ROTHAMSTED RESEARCH

Mechanization and British Agriculture

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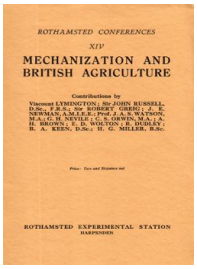

Engineering Devlopments and Possibilities

J. E. Newman

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ENGINEERING DEVELOPMENTS AND POSSIBILITIES

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The cultivation of the soil and the gathering of crops require the expenditure of power. Power is measured by engineers in foot lb. per minute. A man can continuously exert 3,300 ft. lb. per min. A tractor developing 20 draw-bar horse power exerts 660,000 ft. lb. per min., that is, the man seated on the tractor has two hundred times the effective power that he would have if he worked with his own muscles.

There is the fundamental reason why agriculture is being mechanized. Just as the development of the petrol engine has made flying possible and the motor-car what it is to-day, so it has made the farm tractor an efficient and dependable machine, far more powerful and lighter in proportion to its power than it used to be. The fitting of air and oil cleaners, of large filters in the fuel supply, and of impulse starters, together with the general improvement in construction and engineering details which it shares with its cousin the motor-car, has made the tractor of to-day as different from most of those of the period just after the War as is the car of to-day from one eligible for the old crocks' race to Brighton.

Taking actual figures, in 1920, eighteen tractors were tested at the Nebraska Testing Station (and I think that the beneficial influence the Nebraska testing scheme has had on tractor design can hardly be over-estimated): their average weight was 448 lb. per D.B.H.P. At the Ardington trials in 1930, the nine paraffin tractors tested averaged 220 lb. per D.B.H.P. and the lightest tractor in proportion to its power, the Case L, weighed 158 lb. for each D.B.H.P. it could develop.

Those are big advances in ten years, but the advance in wearing powers, in expectation of life, in freedom from irritating minor troubles, in all-round handiness, in short, in general reliability, is much greater.

There is now quite a large number of makes from which to choose. Of makes which are being sold (I am not counting those, either home or foreign made, which no effort is being made to market), there are five tractors which develop 10 to 15 h.p. in the draw-bar, six which develop 15 to 20, and six more which develop 20 to 25.

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Twenty D.B.H.P. hours are required to plough an acre of average land 5 in. deep, so that as a rough working rule the big tractors will plough an acre, the medium ones three-quarters, and the small machines half an acre an hour.

Just as the tractor is developing, so are implements to use with it being evolved. At first the tractor was simply used to pull implements designed for horses. Such implements could not be expected to make the most of the tractor's power. As Mr. Dudley said recently, "So long as you try to use a tractor as a mechanized horse, you will get nowhere." Now implements designed primarily to work with tractors are coming on the market. Thus there are drills 17 feet wide (in America drills up to 28 feet wide are used), there are rollers 26 feet wide, cultivators 16 feet wide, harrows 32 feet wide and so on; 4 and 5 furrow ploughs are becoming common.

Using such implements one man can plough an acre or more an hour, he can cultivate 50 acres a day and harrow 700 acres in a week; with another to help fill the seed box he can drill 7 acres an hour and spread fertilisers over 6 acres in an hour. And the daily rates can be doubled by night work, if necessary. All these things have been, and are being, done in England.

Such performances are so far removed from the ordinary ideas of rates of working, that they necessitate a fresh viewpoint, particularly when the cost of doing these things is considered. If the speeds are high, the costs are low.

On a farm equipped with such implements, 275 acres have been ploughed and planted this autumn in six weeks. The cost for fuel and labour was 7s. per acre, or, including depreciation 11s. per acre, and including the seed 20s. 6d. per acre. There were two men besides the farmer himself, one tractor, a 20 h.p. Caterpillar, all the time, and a Fordson part of the time. The land was medium loam, on the stiff side. There were no horses.

On Mr. Dudley's farm 58 acres were fallowed last year, half of it bare-fallowed and half bastard fallowed after a clover crop. All the work was done by his two 15 h.p. Caterpillar tractors. The clover portion had three one-way disc ploughings and a heavy harrowing, the other half was gone over ten times with disc ploughs, cultivators, pitch-pole harrows and ordinary flexible harrows and finally the whole lot was ploughed with mouldboard ploughs. The cost for fuel and labour was £37 8s. 6d.

