							Gal.	Gal.	Lb.	Gal.	Gal.	Gal.	Lb.	Lb.	A.	G.			

FORM NO. 24

MECHANICAL CULTIVATION SECTION..............STATE..............

Lorry working report for the month of.........................19

Vehicle No.......... Week ending.............. Unit no..............

Date	From	To	Milo meter	Total miles run	Particulars	Petrol issued	Petrol consumed	Mobil oil	Distilled water	Petrol issued to tractor or other vehicles

Technical Storekeeper

Foreman Supervisor,
Unit No...............

Form No. 25

MECHANICAL CULTIVATION SECTION..............STATE..............

Weekly Fuel Stock Statement

For the month of.......................... Unit No.............. Location.............. Week ending....................

Date																							Total			Re-marks
ITEM	Opening stock	Received	Issued	Stock	Received	Issued	Stock	Received	Issued	Stock	Received	Issued	Stock	Received	Issued	Stock	Received	Issued	Stock	Received	Issued	Stock	Received	Issued	Stock	
Petrol																										
H.S.D. oil																										
Engine oil																										
Grease																										
Gear oil																										
Flushing oil																										
B.S.L.D. oil																										
Distilled water																										
Cotton waste																										
Other items																										

Foreman Supervisor

*Unit No.*__________

T. S. K.

FORM NO. 26

MECHANICAL CULTIVATION SECTION..............STATE..............

Mechanical Cultivation Works Register

Unit No...............

S. No.	Name of party	Contract No.	Village	Nature of work					Other works		Amount due for work done during the week		Amount received from the party		Paid under		Amount outstanding with the party	Amount outstanding with Unit	Remarks
				Grading															
				Deep (acres)	Shallow (acres)	Harrow (acres)	H.P. of bull-dozer	Hrs.	Nature	Hrs.	Rs.	Bill No.	Rs.	Receipt No.	Challan No.	Date			

Certificate:—Certified that the work shown above is according to the Tractor Daily Operation Register and actual measurements taken.

Technical Storekeeper

Foreman Supervisor,
Unit No.........

FORM No. 27

MECHANICAL CULTIVATION SECTION..............STATE..............

Monthly Progress Report on Mechanical Cultivation for the month of....................19......in the District

No. of tractors stationed in the district during the month	No. of tractors working during the month	Deep ploughing		Shallow ploughing		Harrowing		Grading & levelling		Other works		Remarks especially regarding reasons for tractors remaining idle & unsatisfactory progress of work, if that be the case
		During the month (a) acres	Progressive from 1st July, 19 . (b) acres	During the month (a) acres	Progressive from 1st July, 19 . (b) acres	During the month (a) acres	Progressive from 1st July, 19 . (b) acres	During the month (a) Hours	Progressive from 1st July, 19 . (b) Hours	During the month (a)	Progressive from 1st July, 19 . (b)	

Copies forwarded with compliments to the Mechanical Cultivation Engineer,.................State.................

Foreman Supervisor,
Unit No......

FORM No. 28

MECHANICAL CULTIVATION SECTION..............STATE..............

Log Book Sheet for Tractor/Bulldozer for the month of....................195 for the Unit No..................at.................

Tractor No./Bulldozer No. ....Engine No.........................

Name of the Driver...................................... Date of Supply of Tractor/Bulldozer

No. of hours worked till the end of the month..............................

Date	Name of party	Village	Meter reading		No. of hours worked	Idle days with reasons	Nature of work done together with extent of work					Maintenance details						Spares	
			Start	Stop			Deep	Shallow	Harrowing	Levelling	Miscellaneous	H. S. D.	Oils	Grease	Petrol	Waste	Repair charges	Heavy parts Rs.	Light parts Rs.
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
	Total for the month ...																		
	Previous total ...																		
	Progressive total ...																		

1. Name of spares issued (Detailed list to be given with cost on the back side).
2. Wages and D.A. of driver and cleaner.
3. Remarks.

FORM No. 29

MECHANICAL CULTIVATION SECTION.................STATE.................

Mobile Maintenance Unit No..........................

Job Card

Job No.. Date ....
From whom received:
Particulars of the job:
Damage Report No.......................... Date ....
Job started .... Job completed.......................

