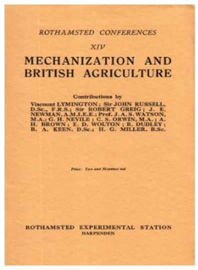
Mechanization and British Agriculture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Contributions by
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Discussion

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DISCUSSION

MR. G. H. NEVILE (Wellingore).—I am glad to see that Professor Watson dealt with the combination of live stock farming with mechanization, because I feel that there has been a tendency to regard power farming as applicable only to specialised grain farms. It is true we must look for a new arable system to take the place of the four course rotation, which has been our stand-by for so long, but farmers are a conservative race, and few can see their way to eliminate live stock entirely from their holdings.

Mr. Newman has dealt with the engineering aspect of specialised farms complete with the most modern machinery, but I should like to touch on equipment for those of us whose enterprise is limited by the good-will of our Bank Managers, and who are in the transitional stage, and gradually altering our systems from horse to power farming.

Our aims are to save £1 per acre in the preparation of our land by substituting tractors for horse power, and by the use of the combine harvester, dispense with the harvest and threshing gang, and possibly save a further £1. in the cultivation of our corn area.

The size and cost of our equipment will largely depend on our land, and on the rotation for which it is best fitted.

In any rotation we may adopt, we have to give due consideration to the maintenance of the fertility and cleanliness of the land, but modern implements capable of ploughing 10 or 12 acres a day, and cultivating or disc harrowing a proportionately greater area, alter our outlook both with regard to costs and the rapidity of work, and it should be our object to compress both the cleaning effect of a root break or bare fallow, and the fertilizing effects of a clover crop, into a single season.

For this reason the three-year rotation where two corn crops are followed by a renovating year, appears to me a practical and simple one, and economic of equipment. A winter cereal followed by a spring cereal undersown with trefoil or trefoil and rye grass, would then be our cropping. The trefoil would be ploughed in from the middle of May onwards, and if cleaning is required there would be time for a bastard fallow before sowing the wheat in September or early October, and thus ensuring a strong plant before winter.

If in place of wheat two spring cereals are grown, cleaning crops for sale such as potatoes or sugar beet could be taken on part of the area in place of the trefoil mixture. If grass land is held with the arable area, some proportion of the third year crop can be devoted to

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roots suitable for the grass land live stock. These may be marrow stem kale and mangolds for dairy cattle, or marrow stem, thousand headed kale, or rape, sown thick to act as a smother crop for sheep food.

In this rotation 66 per cent. of the area is devoted to cash grain crops, but on moisture holding soils in clean condition it may be possible with the aid of artificial fertilizers to devote 75 per cent. or 80 per cent. of the land to such crops. In these cases the time available for both cultural operations and harvest is cut down and a larger equipment may be necessary. This point is intensified by the fact that such rotations will be more suitable for our stronger lands.

Naturally, the strength of the land will have a great bearing on the size of the power unit which is necessary, and I suggest that in studying this point, we can best classify our soils by the number of pounds draw-bar-pull required per square inch of furrow turned.

In the case of my own farm, I have some heavy silt on the Lias Clays where, in its toughest condition, the draw-bar-pull may amount to 20 lb. per square inch of furrow turned. Here a 20 h.p. tractor has a difficulty in ploughing more than four acres a day, though on the same fields after a dry summer when the land is thoroughly cracked, we have ploughed 10 acres a day. On the lightest of my barley loams on the Oolite escarpment, the pull is no more than 6 lb. per square inch, and the same tractor will plough 10 and 12 acres a day under almost any condition of weather. Good medium loams average about 8 to 10 lb. per square inch, and the bulk of the prairie wheat lands in America where a 20 horse tractor is expected to handle four—14 in. furrows with a ploughing output of 12 acres a day, have a pull of 7 lb. to 8 lb.

Until recently the small tractors giving about 10-12 rated draw-bar h.p. with a total draw-bar-pull of about 1,250 lb. on their working speeds of 3 miles an hour have been the commonest in this country. I consider these uneconomic on all but the lighter lands, as their daily output is insufficient to get over the land in time. For secondary cultivations they are useful. When a farmer already has a tractor of this type and is contemplating a larger unit, he will do well to retain his old tractor as a standby and for secondary cultivations, straw and hay loading, and similar work.

The most efficient size tractors for this country appear to me to be the medium sizes of 20-25 h.p. on the draw-bar with a pull of 2,500 lb. at three and one-third miles an hour. The capital cost is substantially less per h.p., and as their ploughing output is double that of the smaller type, the wage cost per acre is halved. They are capable of handling a combine with an 8 ft. cutter bar driven from the power take-off which the smaller sizes cannot do.

In the case of wheeled tractors with standard wheels, I think that 25 draw-bar h.p. is about their limit of utility. Fully loaded at this power they have difficulty in getting a grip on light land in secondary cultivations, and on heavy land in moist condition, their compressive effect may be definitely bad.

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Track-laying tractors have not this defect. Their first cost, however, appears to be nearly £200 more than similar sizes of wheeled tractors, and I think it is a weakness that they are geared considerably lower than the wheeled types. To get the same acreage per hour from them, therefore, requires extra large implements. For secondary cultivations and working on heavy or wet soils, they are much superior to the wheeled types.