Messrs. Alley Bros., on their farm in Norfolk last year, fallowed 550 acres, using two 20 h.p. Caterpillar tractors. These fallows were, considering the season, quite good; they were all sown with mustard which was ploughed in. Messrs. Alley have drilled 580 acres of wheat and propose to drill 100 to 150 acres of barley. I am not able to give their costs, but all their work, with the exception of some extra labour at harvest and the considerable amount they do themselves, has been done by a staff of four. Their tractors worked a little over 3,000 hours each in the year, which means that they consumed around 12,000 gallons of petrol, or 12 gallons per

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arable acre of their farm. This amount is higher, owing to the exceptionally large fallow acreage and the continual bad weather, than it should be in future years.

Take such figures and facts by themselves, and obviously they put a different complexion on corn growing in England, either with or without the combine.

It is perhaps worth while to give a list of the machinery required for a specialised cereal farm. Its size—the ideal size—is determined by the acreage which can be cut by a combine. On such a farm it will only be required to cut as much straw as is necessary to secure all the grain. Short and stiff strawed varieties will be planted. Under these circumstances 20 to 30 acres per day of 8 hours can be cut. As every effort will be made to spread out the harvesting period, there should be no difficulty in harvesting 250 to 400 acres with a single machine, according to its size. If it is proposed to work on a system of three years' cropping and one year fallow, then the acreage required is 330 to 500. Besides the combine, there will be required a tractor and plough, a cultivator to correspond, big harrows—the flexible type is best for tractor work, a drill either with or without fertiliser attachment—if without, a manure drill is required as well. A motor lorry is a necessity and so is a winnower and a grain dryer. That is the bare minimum.

For the 330 acre farm the implements would cost £1,500.

For the larger acreage, it would be advisable, and economical, to have a second smaller tractor to haul the drill and harrows.

The cost, including these extras, would be £2,000 to £2,500 or £4 to £5 per acre.

If bigger acreages are contemplated, the cost per acre falls off considerably. In fact, a 1,000 or 1,200 acre farm would not require an expenditure of more than £3,000.

These figures are subject to variation ; heavy land would require more tractor power. Fuel consumption would not exceed 6-10 gallons per acre, according to the class of soil. Yields may be expected to be at least as high as those prevailing in the district for land farmed in the ordinary way. So far, experience is that the deeper and more thorough cultivations, and perhaps the greater ability to do the various jobs at the proper time, which is a result of the speed at which they can be done, has produced crops above normal. Last year, Messrs. Alley had over 40 bushels of wheat per acre from a 105-acre field, and Mr. Dudley had 40 bushels of wheat from one field, and averaged 32. Mr. Nevile's barley averaged 32 bushels.

To deal with the combines. It is not generally realised how recent and how rapid has been the spread of the combine in Canada and the Great Plains west of the Mississippi. In the three Prairie Provinces of Canada there were only four combines in 1924, now there are over 9,000. Kansas had 3,800 combines in 1925, now it has nearly 30,000. Soviet Russia's grain growing plans are based on the use of combines and tractors. The two great factories of Saratov and Novo-Siberik are planned to turn out 35,000 combines per year.

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The combine cuts out seasonal labour for harvesting. With means available, for drying the grain, its use is perfectly practicable in England, and the combination makes our climate an advantage instead of a handicap to the grain grower.

We can use the same machinery as is used overseas and we can, thanks to our climate, grow bigger crops. The dogma that we are incapable of growing more than a small fraction of our wheat requirements can be challenged.

The length of our straw is the greatest difficulty which combines have to face. If wheat growing extends in this country, the straw question will not be of such importance, as the market for straw is not capable of absorbing much more than it does now. Straw, however, can be handled in various ways. In the past harvest most of the machines left the straw in windrows, from which it was subsequently gathered by hay sweeps or hay loaders. One machine used a straw dumping attachment which left the straw in cocks, about the size of stooks. These were later loaded on to wagons by hand. Another machine used a straw spreading attachment. In this case, the straw was afterwards ploughed in or burned. Where sweeps were used, the straw was either ricked or swept straight to a baler. The adoption of a particular method has depended on local conditions, such as the machinery and labour available, whether the straw was to be consumed or sold, and the lay-out of the farm.