Job Order

To attend the following job and report compliance:—
To

1. Shri
2. Shri
3. Shri

Foreman Supervisor,
Unit M.M.S.
Workshop.

Job work details

Work done	Material used			Person engaged	Designation	Hours worked	Cost	Total cost of job
	Name	Qty.	Cost Rs.					

Add services hired from outside Rs..
Total cost of job: Rs...

Returned to the Foreman Supervisor
Job duly completed.
Returned by Shri..

Job is duly completed and the cost and material shown is correct and is shown in the Job Register accordingly.

Technical Storekeeper

Foreman Supervisor,
M.M.S./Workshop.

FORM No. 30

Trading and Profit and Loss Account of the Mechanical Cultivation Section,................State,

for the half year ending................19......

	Dr. Rs.		Cr. Rs.
To opening stock:		By Receipts from:	
(A) Fuels and lubricants:		(i) Deep ploughing	
(i) Tractors		(ii) Shallow ploughing	
(ii) Vehicles		(iii) Harrowing	
(B) Spare Parts:		(iv) Levelling and bunding	
(i) Tractors		(v) Other operations	
(ii) Implements		,, Capital expenditure transferred (replacement of heavy spares)	
(iii) Vehicles		,, Transport receipts	
(C) Consumable stores		, Miscellaneous receipts	
,, Purchase of fuels and lubricants:		,, Transfers	
(i) Tractors			
(ii) Vehicles			
,, Purchase of spare parts:		,, Closing stock:	
(i) Tractors		(A) Fuel and lubricants:	
(ii) Implements		(i) Tractors	
(iii) Vehicles		(ii) Vehicles	
,, Purchase of consumable stores		(B) Spare parts:	
,, Pay and allowances of operational staff ...		(i) Tractors	
,, Railway freight and other transport charges ...		(ii) Implements	
,, Rent, rates and taxes		(iii) Vehicles	
,, Wages of watchmen and labour		(C) Consumable stores	
,, Incidental charges		,, Gross loss c/d.	
,, Insurance			
,, Pay and allowances of administrative and office staff			
,, Gross profit c/d.			
Total ...		Total ...	

FORM NO. 30

Trading and Profit and Loss Account of the Mechanical Cultivation Section,.................State, for the half year ending.................... 19......

	Dr. Rs.		Cr. Rs.
By Gross loss b/d.		By Gross profit b/d.	
,, Depreciation:			
Tractors		,, Net loss	
Implements			
Vehicles			
Machinery			
Deadstock			
,, Interest on capital			
Audit fees			
,, Leave salary and pension fund contribution ...			
,, Net profit			
Total ...		Total ...	

FORM NO. 31

Balance Sheet of the Mechanical Cultivation Section..............State...........as at......................19.....

LIABILITIES	Rs.	ASSETS	Rs.
Government capital account:		Tractors:	
Opening balance (as per last balance sheet) ...		Heavy	
Add: treasury overdrawals		Light	
treasury withdrawals		Implements:	
Less: treasury remittance		Vehicles	
Government suspense Account:		Equipment:	
Opening balance (as per last balance sheet) ...		Machinery	
Add: additions during the year		Tools	
Less: transfers		Miscellaneous equipment	
Sundry creditors		Sundry debtors	
Net profit		Stock on hand:	
		(a) Fuels and lubricants	
		(b) Spare parts	
		(c) Consumable stores	
		Cash on hand	
		Net loss	
Total ...		Total ...	

FORM A

MECHANICAL CULTIVATION SECTION..................STATE..................

Tractor Log Sheet

Name of Tractor Driver...

Date	From	To	Hours	Total hours	Type of tractor and No.	Type of implement and No.	Petrol	H.S.D.	Shell Ardol	Std. Vac.	Shell Retinax	Trans-mission	C. waste	Grease	Total acres		Nature of work	Name of party	Contract No.
							Gal.	Gal.	Gal.	Gal.	Lb.	Gal.	Lb.	Lb.	A.	G.			

FORM B

(Monthly Log Sheet for Tractors and Implements)

Tractor AD No............for the month of........................ Implement No............for the month of........................