The cheapest load for a tractor is that when it is delivering just its rated h.p. without overloading. To fully load even the 20-25 h.p. tractors on medium and light ground really needs special equipment, but in the transitional stage, we must think twice before embarking on more expensive implements. Where the 10 h.p. tractor can take 3 furrows of 10 in. or 11 in. at 3 miles per hour, a full load for the 20 h.p. tractor would be 6 furrows, but I suggest that in these cases use should be made of the top speed of the tractor, and with four—12 in. furrows at nearly 4 miles an hour we can cover a lot of ground. In America the four-furrow plough with 14 in. furrows and digger or semi-digger breasts seems to be the standard equipment. In the 14 in. sizes, the output per day is put at 12 acres. Personally, I am well satisfied with a 4 furrow plough where the furrows can be altered from 9 in. to 12 in., and a furrow taken off where necessary. This, combined with the use of the top speed on light land gives great flexibility, and a wide range of usefulness. On the heavy land the plough can be shut down to three 9 in. or 10 in. furrows, and a full load can be obtained on the lighter land by ploughing in top gear. At the higher speeds the furrow is more broken, and personally I like the greatest amount of disintegration possible where the soil is suitable.

There still seems a disposition to take the horse's speed of 2½ miles an hour as the ideal ploughing speed. On heavy wet soils where the object is to get rid of moisture, the well set up furrow may be advantageous, but on our light barley soils which suffer from drought, it appears to me that the broken, moisture retaining, furrow, is an advantage.

Similarly with our secondary equipment, while in the transitional stage, we wish to avoid purchasing extra large disc harrows, rolls, drills, harrows, etc. I suggest that this may best be done by harnessing our implements in tandem fashion. For preparing a seed bed this year a 20 h.p. tractor took a three-horse roll, a set of disc harrows and straight tooth harrows in tandem, working round and round the field, followed immediately by a lighter tractor with the ordinary drill. In this way I was able to cultivate and sow up to 25 acres a day with two tractors and two men at a cost of about 2s. 6d. per acre. Sowing immediately behind the harrowings appears to me to give the best results.

We may put the daily cost in round figures of running a 20 h.p. paraffin tractor at 30s. This allows 7s. for the driver 10s. for depreciation, and 13s. for fuel, oil and sundries. Such a tractor should have a life of 1,000 days, and at 10s. per day, we are allowing £500 for depreciation and repairs on a tractor costing about £350.

The ploughing output may be 10 or 12 acres a day in light land, and 4 acres in very tough soils, so that the cost would vary between 2s. 6d. and 7s. 6d. per acre, with 4s. to 5s. as a fair mean. In secondary cultivations 20 acres a day should be possible for roll, disc harrows and harrows worked tandem fashion, or 1s. 6d. per acre. With seeding and distributing artificial manure a total of 10s. or 12s. should cover the cost of planting a corn crop in medium soils. Mr. Newman's figures of 11s. per acre for cultivations for wheat, confirm this view. If we allow 5s. per acre for depreciation on the combine, we may put all harvesting charges at 15s. to 18s. per acre. This covers combining, drying, final sacking for market and transport to station, so that 25s. to 30s. should cover our cultivation costs, with the exception of handling straw. To this has to be added the cost of seed, artificial manures, rent, general expenses, and a share of the cost of fallowing, to arrive at the total cost of the crop.

Looked at in another way, the sum of 25s. to 30s. per acre for cultivation costs will be found to be made of approximately equal shares for wages, fuels, etc., and depreciation. This gives us a measure of possible economies. Wage costs can be reduced by a few shillings if more capital is devoted to field and barn equipment.

As regards fuel, 7 or 8 gallons of paraffin per acre should, I think, provide for all the cultural requirements of our arable area, and with this at 6d. per gallon the use of electricity, promises little, if any, further economy when the cost of installation is considered. The petrol tax makes the use of this fuel prohibitive, and more than doubles the fuel cost. There is an undoubted future for crude oil engines both in the cost and the efficiency of their fuel, but the engines must compete in price and reliability with the present paraffin tractor before they can replace the latter.

Combine Harvesters have only been tested out in this country in the last three or four years, but Mr. Newman's figures show that their general utility is proved, and that they are no longer in the experimental stage. They vary in size from those that harvest a 35 foot swath of grain to those which cut an 8 ft. swath.

For this country the larger sizes are not likely to be economically useful, and the 8 ft. to 16 ft. sizes are probably those which will best meet our needs. Purchasers would do well, I think, to specify for a smaller length of cutter bar than that in use in America. That is to say, if they contemplate taking a 12 ft. cut, they should order the 16 ft. size combine, and use only the 12 ft. bar, while for the 12 ft. size combine, the 10 ft. cutter bar is ample: this allows for more margin in the drum, riddles, and straw handling sections. Both beater drum and peg drum types are in use. The peg drum types thresh the grain quite as cleanly and with as little damage to the grain as the beater drum types.

For handling the straw again two types are in use, a rotary system and the ordinary straw shaker type. The former is reputed to give better results in hilly land, but from what I have seen I think the shaker type riddles out more of the grain that has been carried over with the straw, and there is less loss of grain.

The 8 ft. size of machine is made to work off the power-take-off of a 20 h.p. tractor, and for larger sizes an auxiliary engine on the combine drives the cutting and threshing mechanism, and a tractor of 15 h.p. is suitable for the haulage. The larger machine has two engines, and a crew of three men, as against one engine and two men on the 8 ft. size, but I have formed the opinion that the greater flexibility of the larger machines more than repays the extra capital and working costs where the acreage is at all extensive.

Windrowing in America has largely extended the usefulness of the combine. In this system the crop is cut at the time when it would be ready for the binder and left for a few days in windrows 2 ft. to 3 ft. wide on the top of a high stubble, so that with wind passing freely through the windrows, weeds and unripe corn may wither and dry out. The combine with a pick-up attachment in place of a cutter-bar then goes over the field again and threshes the grain. Possibly influenced by two exceptionally wet harvests, I have formed the opinion that where a dryer is used, the windrower is an unnecessary expense, and I should prefer to leave the grain standing till fully ripe, and leave the dryer and dresser to dry the corn and make a good sample.