When the travelling baler, which moves along the windrows and bales the straw as it goes, is obtainable in this country, another way of handling the straw will be available.

The baled straw from the combine has been sold at the same price as baled straw threshed out in the ordinary way.

Combines are generally, however, unable to deal with straw over 3 feet or 3 feet 6 inches in length, unless they leave a long stubble or go very slowly. There are no inherent reasons why combines able to deal with longer straw should not be built and Messrs. Clayton & Shuttleworth's combine can do so.

However, the less straw is cut the more acres per hour the combine can do, and whether it will pay to cut all the straw and work more slowly, depends on the relative value of straw and grain. At present, in districts which grow long straw, and where straw commands a big price, those who wish to make the most of it should use binders. Where the straw does not grow so long, the combine user can bale and sell or use his straw just as does the man who harvests in the ordinary way.

One reason why some of the combines are unable to handle long straw is that the platform canvas is too narrow; 36 inches is a standard size and some are only 30 inches wide. Consequently straw over that length cannot lie on the canvas. Bigger canvases present no constructional difficulties, nor should it be difficult to fit binder type beaters to combines, at any rate, for cuts up to 10 feet. They would be more efficient than the type now fitted, which can only be adjusted with a spanner when the machine is

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stationary. And a 10 feet cut is, in my experience, wide enough to keep any combine busy in a respectable crop. If the combine is travelling at 3 miles per hour, and averaging a 9 feet cut, it will, allowing for corners, cut 3 acres per hour. In a 40 bushel crop it would turn out 30 sacks in the hour. It could not do more if it had a wider cut; it would only have to be pulled more slowly. The International Harvester Company's new small combine is to have 5 feet and 7 feet cuts and a binder type platform and beaters.

There is the possibility that the future English combine may be a breakaway from present practice, possibly a push combine with cutter bar 5 feet wide and a drum of the same width straight behind it. The platform canvas would run from the cutter bar straight back to the drum mouth. Shakers and riddles would be the full width of the drum. There would be no canvas troubles, laid crops would cause a minimum of inconvenience, the feeding would be absolutely regular over the full width of the drum, and the straw and chaff would be spread out evenly and thinly on the shakers and riddles.

Drying grain is not really a difficult matter. The bare facts are that wheat will keep safely in sacks if it has 16 per cent. moisture or less, and in bulk if it has under 14.2 per cent. It will keep for a few days—long enough to send it to the miller—if it has 19 per cent. or 20 per cent. Ripe standing grain dries very quickly in sun and wind, 1 per cent. per hour is not an unusual figure. I am speaking of the removal of moisture due to rain or atmospheric conditions. Wheat may be 14 per cent. moisture one afternoon and 18 per cent. at 9 o'clock the next morning and down to 14 per cent. again or lower by the following afternoon. Wheat can be combined when its moisture content is as high as 30 per cent. In the ordinary way, however, the dryer is not likely to have to remove more than 6 to 8 per cent. and the bulk of the drying will involve removing only 3 to 4 per cent.

The dryers used by most of those who work combines are really much the same as the old kiln dryers, but the grain is only 5 inches deep and the air is driven through it by forced draught. The layers of grain may be vertical instead of horizontal—that is 5 inches thick instead of 5 inches deep; the principle is the same. In the dryer made by Messrs. Turner, and in the Sugar Beet and Crop Driers' conveyor dryer, the grain is continuously discharged, whereas in the home-made dryers (except one of Mr. Nevile's) the batch system is used. The latter are the cheapest in first cost and the former should be slightly more economical in fuel. These dryers handle from 1 to 2 tons of grain per hour, according to the moisture content. A 5 to 8 h.p. engine will drive the fan; and the furnace which heats the air consumes from 30 to 50 lb. of coke per ton of grain dried.

In planning an outfit, I think that if the dryer is capable of dealing with grain at half the normal hourly rate of the output of the combine, that is sufficient. In continued fine weather, when

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the combine can work long hours, the grain will need little drying; in wet weather, when it wants more drying, the combine works only short hours.