S. No. of tractors and type	H.P.	Meter reading		Working hours			Nature of work done together with extent of work	Earnings Rs.	Consumption and cost for actual work done					
		Start	Stop	No. of hours worked	No. of idle hours	Progressive hours			H.S.D. Qty.	Value Rs.	Oils		Misc. Item	
											Qty.	Val.	Qty.	Val.

Consumption and cost for idle run						Cost of spares used Rs.	Cost of repairs Rs.	Total expenditure Rs.
H.S.D.		Oils		Misc. items				
Quantity	Value Rs.	Quantity	Value Rs.	Quantity	Value Rs.			

Implement S. No.	Make and type	Hours worked	Progressive hours worked	Cost of spares used Rs.	Cost of repairs Rs.	Total expenditure Rs.

Form C

(Monthly Vehicle Working Report)

Vehicle number milo-meter	Miles run	Total miles run	Pay of M.T. Drivers	Period		Oil		Other items		Spares value	Insu-rance*	Repairs value	Total expenditure		
				Qty.	Amount Rs.	Quantity	Amount Rs.	Quantity	Amount Rs.	Rs.		Rs.	P.O.L. Rs.	Spares repairs Rs.	Pay of M.T.D. Rs.

Tractor A.D. No.	Total miles run	Spares value Rs.	Repairs value Rs.

*Repairs:— (i) The cost of repairs as shown in the *Job Cards* (Relevant) in three series.
(ii) The cost of repairs carried out in outside workshop.

N.B.—The Divisional Offices will also submit this return in respect of vehicles attached to the Divisional Offices.

FORM D

(To be submitted monthly by M.M.S. Unit & Workshop)

Cost of establishment (i) Pay of Foreman Supervisors (ii) Pay of the other staff for the *idle time*	S. No. of machine	Machinery		Spares	Repairs	Other workshop expenses (excluding *already included* in Job Cards)			
		Hours worked	Progressive hours	Rs.	Rs.	Power Rs.	Gas Rs.	Coal Rs.	Misc. Rs.

FORM E

To be submitted by the Divisional Office monthly in respect of tractors, bulldozers, implements and other machinery

S. No of machine or any other assets to be specified	Capital cost Rs.	Working hours	Depreciation Rs.	Interest Rs.	Establishment		Miscellaneous Rs.
					Direct Rs.	Indirect Rs.	

N.B. (i) The expenditure on Establishment (*direct*) incurred during the month would consist of the employment of *all* (a) Tractor Drivers (b) Bulldozer Operators. The Divisional Office in the column 'Establishment (Direct)' will show these two figures only.

(ii) Indirect Establishment charges could cover the employment of Operational Unit (i.e. Foreman Supervisor, Mechanic, Technical Storekeeper and Cleaner) plus the proportionate expenditure on the Divisional Office Establishment. The figures of indirect charges in the case of each Unit should be shown separately.

(iii) Miscellaneous Charges would include all the expenditure incurred at the Unit or at the Divisional Office which is not incurred under any of the Columns of 'B', 'C', 'D' and 'E' Expenditure under this head will be shown in this column without reference to any particular machine.

FORM F-1

(A register of tractors and bulldozers)

S. No. of tractors and type	H.P.	Meter reading		No. of hours worked	Progressive hours	Capital cost	Nature of work done together with the extent of work	Earnings	Expenditure on actual work					
									H.S.D.		Oils		Misc. items	
		Start hours	Complete hours		Rs.	Rs.		Rs.	Qty.	Val. Rs.	Qty.	Val. Rs.	Qty.	Val. Rs.

Expenditure for idle run						Cost of spares	Cost of repairs				Transport			
H.S.D.		Oils		Misc. Items										
Qty.	Val.	Qty.	Val.	Qty.	Val.	Rs.	Direct (from Job Cards)	From Form 'D'	From Form 'C'	Total	Unit level	Divisional level	Sectional level	Total

Establishment		Miscellaneous	Depreciation	Interest	Total
Direct Rs.	Indirect Rs.	Rs.	Rs.	Rs.	Rs.

FORM F-2

(A Register to be kept at the Central Office in respect of implements)

S. No. of implement	Make and type	Total hours worked	Capital cost Rs.	Cost of spares Rs.	Cost of repairs			Depreciation	Interest	Total expenditure Rs.
					Direct (from Job Cards)	From Form D Rs.	From Form C Rs.			