In weedy fields, or where clovers have been under-sown and some are cut with the corn, it is impossible to separate all green leaves and pieces of stem from the corn as it comes from the combine. This green trash carries much moisture, which is rapidly taken up by the corn, and may increase its moisture content by 5 or 6 per cent., and so would prevent safe storage. If a drying system is in use, this material is easily blown out as soon as it is dried. Up-standing crops of wheat cause little trouble and are easy to combine, but where barley is left till fully ripe some is sure to be storm broken, and the crop must be cut low to get as many heads as possible. This makes the cutting of a considerable amount of trash inevitable.

I think that while we are still in the transitional stage more attention is given to straw than will eventually be the case when our live stock management is adapted to power farming. We are still inclined to aim at obtaining the close binder stubble, whereas, as time goes on we shall aim at cutting as little straw as possible, and ploughing the remainder in direct. Cow keepers and poultry men are now finding peat moss litter a cheap substitute for straw.

Much green trash considerably delays combining. With up-standing crops of wheat I have on several occasions cut 18 acres in a day with a 10 ft. cutter-bar, but for barleys 11 to 14 acres has been a more average figure. In storm broken crops the least dampness in the straw makes it tough, and it does not readily slide up the long points, and is consequently pulled up by the roots and causes stoppages. The steep angle of the long points owing to the height of the cutter-bar is a detail that should be improved on the combines with which I am acquainted.

Grain Driers are, I feel, a necessary adjunct of the combine in this country, and Mr. Newman has dealt with these, but they should I think be designed to dry the full output of a combine at the same rate at which it is cut, and should have a capacity of 30-40 cwts. an hour. Drying and dressing for market should in my opinion, be one operation, and few barley samples come direct from the combine in a saleable condition, though wheat may do so. The tray drier, taking one ton lots of corn, and handling about 60 qrs. a day seems to me the most foolproof and cheapest in first cost, though it takes more labour than is the case of continuous process plants. Where a machine is in use for only 30 or 40 days a year, however, economy in operation may be counterbalanced by increased capital cost. The tray drier has the further advantage that it will dry other crops as well as grain.

As Mr. Newman says, the capacity of the combine harvester appears to be the chief factor in determining the most economical combination of land and power. A combine with a 10 ft. or 12 ft. cut should command 400 acres of grain crops under our conditions. This implies a total area of 600 acres of arable under the three year rotation, or 800 acres under a two year rotation. In harvest years like 1928 and 1929 the area commanded would be 50 per cent. greater.

In America it is stated that a farmer should not have more than 5 dollars an acre invested in machinery under Montana wheat conditions of half wheat and half fallows, and in some of the larger farms the figure is reduced to 3 dollars per acre.

There it is considered that a four-plough tractor (say the 20-25 h.p. sizes) can economically work up to 1,100 acres. This size tractor costs at present about £350. For plough, cultivator, disc harrows, harrows, drill, manure distributor, etc. we may allow a further £250. The combine harvester, dryer and dresser should not cost more than £550, so that the main items of our equipment should be available for about £1,100 to £1,200. This outfit would command 400 acres of corn and 200 acres of fallows on a three year rotation. For hay and straw, collecting implements, hoes for roots, etc., I am considering that the implements at present on the farm would suffice, and that a motor lorry can be hired for grain transport at harvest time.

In some quarters stress has been laid on the small size of English fields as being a hindrance to power farming. Large fields are no doubt preferable, but I can see no economic justification in the present stage of our knowledge for a wholesale grubbing up of hedges.

Rent, fuel, manures and seeds cost the same per acre whether fields are large or small. Labour forms but a small item of our total cost. Ploughing small fields in bouts with constant turning on the headlands is wasteful of time, but this may be got over by ploughing round and round the fields.

Where the combined harvester has to be dismantled and re-erected when changing from one field to another, a further loss of time takes place, but this can be measured in minutes. The chief loss is in keeping the fences trimmed, but fences are necessary where any live stock are to be kept, in a system of alternate husbandry, and although their care may cost us 2s. or 2s. 6d. an acre per annum, the expense is justified if their retention enables us to utilise for live stock, the area which would otherwise be bare fallow.

Another stumbling block in the way of mechanized equipment is its capital cost at a time when farmers' resources have been reduced to vanishing point. If I am right in my contention that £2 or so per acre is sufficient in fair-sized farms to provide the essential equipment, and that a saving of a similar amount per acre of corn grown can be obtained by this means, it appears to me that expenditure in this direction will be much more productive than a similar amount spent or locked up in live stock for winter feeding under the four-course system.

My advice is—sell some stock to buy a harvester, and save money to buy stock when meat shares in the 10 per cent. tariff.

LORD LYMINGTON (Farleigh Wallop) stressed the importance of Professor Watson's figures showing the relative importance of cereal as against live stock products in the total value of the output of Great Britain. He further added that the imports of live stock products into this country (which he said we are quite capable of producing ourselves) amounted to some £200,000,000 and these products, if produced at home could give employment to 500,000 people ; while the value of our imports of cereal products was only £100,000,000, no more than one-third of which we could produce for ourselves. Lord Lymington went on to say that if tendencies were to be judged in order to prophesy for the future, extra cereals for sale off the farm would probably be produced by mechanization with far less employment on the land than there is to-day. As far as his own experience on a mixed farm was concerned, and especially since his acquaintance with caterpillar tractors was of very recent date, he was not prepared to lay down any figures for costs. He had had no opportunity, and he believed very few other people had either, to ascertain the true amount to be charged for depreciation in the implements, and the regulation of overhead costs was by no means as simple as it seemed. In addition, the shape of the field played an absolutely essential part in the ascertaining of costs. For instance, he had found that the cost of ploughing a thirty acre field varied from 3s. 3d. to 6s. 1d. an acre ; the variation being due not only to the strength of the soil but to the amount of corners in any particular field. Until he had done accurate costings over some years he would not be prepared to give any figures based on a scientific valuation.