It would not be right to leave the subject of corn growing without saying that the tractor binder, which can have its levers arranged so that the tractor driver can work them, and is operated by the power take-off from the tractor, is a great advance on the ordinary binder. It does not slip on wet ground, its wheels and the wheels of the tractor pulling it mark such ground less, and heavy crops are tackled more easily. Low bodied harvest wagons, such as are used by Mr. Hosier, are another means of obtaining economy. A load can be got on to them very quickly.

To return to the tractor, one of the outstanding questions is that of the relative merits of crawler or caterpillar tracks and of wheels. How far the advantages of tracks over wheels are worth their extra cost I hope the survey of mechanized farms, which the Institute for Research in Agricultural Engineering is carrying out, will be able to tell us in due course. The wear of Caterpillar tracks depends very much on the soil they are working on. On flinty or sandy soils it is heavy and fortunately it is on those soils that they are least needed; on the really heavy clay soils on which I should always choose to use them in preference to a wheeled tractor, if only because on such land they can be worked on many more days in the year, their wear is not excessive.

In one particular instance, on a soil rather on the light and abrasive side, tracks have done 3,000 hours' work before their pins needed turning, and their total life should be about 5,000 hours. On a clay soil I should expect their life to be 8,000 to 10,000 hours.

A combination of a big wheeled tractor and a small Caterpillar is in some cases a very useful compromise. The wheeled tractor will do the ploughing and heavy work, the small Caterpillar will do drilling, harrowing, manure distributing, and so on. It will be economical in fuel and there is no question of any damage to the soil or the crops. Spring corn can be drilled earlier than with horses. On the question of the padding of the soil, which used to figure so prominently in all discussions on tractors, it may be worth while pointing out that whereas a two furrow tractor pads half the ground it ploughs, a four furrow tractor pads only one-quarter. And when a tractor is pulling harrows 32 feet wide, the two feet it runs on are of relatively small importance, whether the tracks do harm or, as Mr. Davies' work at Wye suggests—and we have had similar experiences in our observation—good.

It is not certain that wheels are in their final stage of evolution. Spuds have, except on the product of that staunch conservative, Mr. Henry Ford, supplanted strakes. They pad the soil less. A wheel which will grip on stubble or on ground already worked, and which will run on the ordinary farm road or on grass without damaging them or shaking the tractor about, is wanted, particularly for the

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smaller tractors and the smaller farms. Some form of skeleton wheel should meet the case, or we may come to changing the wheels as necessary.

Before leaving the subject of crawler track *v.* wheeled tractors, it may be said that with wheels as they are, the two-wheeled tractor has probably already reached its maximum effective power. If more powerful wheeled tractors are to be built, then the four-wheel drive or bigger diameter wheels must be employed. Caterpillars, on the other hand, can be and are built in more powerful sizes. It is, however, doubtful if larger tractors than those now built would have any great field open to them in England. This is certainly true if light land is being considered. On heavy land a properly spudded wheel can get more grip and transmit more power. As it is on heavy land that extra power is needed, this, like the fact that caterpillar tracks wear least on the soils where they are wanted most, is an instance of providence favouring mechanization.

Is there a need for a smaller tractor than anything we now have? A tractor which will do two or three horse jobs, but is able to do them if necessary at high speeds? A tractor which will mow, pull a small binder, pull a tedder or rake, a drill or harrows and make itself generally useful? Such a tractor would be found plenty to do, particularly on a farm which was mainly grass. Even if it only pulled a single furrow plough, it could turn over quite a proportion of the small amount of arable on such a farm. Such a machine is likely to make its appearance this season, but while the idea is attractive, one must remember that the cost of such a tractor may be nearly that of the more powerful Fordson.

Mr. Hosier has been using old motor-cars to do light work, and there are distinct possibilities about the idea. They are cheap, and if only used for agricultural work, can be licensed as tractors. Fitted with chains, they get grip enough under bad conditions. For hay-sweeping he prefers them to the orthodox tractor. Any fairly heavy car will work a hay-stacker. When it is used in this way, it is better to drive backwards when hoisting, so that the load can be watched and the final flick, which jerks it a couple of feet further forward on to the rick, given at the right moment.