FORM F–3

(A register to be kept at the Central Office in respect of vehicles)

No. and make	Capacity & H.P.	Capital cost	Milo-meter		Progres-sive miles	Engine oil		Other lubrication oil		Petrol		Cost of spares	Cost of repairs
			Start mile	Completed mile		Qty.	Val.	Qty.	Val.	Qty.	Val.	Rs.	Rs.

Pay of M.T.D.	Depreciation Rs.	Insurance Rs.	Interest Rs.	Total expenditure Rs.

FORM F-4

A register to be kept at the Central Office in respect of machinery

Depreciation of machinery	No. and make	Capital cost Rs.	Hours worked	Progressive hours	Cost of spares Rs.	Cost of repairs Rs.	Depreciation Rs.	Interest Rs.	Total expenditure Rs.

Form G-1

(Showing the mechanical efficiency of different machines per B.H.P. hour)

Description of machine	H.P.	No. of total hours worked	Progressive No. of total hours worked	Work done	Consumption of petrol, oil and lubricants per B.H.P. hour						Consumption of spares and repairs per B.H.P. hour	
					H.S.D.		Engine oil		Trans. Oil			
				Deep Shallow Harrowing Grading	Quantity	Value	Quantity	Value	Quantity	Value	Spares value Rs.	Repairs value Rs.

Capital cost Rs.	Depreciated value Rs.

FORM G-2

(Showing the working cost of each Unit)

Unit No.	Machine Sr. No.	Folio No. of *F—I*	Total hours worked	Work done	Earnings	EXPENDITURE										
				Deep Shallow Harrow-ing Grading		Misc.	*P.O.L.*	*Spares*	Repairs	Establishment		Trans-port	Depreci-ation	Interest	Total
										Direct	Indirect				
					Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.

Excess of income over expenditure ... Rs.........................

FORM G–3

(Showing the cost of each different operation for each type of machine)

Machine S. No.	H.P. and type	Hours worked	Folio of F-1	Type of each operation	Extent of work done	P.O.L. Rs.	Spares Rs.	Repairs Rs.	Establishment		Trans-port Rs.	Depre-ciation Rs.	Interest Rs.	Misc. Rs.	Total expendi-ture Rs.
									Direct Rs.	Indirect Rs.					

APPENDIX

Statement 1 showing specifications for some typical tractors

Name of model of tractor	Wheel or track	Agents	Fuel used	Method of starting	No. of cylinders	Rated R.P.M.	Net weight lb.	Maximum belt H.P.	Maximum draw bar H.P.	Class	Maximum pull for the 1st gear lb.	Speeds in miles per hour
1	2	3	4	5	6	7	8	9	10	11	12	13
Caterpillar D7	Track	M/S. Larsen & Toubro Ltd., Fort, Bombay.	H.S.D.	Separate starting engine 24 H.P.	4	1,000	25,130	93	81	I	23,900	F: 1·4, 2·2, 3·2, 4·6, 6·0. R: 1·6, 2·6, 3·8, 5·4.
,, D6	,,	,,	,,	,, 15HP	6	1,400	16,725	76	66	II	18,700	F: 1·4, 2·3, 3·2, 4·4, 5·8. R: 1·8, 2·8, 3·9, 5·4.
,, D4	,,	,,	,,	,, 10HP	4	1,400	10,065	48	43	III	10,600	F:1·7, 2·4, 3·0 3·7, 5·4. R: 1·9
,, D2	,,	,,	,,	,, ,,	4	1,525	6,740	38	32	IV	7,550	F: 1·7, 2·5, 3·0, 3·6, 5·1. R: 2·1.
International Crawler T.D. 18A	,,	M/S. Volkart Bros., Bombay	,,	Hand/self	6 vertical	1,350	22,570 (narrow	101·98 gauge)	89·29	I	20,234	F: 1·7, 2·2, 2·7, 3·5, 4·6, 5·7. R: 1·7, 3·5.
T.D. 14A	,,	,,	,,	,,	4 ,,	1,400	15,520	75·30	65·90	II	14,652	F: 1·6, 2·0, 2·6, 3·4, 4·4, 5·7. R: 1·6, 3·4.
T.D.9	,,	,,	,,	,,	4 ,,	1,400	9,525	45·91	38·88	III	9,909	F: 1·5, 2·3, 3·0, 3·9, 5·3. R: 1·7.
T 6	,,	,,	Powerine	,,	4 ,,	1,450	6,750	36·38	31·63	III	7,434	F: 1·5, 2.2, 3·1, 3·8, 5·4. R: 1·7.
T.D. 6	,,	,,	H.S.D.	,,	4 ,,	1,450	7,010	36·23	29·49	III	8,131	F: 1·5, 2·2. 3·1, 3·8, 5·4. R: 1·7.