Another point he wished to emphasise was that mechanical farming is in the hands of a few pioneers some of whom rightly were intimately connected with implement makers and whose repair and depreciation accounts might therefore be greatly lessened. Also where people with considerable capital were doing a great deal in the way of experiment their costs might quite unconsciously be varied by a tendency to confuse experimental accounts with running costs. Therefore nothing was more misleading than to delve into the question of costs until these had been carried out accurately by practical farmers for some years. For this reason he made no excuse for going away from the engineering side of which he had very little experience in comparison with many others at the Conference, and making some remarks as to the general direction to which mechanization was leading.

For himself the introduction of mechanization for the production alone of cereals for sale off the farm seemed to be the magnum opus of antichrist. For this reason—that every nation in the world was lamenting that it had lost, or was tending to lose, the balance between industry and agriculture which was the fundamental root of the people's lives. As an extreme example he quoted the case of certain farming operations in Canada where the tractors came across the border in the Spring, ploughed up waste land in hundreds and thousands of acres, planted a crop, left the land uninhabited until the Autumn when combine harvesting machinery arrived, took the harvest and went away leaving the land again derelict until the following Spring. Thus, Lord Lymington said, if mechanization was going to serve the health as well as the pockets of the people, it must be capable of giving more rather than less occupation on the land. If Mr. Dudley's experiments, from which he had learned so much and to which he owed so many thanks, proved that mechanization, perhaps with the help of a wheat subsidy, was only going to develop the growing of cereals for sale off the farm, they would probably cost the Nation more than they were worth. If, however, they were part of the large whole and would enable us to produce more live stock, to save the imports and to give the employment he had envisaged at the beginning of his remarks, then with stability of imports and without raising the cost of living to an industrial population we could be assured of health and safety on the land.

Lord Lymington followed up this point by saying that he was not sure that the future of the combine harvester in this country—though it might be imminently useful for crops like malting barley—was going to be the mechanical development that would save English agriculture because of two things. First, the weather risks in which the crop had to grow from the winter sowing to autumn harvesting and the consequent tendency that the heavier your crop was, the more likely it was to be lodged : and secondly, the extra expense in bad weather of getting in the harvest as compared to the harvesting operations in the New World. And in addition to that in most circumstances the threshed grain required drying.

Therefore, Lord Lymington said, he would like to put the following problems as those demanding immediate mechanical solution for the health of the industry.

Our climate is not only capable of growing better live stock, but of producing more crops than almost any other in the world with the exception of New Zealand. Thus if, instead of long straw crops of which perhaps, three, in four years, was the maximum for which one could hope, implements could be developed which could be used throughout the summer for the purpose of harvesting all sorts of catch crops ; one would have a spread of the capital cost of the implement over the widest amount of working time combined with a large cropping possibility. It was a well-known scientific fact for instance that young grain of all sorts as well as young grass and lucerne at the height of 8-12 inches produced more fodder value for animals than did the harvested grain in the long straw. The land could be kept cleaner and one could average probably two crops a year instead of three crops in four years. This postulated a drying plant whose value for agricultural purposes would be incalculable. In the second place in connection with mechanized farming its only special value apart from the cheapness of production lay in its ability to limit casual labour, the least desirable of all forms of labour. Now animals, whether one milked mechanically or fed pigs by electricity, required personal attention and demanded special knowledge which is the foundation of agricultural lives and the basis of agricultural employment.

The business, therefore, was to get rid of casual labour in connection with the keeping of live stock and at the same time to ensure the production of a sufficient margin of food to keep the land stocked economically. Crop drying would supply the margin.

On the other side the problem of the dung cart and feeding remained. The essence of successful modern agriculture seemed to him to lie not in revolution but in the application of the old well tried practices to modern conditions. Thus the Hosier system of dairying would seem on first sight to be a revolution but it was in fact only the combination of milking out of doors, as Thomas Hardy described in "Tess of the d'Urbervilles," and using the methods of folding sheep on the land in order to make the animals do their own dung carting. In this connection he had seen outdoor milking without the folding, as is done in East Prussia by gathering the cattle into an enclosure before milking—a scheme almost identical in its aspects to the Hosier scheme : while in central France he had seen cattle folded and moved from day to day on the mountain side without the milking. It might well be that some combination of fixed yards for winter and movable dairies for summer would solve the difficulties of heavy ground. The old arable folded flock with all its attendant labour had probably gone for ever as he himself had found to his cost. On the other hand some development of the sheep folding system of quickly erected folds on lines of common sense, with breeds that could both fold and graze might still be a

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possibility. Similarly the organisation of arable pig farming was absolutely in its infancy as was also the question of making chickens spread their own droppings and keep healthy by moving continually over fresh ground.

He made no excuse for postulating these problems or for reiterating the necessity for these improvements to be accompanied by the assurance of national stability because without it the farmer may not be able to induce his bankers to give him credit to carry out the improvements.

In conclusion Lord Lymington said that he believed the ideal form of future agriculture would be one which any of our farming ancestors with sound instinct and adapted intelligence could return to carry out and even improve.

MR. C. S. ORWIN (Oxford).—I have listened to the papers and speeches to-day with the greatest interest. The work in progress at Rothamsted which Sir John Russell has described, is providing just that information which is needed for the guidance of those who are trying to maintain soil fertility by agents less expensive than farmyard manure. Mr. Newman and Mr. Nevile have given us their valuable experience of machinery technique, and Professor Watson has addressed himself to the very practical question of the extent to which the everyday mixed farmer can take advantage of this technique without involving himself in revolutionary changes of practice.