Motor lorries are used in Australia to distribute artificials. A whirling table and hopper, similar to the Wallace artificial manure distributor, are bolted on to the back of the lorry, and driven off a sprocket bolted to one of the back wheels. The manure is carried on the lorry and fed into the hopper of the distributor as it travels. As the lorry can be driven at high speeds, very big acreages can be covered, particularly under Australian conditions, where 84 lbs. per acre is an average dressing. I mention this as a matter of interest and not as a method I expect to see widely adopted here.

I only want to call attention in passing to the general use of motor lorries for all road work, as an instance that farmers are not so backward in adopting new methods, when they are of obvious utility, as some of their critics contend. And also to suggest that

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the motor lorry, from the standpoint of the student of farm organisation, occupies a very important position. It has taken over all road work from the horses and does extremely well what the tractor could never have done satisfactorily.

To quote an American authority: "Modern machinery is not tending to eliminate the family-operated farm, but is giving the farm family the opportunity to demonstrate its ability to meet changed conditions and continue as the best form of farm organisation for economic production, as well as for social welfare. In certain cases, however, family operated farms have increased in size as new machines have made profitable increases in the acreage which can be handled by the family." Mr. Fletcher was referring to the row crop tractor, which has become so popular on the small farms of the Middle west that the I.H.C. were in 1930 making 250 a day. The features of the row crop tractor are that its tools, such as drills, hoes and scuffles, are attached directly to its frame, usually in front of the driving wheels, where they can be seen by the driver, and in which position it is much easier to steer the hoes close to the rows accurately. The tools are lifted at the headlands by the engine-power. It has a high ground clearance and quick turning powers. With one of these tractors, and its appropriate implements, all the jobs, including root crop drilling and hoeing, mowing and binding, can be done single-handed. The range of equipment available even includes cultivating tools for lettuce. In Maine and Pennsylvania I saw potato crops, all the cultivations of which, ploughing, ridging, planting, hoeing and earthing up, spraying and lifting, had been done with these tractors. Cambridge University Farm will be trying one of them with a tool equipment this year and a number are already in use in England as ordinary tractors.

The tools and widths are adapted to American conditions. Some are unsuitable to conditions in this country, and the width of row is often greater than that preferred here. While it would usually be possible to adapt the existing equipment, a range of tools made in this country to suit our crops and conditions would greatly increase the usefulness of these tractors, particularly on the small and medium-sized farms for which they are intended, and in the market-garden industry. The Farmall was the original tractor of this type. Similar machines are now made by most of the leading overseas tractor firms, including the Case and Massey-Harris Companies; and the Farmall is being made in a larger size, corresponding to the well-known 22/36 I.H.C. Tractor. They are made with either three or four wheels, and usually the track width can be varied.

A report of a Committee of the A.S.A.E. on Row-Crop Equipments says that: "Farm machines cannot be made of rubber, to stretch to meet all variations of row widths. This being true, and row widths of the same and different widths varying greatly within small areas, row crop equipment costs more to produce and is more limited in use than would otherwise be necessary. The Committee propose to get more data on row widths preliminary to standardisa-

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tion efforts." Quite a number of morals could be drawn from that statement.

How far any branch of agriculture can be mechanized depends on whether suitable implements to work with the tractor are available. Cereal growing already has such implements. So has grassland farming. Hay can be made without horses. The tractor power-drive mower, the tractor hay-sweep and the hay-stacker together make a most efficient combination as revolutionary in their effect on haymaking as has been the combine on corn growing. Others will speak of them and I only want to say that the power take-off drive and the safety clutch have made the motor mower a thoroughly good tool, and that all the users of hay-stackers whom I know are pleased with them. The objection to silage-making, the heavy weight of the green material, is largely discounted when tractor power is used to move it.

I have mentioned the row crop tractor and its use in potato growing in the U.S.A. It should be equally successful here. But a real harvester is wanted. To lift the potatoes out, and then drop them back on to the ground again is wrong. It ought to be possible to drop the potatoes into some vehicle, which would be emptied on the headland. The same thing is true of sugar beet, and possibly of mangolds, which in some ways would be much easier to lift mechanically than are beets. But speculation is easier than achievement. Still, when one considers the advances made in the last few years, and the possibilities ahead, I think the confidence of those who feel that mechanization provides the means by which agriculture could do more than any other industry to redress the balance of trade has sound foundations.

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