APPENDIX

Statement I—(*Continued*)

Name of model of tractor	Wheel or track	Agents	Fuel used	Method of starting	No. of cylinders	Rated R.P.M.	Net weight lb.	Maximum belt H.P.	Maximum draw bar H.P.	Class	Maximum pull for the 1st gear lb.	Speeds in miles per hour
1	2	3	4	5	6	7	8	9	10	11	12	13
Allis Chalmers HD 9	,,	M/S. Pashabhai Patel & Co., Bombay.	Diesel	Electric starting	4	1,600	18,500	84	70	I	16,650	F: 1·39, 2·10, 2·93 3·77, 4·41, 5·68. R: 1·56, 3·45, 4·43.
HD 5	,,	,,	,,	,,	2	1,800	11,250	50·25	40·26	III	10,800	F: 1·46, 2·44, 3·30, 3·96, 5·47. R: 1·99.
WD	Wheel	,,	Powerine	Electric & Hand starting	4	1,400	3,975	35·8	31·68	IV	...	F: 2·5, 3·5, 4·75, 9·0. R: 2·0.
Fordson Major Row Crop	,,	M/S. Ford Motor Co., India Ltd., Bombay.	H.S.D.	Electric starting	6	1,400	6,970	45	35·4	III	5,300	Stq: F: 2·8, 3·9. 12·0. R: 4·1 Spl. F: 2·2, 3·2, 12·0. R: 3·0.
,,	,,	,,	Powerine	,,	4	1,200	6,754	28·2	24·8	IV	4,600	Stq: F: 2·73, 3·85, 10·0 R: 4·04. Spl: F: 2·16, 3·06, 10·0 R: 2·93.
Fergusson TD 20	Wheel	M/S. Kamani Engineering Corporation. Ltd., Bombay.	Powerine	Starter motor	4	2,000	2,400	24	18·4	IV	1,840	F: 2·5, 3·5, 4·75, 9·75. R: 3·0.

Abbreviations: F: Forward. R: Reverse.

APPENDIX

Statement II showing specifications for typical agricultural tractor implements and cultivation machinery

Class of Tractors

Class I ... 80 H. P. and above
Class II ... 60 to 79 H. P.
Class III ... 40 to 59 H. P.
Class IV ... Below 40 H. P.

PLOUGHS (MOULDBOARD)

S. No.	Make and number	Type	Number of		Depth of plough in inches	Width of each cut	Maximum acreage per day	Suitable for class of tractor	Weight in lb. (Net)	Agent
			Bottoms	Discs						
1	John Deere No. 77	Mould board	3/4/5	...	12 to 14	48″/66″ 80″	3 to 8	I or II	2100/2445 2963	Larsen & Toubro Ltd., Bombay.
2	John Deere No. 55B	,,	3	...	6 to 12	42″	5	III	1274	,, ,, ,,
3	John Deere No. 44A	,,	2	...	3 to 10	28″	3	III & IV	877	,, ,, ,,
4	Ransomes Duratrac TS 49A	,,	5	...	14	70″	6	I to II	3900	William Jacks & Co., Ltd., Bombay.
5	Ransomes Duratrac TS 48 A	,,	4	...	14	56″	6	II & III	3250	,, ,, ,,
6	Ransomes Duratrac TS 47	,,	3	...	14	42″	5	III	2520	,, ,, ,,
7	Ransomes Giantrac TS 4T	,,	3	...	14 to 18	48″	4	II & III	2975	,, ,, ,,
8	,, ,, ,,	,,	2	...	14 to 18	32″	2	III	2445	,, ,, ,,
9	Fraugde 3 Furrow 14″ EP	,,	3	...	11	42″	6	III		East Asiatic Co., Ltd., Bombay.
10	Fraugde 3 Furrow 12″ FN & EP	,,	3	...	9	36″	6	III		,, ,, ,,
11	Fraugde 2 Furrow 12″ FN & EP	,,	2	...	9	24″	4	III		,, ,, ,,