Professor Watson's paper is timely because the best-known examples of power farming, whether on plough land or on grass, demonstrate an entirely new farming technique, evolved by its exponents for exploiting to the full the means to lower production costs afforded by mechanical equipment. Thus, we know of Mr. Nevile's and Mr. Dudley's new crop husbandry, and Mr. Hosier's milk production system is even better known. But it will be a long time before any considerable proportion of farmers in the corn-growing counties, or in the dairying districts of the south, will be so completely mechanized.

But while doing what we can for this predominant class of the farming community, we must remember that in districts and on types of farming to which the new power machines are applicable, all attempts to graft the new methods on the old should be regarded only as an expedient, as the first step in the evolution of power farming. Sir John Russell indicated quite clearly that he is thinking of new technique for farming by mechanical power, in his work at Rothamsted, and Mr. Nevile had clearly the same idea in his mind when he told us that " the four-course rotation is done."

Now what I want to suggest is that side by side with the study of engineering problems and of soil physics problems, there is need for the study of the farm management problem under mechanical labour systems. All our existing farming systems are based upon the speed and the capacity of the horse ; all the operations of the farm are controlled by the fact that the horse can only walk at the rate of $2\frac{1}{2}$ miles an hour and work for an eight-hour day. At the same time, he must be fed and cared for, work or play. And so was evolved the magnificent farm routine which has served the farmer so well for countless generations, by which the work of the farm was spread evenly over the seasons, involving the cultivation of crops of all sorts, each in due season—some for man and some for stock to be returned to the land as dung. Only by such a system was it possible to give economical employment to the only available form of power—the horse.

But surely mechanical power, independent of rest, independent of daylight, costing nothing when idle, and making the farmer for the first time virtually independent of the weather, must have altered the whole approach to economic farming. The farmer for the first time can take short cuts, and freed from these restrictive influences, can set himself to evolve a power-farming technique adapted to the new conditions, which will mark an advance in economic production from the land as great as that which must have marked the substitution of bullock and horse teams for manual labour.

The technical problems of farm organisation under the new conditions call for the fullest consideration if the maximum advantage is to be derived, and it is along this line that the work of the pioneers we have heard to-day is so valuable. Some of them have confined their efforts to the economical production of particular commodities—corn crops or milk—but though intense specialisation of this kind is possible, and probably profitable, it must not be thought that mechanized farming necessitates concentration on one commodity if the best results are to be secured. Others here to-day, Lord Lymington and Mr. A. H. Brown produce both animal and crop products, and much more work is needed before we shall know what are the greatest possibilities and what are the limitations of the application of power to farming.

Mr. A. H. Brown (Hayling Island) emphasised the fact that corn growers were faced with two alternatives, either they must give up corn growing, or reduce the cost of production. There were, he pointed out, several ways of reducing costs. One was to increase the yield by better cultivation and more intelligent manuring, then to mechanize all operations whenever such a procedure was practicable. Mechanization would entail reduction in both horse and man labour. It should also mean the cutting and grubbing up of hedges, so that fields could be thrown together for the purpose of large area cultivation.

With fewer men, it would be possible to pay higher wages, and higher wages would attract a more intelligent type of worker on the land. It was certain that the cutting of wages would not produce this.

The Rothamsted experiments he continued had proved to him that corn could be grown continuously with the use of artificials only. He had applied that knowledge to his own farm with considerable success.

In 1913 he set aside a field to be cropped without the use of dung or sheep. In 1914 the yield of spring oats from the field amounted to 2½ sacks. The following year it was bare fallowed: but from then onwards it has been cropped every year with a succession of crops—no particular rotation being followed. The yield of corn averaged 6 quarters of wheat and 8 to 10 quarters of oats. Three white straw crops have frequently been taken in succession and sometimes four or five.

It was at the present time, continued Mr. Brown, an easy matter to keep land clean. This could be accomplished by the intelligent use of tractors after harvest. Clean land was, of course, the basis of good farming and good crops. Badly or half-cultivated land would not grow good crops even if one were foolish enough to manure it heavily.

He maintained that the small farmer would be wise to leave corn growing to the large farmer and the foreigner and to concentrate his capital and capabilities on something that would give a larger turnover. He did not see how 50 acres of corn could be made to pay any money. Neither did he believe that cereals would rise or be fixed at some fancy price. Even if corn were stabilised it was very doubtful if the Nation would long continue to foster the inefficient corn grower, for that was what a subsidised price would mean. Even with corn at 40s. a quarter, a 5-quarter yield only gives £10 for the corn. How many small farmers can get their costs below £10 an acre, and how many can obtain an average of 5 quarters? But he believed the large farmer could get his costs nearer £5 than £10 and also average 5 quarters per acre.

Mr. Brown summed up his remarks as follows:

(1) That any land that is worth keeping under the plough can be made to grow good crops indefinitely with the use of artificial fertilisers alone, provided it is given good cultivation and intelligent manuring.

(2) That such a method is more economic than using either the dung cart or the sheepfold. For many years he had believed that arable sheepfolding and yard fattening bullocks merely for the purpose of obtaining manure was economically wrong. If, as in his case, dung was produced as a bye-product, then it had to be used.

(3) Land farmed in the way he had indicated would definitely increase in fertility.