APPENDIX

Statement II (*Continued*)

PLOUGHS (DISC)

S. No.	Make and number	Type	Number of Bottoms	Number of Discs	Depth of plough in inches	Width of each cut	Maximum acreage per day	Suitable for class of tractor	Weight in lb. (Net)	Agent
1	Massey Harris No. 402	Disc	...	2	6	...	3	IV	...	Rallis India Ltd., Bombay.
2	,, ,, No. 403	,,	...	3	8	...	4 to 5	IV	1575	,, ,, ,,
3	,, ,, No. 503	,,	...	3	8 to 12	...	4 to 5	III & IV	2025	,, ,, ,,
4	,, ,, No. 504	,,	...	4	8 to 12	...	6	III	2275	,, ,, ,,
5	,, ,, No. 505	,,	...	5	8 to 12	...	6	II & III	2535	,, ,, ,,
6	,, ,, No. 605	,,	...	5	10 to 12	...	6	II & III	3670	,, ,, ,,
7	,, ,, No. 606	,,	...	6	10 to 12	...	6	II & III	3920	,, ,, ,,
8	Oliver No. 156	,,	...	6 (convertible to 4 & 5)	...	...	8	I & II	3104	William Jacks & Co., Ltd., Bombay.
9	Ransome Shugadisc TD 9A	Disc	...	4	10 to 14	...	6	I & II	6960	William Jacks & Co., Ltd., Bombay.
10	,, ,, ,,	,,	...	3	10 to 14	...	6	I & II	6045	,, ,, ,,
11	Ransome MF	,,	...	6	10	...	8	III & IV	3000	,, ,, ,,

APPENDIX

Statement II (*Continued*)

CULTIVATORS

S. No.	Make and mark	Type	No. of tynes	Capacity to work per day	Width of cut	Class of tractor	Weight in lb.	Agent
1	2	3	4	5	6	7	8	9
1	Ransomes, No. 3 Dauntless ...	Curved tine, spring mounted	11	15 acres	7′	IV	1,000	William Jacks & Co., Ltd., Bombay.
2	Ransomes, No. 9 Dauntless ...	,,	13	20 ,,	8′-8″	IV	1,135	,, ,, ,,
3	Ransomes, No. 11 Dauntless ...	Rigid vertical	11	15 ,,	7′	IV	1,050	,, ,, ,,
4	Ransomes, No. 16 Dauntless ...	Curved tines, spring mounted	13	20 ,,	10′-3″	IV	1,575	,, ,, ,,
5	Ransomes, C 65 A	Rigid	7	10 ,,	5′-3″	IV	1,405	,, ,, ,,
6	Ransomes, C 65 B	,,	9	12 ,,	6′-9″	IV	1,500	,, ,, ,,
7	Ransomes Equitine, C 31 B ...	Steel curved	9	10 ,,	5′-8″	IV	1,260	,, ,,
8	John Deere Killefer, 5C4 ...	Coil spring	9	16 ,,	9′-0″	IV	969	Larsen & Toubro, Ltd., Bombay.
9	John Deere Killefer, 8C12 ...	,, ,,	21	25 ,,	12′-0″	III & IV	1,577	,, ,, ,,
10	Massey Harris, No. 25 ...	Stiff tooth	13	20 ,,	10′-0″	IV	1,375	Rallis India, Ltd., Bombay.
11	MasseyHarris, No. 26	Spring tooth	16	15 ,,	7′-6″	IV	795	Rallis India, Ltd., Bombay.
12	Rud Sack M. G. 19	Spring loaded (Also spring tyne)	13	20 ,,	12′-0″	IV	1,600	Das and Co., Das Chambers, Dalal Street, Fort, Bombay.
13	Rud Sack MG 13	,, ,,	26	30 ,,	16½′	III	2,880	,, ,, ,,

APPENDIX

Statement II (*Continued*)