Mr. E. D. Wolton (Norfolk).—All the previous speakers have dealt with mechanization as applied to large areas of land and I think 300 acres of arable was the smallest extent mentioned. They have also spoken in detail about the combine harvester and in short considered the subject on a large scale. But this aspect is not of much use to the average small farmer farming about 150 acres and in my talk I should like to dwell on mechanization as applied to the small farmer who cannot possibly mechanize on the combine harvester scale. Unfortunately the terms " mechanization " and " combine harvester " seem to have become inseparable and when one is mentioned the other invariably follows, with the result that the small farmer is inclined to think that mechanization is totally unattainable for him. He sees photographs of tractors ploughing six furrows at a time, drawing three drills and harrowing in one day more than the acreage of his whole farm, and all these new developments depress him. I hope to prove that the small farmer having about 150 acres, half of which is arable, need not fear this new development and that mechanizing his farm should be of equal advantage to him as to the large scale farmer. In the days of horses the small farmer could not really compete with the large farmer in the production of corn but somehow he managed to get a living and I contend that if he mechanizes he can regain his former relative position.

It is said by many farmers that owing to small fields it is impossible to mechanize on small farms. I should like to point out that the low-powered tractor will always take two furrows as against one furrow with horses and therefore with a tractor there is only half the turning. Also the fact that however little way a horse ploughs, whenever it turns round it always has a breather, and be as strict as you like, it is impossible to prevent the horses and men ceasing work for a time. A tractor, however, never has a rest and these reasons prove that a tractor ploughing a small field is certainly not at a disadvantage compared with horses.

It seems obvious to me that the small farmer who relies on horses for power is doomed. He may hang on by reducing his standard of living and working from dawn to dark, but this course does not allow him to live as life should be lived, as he has become a slave. The small farmer who refuses to make his conditions of work worse than a labourer goes bankrupt. Horse power cannot possibly compete with a tractor which :

(1) Does the work of at least three men and six horses.

(2) Ploughs all day—and night if necessary—by working in reliefs, and so takes full advantage of favourable weather.

(3) Always has ample power available.

Also the whole urge of the horse plough-man is to go home. He and his horses get tired walking all day and the latter are even more eager to get home than he is. When he gets home he has to pump them water, feed and groom them and so naturally he wants to get home early and so is reluctant to take advantage of favourable weather and keep on with his work. The tractor man, however, sits all day and so does not get so tired and as soon as he finishes his work, he can go straight home.

Tractors have flexibility and adaptability to circumstances but

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horses usually work the same hours whether the weather is good or bad.

Another advantage of a tractor over horses is that if a tractor breaks a part it is usually available in a few days. If a horse breaks a leg, it is a complete loss.

In addition to these great advantages there are others less obvious but by no means less important, which should be taken into account. The mere fact that the tractor man rides and a horseman walks, gives the former a superiority complex and this combined with the fact that riding is much less tiring than walking spurs him on to greater efforts and there is never any trouble about working overtime. This superiority complex is an asset which cannot be valued high enough.

Then there is the psychological factor that the tractor engine is always turning over at a fast rhythm and this does subconsciously impel the tractor man to get on as fast as he can so as to be in harmony with the tractor. The tractor urges its driver on but the influence of horses is to retard the ploughman. Speed to a tractor man is a joy—to the horseman an effort.

I do not consider that small farmers should attempt to copy the large scale methods of mechanization but should adapt their present systems of farming to the needs of the tractor. Thus it would be advisable to drill as much corn as possible in the autumn before the land gets wet and while the tractor can get about easily. They must alter their whole conception of the tractor as supplementary to horses, and realise that the tractor must be the main source of power, with a horse or pair of horses to supplement it. The tractor must be first and horses last. By adapting—not discarding—their present systems of farming to the tractor small farmers can keep to their traditional mixed farming and there would be no revolutionary changes, with their consequent problems to solve, such as farming without stock, difficulties of keeping up fertility, disposing of straw, etc.

To illustrate the lines on which I suggest small farmers should proceed I will relate how I have adapted mechanization to suit my own farm which consists of 150 acres of heavy land, half of which is arable. My Fordson tractor—

(1) Ploughs all the land including opening and shutting furrows.
(2) Cultivates and also breaks down for seeding all land.
*(3) Drills and rolls (or harrows) in one operation.
(4) Rolls and harrows all land in one operation.
(5) Draws the mower and so cuts all hay.
*(6) Cocks the hay.
*(7) Loads all hay by pulling wagon and hay loader.
*(8) Draws all full loads at haysel and harvest to hard road.
(9) Draws the binder and so cuts all corn.
(10) Grinds my corn.
*(11) In conjunction with a neighbour's does my mole draining.

**Notes*

(3) When drilling, a man sits on a platform fastened to the back of the drill, it would be impossible for him to keep up with the tractor if he had to walk.

(6) The cocking machine draws the hay from the rows into large high heaps and these just need putting into shape by hand.

(7) All my wagons have frameworks fitted by means of bolts all the way round, at the sides these come out one foot beyond the usual edge. The front and back frameworks are joined on to the usual ladders at an almost perpendicular angle. From the tops of the front and back frameworks, stays come down to the centre of the bottom of the side frameworks and this leaves a space in the middle of the sides of the wagon unframed, this is for unloading hay, loading and unloading sheaves of corn. The effect of the frameworks is to make the capacity of the wagon very large and to obviate all necessity of careful loading and to avoid waste of time roping. The hay loader is fastened behind the wagon and the tractor draws them both along the row. The hay comes up at such a rate that it is all the two men in the wagon can do to get rid of it. (I do not use a sweep as my meadows are too small). In harvest the frameworks save one man, as one man in the wagon can deal with two men pitching when he does not have to mind how he loads. When there are only two men they can both pitch and make a good load without either of them getting in.

(8) If there are hills or if there is no time to spare the tractor can bring the full wagons to the hard road very much quicker than horses. There is an attachment which is fastened in a few seconds to the shafts and then to the tractor so there is no time wasted changing shafts.

(11) Where the drains were to go, I ploughed as deep as I could Then my neighbour came with his tractor and mole drainer and by fastening both tractors to the drainer and by driving them tandem we were able to drain to a total depth of 18-20 inches. He did two days at my farm and I did two days at his and it cost us nothing except fuel as we did not charge each other.