HARROW

S. No.	Make and type	No. of teeth per section	Size of tooth in inches	No. of sections	Weight in lb.	Width of cut	Capacity	Class of tractor	Agents	
1	2	3	4	5	6	7	8	9	10	11
1	Massey Harris, No. 6 Spike Tooth Drag Harrow								Rallis India Ltd., Bombay	
	*Light	20	½	1 to 6′	40 per section	3′-4″ per section	10 acre per section	IV		*Light harrow is usually called seed harrow.
	Standard	20	9/16	,,	60 ,,	,,	9 ,,	IV		
	Medium	20	⅝	,,	65 ,,	,,	8 ,,	IV		
	Heavy	20	¾	,,	79 ,,	,,	7 ,,	IV		
2	Minneapolis-Moline, Allsteel Harrow AS 60 ...	30	¾	2	249	9′	15 to 18 acres	IV	Rallis India Ltd., Bombay.	
	AS 140	35	¾	4	580	20′-8″	30 acres	III		
3	Cockshutt "LT 255" ...	24	⅝/x7	4	530	16′-6″	30 acres		The Bombay Company Ltd., Bombay.	
	Spike Tooth Harrow ...	,,	,,	3	410	12′-4″	22 ,,	...	,, ,,	
4	Turner "Yeoman" Harrow, IMBRU, Set of three *Light Seed Harrows	20	...	3	164	10′ (approximately)	30 ,,	IV	The East Asiatic Co., (India), Ltd., Bombay.	

APPENDIX

Statement II (*Continued*)

DISC HARROWS

S. No.	Make and type	No. of discs	Size of disc in inches	Capacity to work per day in acres	Width of cut in ft.	Class of tractor	Weight of the implement in lb.	Agents
1	2	3	4	5	6	7	8	9
1	Athens Heavy Duty Disc Harrow	12	26	10	6	III	3005	Voltas
2	,, ,, ,, ,,	16	26	12	8	II	3796	,, ,, ,, ,,
3	John Deere Killefer, No. 206 ...	16	24	10	6	III	1527	Larsen & Toubro Ltd., Bombay.
4	Ransomes No. 3, Baron, Disc Harrow HR 14	44	20	18	12	III	3100	William Jack & Co., Ltd., Bombay.
5	Ransomes No. 3 Baronet Disc Harrow HR 9	28	(plain type 20 or 24)	16	11½	IV & III	2725	,, ,, ,, ,,
6	,, ,, ,, ,,	28	(cut away 20/22/24)	16	11½	IV & III	2725	,, ,, ,, ,,
7	The Rome Master, TM 10-28 ...	10	,,	16	11	III	3700	Larsen & Toubro Ltd., Bombay.
8	,, ,, M 16-28 ...	16	,,	12 to 15	9	II	6050	,, ,, ,,

APPENDIX

Statement II *(Continued)*

ROLLERS

S. No.	Make	Pattern	No. of gangs	Width	Diameter of: Rings	Diameter of: Rolls	Weight in lb.	Class of tractor for which suitable	Agent
1	2	3	4	5	6	7	8	9	10
1	Ransomes	Plain or flat	1	7′	...	20″ / 24″	812 / 975	IV	William Jacks & Co., Ltd., Bombay.
2	,,	,, ,,	1	8′	...	20″ / 24″	950 / 1080	IV	,, ,, ,,
3	,,	,, ,,	3	13′-6″	...	20″ / 24″	1990 / 2090	IV	,, ,, ,,
4	,,	,, ,,	3	17′-4″	...	20″ / 24″	2370 / 2590	IV	,, ,, ,,
5	,,	Combridge or ring	1	8′	20″ / 22″ / 24″	... / ... / ...	1625 / 1645 / 1930	IV	,, ,, ,,
6	,,	,, ,,	3	16′	20″ / 22″ / 24″	... / ... / ...	3140 / 3670 / 4060	IV	,, ,, ,,
7	Flemstofte Maskinfabrik No. 21	Plain or flat	3	7′	15″ Extra heavy	...	1403	IV	East Asiatic Co., Ltd., Bombay.
8	,, ,, No. 973	,, ,,	3	10′	13″	...	1233	IV	,, ,, ,,
9	,, ,, No. 533	,, ,,	3	18′	15″	...	2676	IV	,, ,, ,,
10	,, ,, No. 536	,, ,,	5	15′	15″	...	2456	IV	,, ,, ,,
11	,, ,, No. 538	,, ,,	5	15′	15″ Extra heavy	...	2967	IV	,, ,, ,

APPENDIX

Statement II (*Continued*)

MANURE DISTRIBUTORS

S. No.	Make	Length of box inside	Width of box inside	Height of load	Wheel base	Beaters	Width of spread	Net weight in lb.	Feed range	Tyre size	Agent
1	2	3	4	5	6	7	8	9	10	11	12
1	Cockshutt 4″	113″	40″	18″ to 33″	106″	Two of steel angle iron.	7′ covering both wheel-tracks.	1,405	4,8,12,16 loads per acre.	Front 16″x5·50″ Rear 18″x7·50″ (pneumatic).	The Bombay Co., Ltd., 9, Wallace Street, Bombay.
2	Cockshutt 6″	113″	40″	18″ to 33″	106″	do	do	1,300	do	do	do
3	Massey Harris, No. 10	91½″	35¼″	39½″	86″	Two steel angle bar construction.	do	...	4,8,12, 16 or 20 loads per acre.	Front 26″x4·5″ Rear 38″x5″ (Steel wheels)	Rallis India, Ltd., Bombay.

APPENDIX

Statement II (*Continued*)

SEED DRILL

S. No.	Make and type	No. of discs	Weight in lb.	Capacity	Agents
1	2	3	4	5	6
1	Cockshutt 8" Grain Drill	20	1820	18 acres	Bombay Company, 9 Wallace Street, Fort, Bombay.
	... ...	24 28	2010 2240	22 ,, 25 ,,	
2	Nordsten Ceres	25	...	22 ,,	The East Asiatic Co. Ltd., Bombay.
3	,, ,, ...	29	...	26 ,,	,, ,, ,, ,,
4	,, ,, ...	31	...	28 ,,	,, ,, ,, ,,
5	Massey Harris No. 5	11	860	10 ,,	Rallis India Ltd., Bombay.
6	,, ,, ,, ...	13	950	11 ,,	,, ,, ,, ,, ,,
7	Massey Harris No. 306	20	1700	18 ,,	,, ,, ,, ,, ,,
8	,, ,, ,, ...	24	1950	22 ,,	,, ,, ,, ,, ,,
9	,, ,, ,, ...	28	2200	25 ,,	,, ,, ,, ,, ,,
10	John Deere, Mode 'B' Plain 12 ...	...	...	11 ,,	Larsen & Toubro, Ltd., Bombay.
	14 ...	...	...	12 ,,	
	16 ...	...	...	14 ,,	
	18 ...	...	...	16 ,,	
	20 ...	...	...	18 ,,	
	24 ...	...	...	22 ,,	
	28 ...	...	...	25 ,,	

APPENDIX

Statement II (*Continued*)

ROTARY HOE

S. No.	Make and mark	No. of sections	Width of each section	No. of wheels for each section	No. of teeth on each wheel	Total net weight in lb.	Capacity	Agent
1	2	3	4	5	6	7	8	9
1	John Deere, No. 214-A ...	2	3½′	14 wheels staggered on two axles.	16	700	40 acres per day (of 10 hours)	Larsen & Toubro, Ltd., Bombay.
2	John Deere, No. 414 ...	4	3½′	,, ,,	16	1413	80 acres per day (of 10 hours).	,, ,, ,,

APPENDIX

Statement II (*Continued*)

HARVESTER COMBINES

S. No.	Make	Type	Width of cut	Feed	Power	Capacity of grain tank	Speeds forward	Agent
1	2	3	4	5	6	7	8	9
1	Massey-Harris ...	Super 27 C	16′	Auger feed	6 cylinder engine 55 HP	60 bushels	0·9 to 7·6 M.P.H.	Rallis India Ltd., Bombay.
2	Cockshutt ...	S.P. 132	10′ to 15′	,,	55 H.P.	45 bushels	0·64 to 9·1 M.P.H.	Bombay Company, Bombay.
3	John Deere ...	36 B	16½′ to 20′	Chain type	40 H.P.	65 bushels	...	Larsen & Toubro, Ltd., Bombay.

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INDEX