I find that every spring I can clean half my foul land in time to drill it with barley. The other half I grow with winter tares or another cleaning crop and pull the land about after the crop has been taken off thus through mechanizing I avoid all long fallows and take a crop off each field each year and so benefit in cash.

Now that I have stated what my tractor does I think everyone must be convinced that there is ample work for a tractor on a small farm.

Not only should the small farmer benefit from mechanization but he has the following advantages over the large mechanized farmer :

(1) If his tractor breaks down he normally has two horse sand these can be used and so he has an alternative source of power.

(2) His system is flexible and can be adapted to new conditions easier than the purely mechanized farm. All his eggs are not in the basket of corn production and live stock will always have a place. If oil rose to a prohibitive price he could easily change back to horses.

To sum up :

(1) By mechanizing, the small farmer can put himself in the same relative position to the large farmer as he used to hold before mechanization.

(2) He must mechanize on his own lines and not necessarily copy large scale mechanization.

(3) Mechanization extends the size of farm which can be run as a family farm.

(4) Tractor power is progress and if adapted by the small farmer to his needs should be his salvation.

For these reasons I consider that mechanization should be of at least equal advantages to the small farmer as to the big and that the small farmer has nothing to fear, but everything to gain, from mechanization.

Mr. R. Dudley (Andover).—I am in entire agreement with all that Mr. Nevile has said with reference to the use of the combine harvester. On the question of windrowing grain I have tried this and given it up in favour of direct combining " once over, all over " *provided one has an efficient dryer*. My reason for this is that in this climate the risk of a heavy crop of grain (for we must grow heavy crops if they are to pay) lying in the windrow is too great to be taken. The grain has in any case to be treated at the farm and it can therefore be winnowed to take out the thistle heads, poppy heads and broken pieces of weed and straw before being passed through the dryer.

On the general question of cereal production it has now been proved that we can produce, by the aid of modern machinery grain of the highest quality almost independent of the weather hitherto our greatest bugbear. Machinery too can enormously add to the production of feeding stuffs for live stock.

We have then on our own doorstep the very market that our manufacturers are searching the world for in vain, a market of at least £200 millions, if the Government would only see that measures are taken whereby the wholesale prices are made remunerative. This would not necessarily mean that the retail prices should rise.

It must never be forgotten that almost every item of cost on a farm is fixed by Parliament, wages, tithe and even a tax on the most efficient fuel we have for cultivation on the mechanized farm, viz., petrol.

It would therefore seem but elementary justice that competition should be placed on a fair basis by making the foreign product bear the cash equivalent of exactly the same burden as is inflicted by the State on the home product, no more but no less.

Sir R. Greig (Dept. of Agriculture, Scotland).—In my view the development of the internal combustion engine along with the possible utilisation of electricity is opening up a new era in the technique of agriculture. Great advances have been made in the last ten years in the application of the motor tractor to cultivation, and some other operations on the farm. Several cultivations can now be carried out in one operation, and there is no reason to believe that further adjustments between power and its application will not be made. The first obvious use of power traction is in the sphere of large-scale cultivation. But the possibilities are far from ending there. A motor can be any size, placed in any position, and worked under almost any circumstances. It is a matter of time and experiment to ascertain its further uses. The main point is that while steam engines made a radical change in the methods of the industrialist and but little change to the farmer, the internal combustion engine now enables the farmer greatly to increase the power of a man and the workability of the land.

The new possibilities involve a new technique or new methods or adjustments in agricultural practice. The new methods will be profitable if they reduce costs and increase output. This may involve reduction of labour if large scale mechanization is the sole outcome. But is the story ended here? That depends upon the ability of the present-day farmer to increase the output of a man's labour not only in large scale operations but in so-called intensive and mixed farming. By far the larger part of the country is unsuitable for large grain farms. It is on this larger part that new methods must be tried. If they succeed through the application of power units, not fewer but more men may be employed. Heavy clay land now all in grass may be brought into profitable mixed farming. The turnip and mangold may be out of date and other forage crops capable of machine handling may take their place. In any event it is not necessary to assume that the mechanization of agriculture means only large scale cultivations.

Since the war the productive efficiency of a man has greatly increased in most industries. In some industries this efficiency has increased 100 per cent. In agriculture it is understood to have increased about 50 per cent., but if by the use of power and changed methods the efficiency of a farm worker can be doubled, there is a possibility of employing more labourers, for the following reasons.

The British home market is practically unlimited. If by the use of power units and a new technique the cost of production of a gallon of milk, a ton of silage, a cwt. of beef, mutton or pork, can be reduced, then it will be possible greatly to develop much of the land now in grass or on the margin of cultivation. Such development will be likely to maintain, if not to increase, employment on the land. Progress in that direction will depend upon (a) further experiments upon the use of power units from 100 horse power downwards, (b) the invention of power machines for drilling and harvesting or collecting forage crops, (c) the advantages of the artificial drying of forage crops, and (d) the possibility of making new adjustments as between crop and stock and the development of a technique for the purpose.

Dr. B. A. Keen (Rothamsted).—Mr. Newman's paper was naturally mainly confined to the engineering aspects of mechanization, and I am glad that some of the subsequent speakers directed their remarks towards the practical field problems connected with the use of mechanized implements and farm machinery.

There is a tendency to regard the problem as primarily that of the replacement of the horse by some suitable form of mechanical or electric power; so far as haulage, elevating machines, and the general class of barn machinery are concerned this is true, but in the matter of cultivation implements, it is only part of the problem, and probably not the most important part. For this class the real problems are the following: (1) whether the essential agricultural features of the present horse-drawn implements (i.e., the design of those portions entering the soil) are still substantially correct for power-drawn models, and (2) whether some radical departure in design should be made, such as rotary cultivation or, alternatively, the combination, on one frame, of implements which are at present used separately.

The final answers to these questions cannot be expected at once, because they hinge on first answering the question of exactly what effect on the soil is produced by our cultivation implements. We know, in a general way, that the object is to produce a tilth, and we can recognise a tilth when we see it. We recognise, further, that one part of the action of an implement is to break down, or to refine, the large lumps of soil into smaller ones. But that is about as far as our empirical knowledge goes. We cannot predict, for example, what will be the effect on the final tilth of the initial operation if ploughing is performed at a speed of 4 m.p.h. instead of the 2-2½ m.p.h. customary with the horse-drawn implement. The study of cultivation implements with special reference to the result of their work on the soil, and on the subsequent growth of the crop has therefore been carried on at Rothamsted for some years past.

We have shown by dynamometer measurements of soil resistance that, for any given implement, the force necessary to draw it through the soil is but little affected by the speed of travel. In the case of ploughing, an increase of speed from 2½ to 4 m.p.h. resulted in only

7 per cent. increase in draught. This is a very important result. In the design of any implement, the agricultural engineer has to balance as far as possible a number of conflicting requirements and, but for the result just mentioned, he would certainly have assumed that the draught increased greatly with increased speed, with the result that he would have decided on a smaller and more robustly built implement than the circumstances warranted. The conclusion is of general application ; it means that the development of the tractor and of power-drawn implements should aim at the highest possible speed consistent with mechanical reliability. The need for increased speed of work, on both climatic and economic grounds, is now generally recognised, and it is fortunate that one possible objection to it has been shown to be without real foundation.

Our field experiments at Rothamsted have shown the predominant effect of season on tilth in medium heavy soil. The conventional range of horse implements is unable to do more than mitigate the ill effect of bad weather. Thus in one series of experiments in which a bad season for cultivation followed a good one, the most efficient implement produced a worse tilth in the bad season than the least efficient implement in the good season. It is not far wrong to say that if the autumn and winter climate has been suitable, then almost any tool will produce a good tilth. This conclusion stresses the need for a close study of the possible improvements in cultivation methods, since on the average we can only count on about one favourable season in three.

Mechanization does offer such possibilities : greater power and speed enable us to work the soil more vigorously and in particular to do several operations at once. Our experiments have shown that there is a greater latitude in the times and methods of cultivating medium heavy soils than is generally supposed. In particular, the stages of producing a tilth can frequently be telescoped into one operation by hitching implements in tandem, or in series, behind the tractor. Cultivators, harrows, and rollers have been used by us in this way with success, and with no detriment whatever to the yield as compared with the orthodox methods. There is much scope here for implement designers to produce compact and easily assembled units for these combined operations, thus avoiding the present clumsy necessity of hitching existing implements in a long train behind the tractor.

The range of disc implements merits greater use with tractors. They are unequalled in their ability to " force " a tilth in difficult conditions although, in passing, it may be mentioned that our experiments have shown the ridging or bouting plough to be surprisingly effective in this direction. Disc implements admittedly leave the work in a rough condition, and there is some prejudice on this count, especially against the so-called disc-plough. But the preference for the smooth, well set-up, and nearly unbroken furrow is gradually fading ; provided the land is left well ridged and with plenty of large lumps (and the disc plough can easily be set to

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secure this) the danger of beating down under bad weather to an unkindly condition is no greater than in the case of the smooth furrow slice and, in addition, the subsequent cultivations are much easier and more immediately effective.

On the question of entirely new departures in implements suitable for power, rotary cultivation has received much attention. It is now well established in market-garden and orchard work, and attempts are being made to introduce it into ordinary arable farming, with more or less success. The primary claim is that it will produce a seed-bed in one operation and thus appreciably reduce the costs of these operations as at present carried out. We have made extensive experiments at Rothamsted over a number of years on the production of spring seed-beds, on autumn-ploughed land, using rotary cultivation in comparison with horse and tractor implements. In every case the rotary-tilled seed-bed gave better and quicker seed germination, and superior early growth of the plant. But, also in every case, the early advantage was completely lost as growth proceeded, until at harvest the rotary-tilled plots were no better, and often worse, than the others. This effect was traced to the form of tilth produced by rotary cultivation. It is not a finer tilth than that secured by the usual methods, but is much looser or "fluffy." Subsequently, it settles appreciably, to the detriment of the well-developed root system which the earlier and looser tilth had encouraged. Another contributory factor is the heavier growth of weeds on the rotary cultivated plots. The thorough mixing of the soil produced by rotary cultivation also implies that the weed seeds are distributed throughout the full depth of cultivation ; this factor results in the survival and active growth of many weeds that would otherwise have been destroyed or rendered innocuous in the normal cultivation operations.

These two factors—the ultimate loss of the initial superiority in early growth, and the trouble with weeds—are serious disadvantages, but the difficulty of avoiding them is probably not insuperable. They constitute, of course, the main obstacle in the replacement of traditional cultivation tools and methods by a single machine producing a seed-bed in one operation. A second obstacle is the problem of using rotary cultivation instead of the plough for autumn and winter work. Our experiments indicate that a rotary cultivator with a ridging attachment behind it may solve this problem. If this is borne out by further trials, and if the two difficulties already mentioned connected with its use for spring work can be overcome, then there will be full justification for the claim that the extensive range of cultivation implements and the detailed and numerous operations at present required to produce a tilth, can be replaced by the much simpler equipment and the greatly reduced number of operations characterising rotary cultivation. Then the saving in implements and labour, and the ability to make full use of suitable weather in a difficult season, would certainly make rotary cultivation one of the triumphs of mechanized farming.

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