THE AGRIMOTOR.

PRESENT FAILINGS AND FUTURE PROSPECTS.

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THE authors have tried to make this paper short and suggestive, rather than of necessity informative, although they hope it will not prove to be entirely void of value in the latter respect. The principal object they have in view is that of originating a discussion which shall have the result of interesting Members of the Institution, and of directing attention to a subject which offers immense scope for the exercise of engineering and inventive ability. They have attempted briefly to outline the tractor position to-day as they see it, supplementing that by reference to difficulties and troubles which they have jointly and severally encountered, either as personal experience, or as the result of observation of other peoples' troubles. This is followed by reference to a few ideas which they have as to the probable future development of the tractor, or agrimotor, as they prefer to call it. It will be seen that, as might have been imagined, the first portion of the paper leads naturally to the second.

It is the authors' opinion that papers on tractors generally defeat their own object by attempting too much. The scope of the subject is wide, much wider than the ordinary layman or even the automobile engineer who is not directly acquainted with the subject can imagine.

The agricultural motor presents problems which equal in their difficulty any with which the engineer has had to grapple. They are certainly more difficult than those which have hitherto been faced by automobile engineers, and consequently, when it has been suggested that a paper on tractors should be read, an attempt to cover the whole subject in a general way has almost invariably been the response. Such an attempt, as the authors have indicated, is necessarily foredoomed to failure because of the magnitude of the task.

On this occasion, although the authors have been invited to read a paper on tractors, they have taken a certain amount of license, and instead of presenting a general paper on the subject have selected a few ill-ventilated aspects of it and incontinently dragged them into the light in the hope that in the discussion, which it is anticipated will result something of gain to the Industry at large may ensue.

Present methods of farming have developed largely as the result of making the best of the means at hand. The motive power of most tillage operations—the horse—unless available in unlimited numbers, a condition which is not economically practicable, has very definite limitations. Moreover, even if it had not, the prevailing custom, which has grown up in connection with nearly all implements of tillage, of allowing the operator to walk in the rear of the machine, is a sufficient brake upon progress in connection with the operation itself.

If we consider a small farm, on which there are ten horses, of which six may be engaged at any one time in ploughing, their utmost capacity would be two acres per day, so that if 100 acres have to be ploughed, there is at once fifty days' work. It would naturally be impossible to accomplish this in the short period of good weather which follows the harvest. The question as to whether to put in winter oats or to plant spring corn is therefore generally decided for the farmer by the conditions under which he works rather than as the result of his own personal choice or as the outcome of any considered programme. Additionally, there is to be considered the natural fatigue from which animals suffer. Horses may not be taken straight from the hard work of the harvest and put on to ploughing, so that with the limitation in the number of horses available further delay necessarily occurs on this account.

None of these drawbacks applies in the case of the tractor. It harvests quickly, and can go straight from harvesting to ploughing without any question of fatigue arising. Moreover, it can plough easily as much in an hour as a pair of horses can in a day. The sowing of greater proportions of winter corn is already becoming a habit with the tractor farmer, and since its more regular use necessitates more rapid cultivation of the ground for reception of the seed, the result within a comparatively short period will be, in the opinion of the authors, a revision in the methods of cultivation generally. It will eventually, in a good many districts, involve the use of implements somewhat similar in principle to the "Once-over" tiller and the "Somua" Rotary Cultivator, which pulverise the soil and prepare it for seed at the same time as it is ploughed. Whether this change comes about quickly, or whether it be some years before it arrives, it will have the effect of rendering obsolete the tractor as we now know it, substituting for it a power-driven cultivator, designed to be useful not only for cultivating the soil, but for effecting those operations such as hoeing, ridging, etc., which have to be carried out amongst growing crops as well as for harvesting the crop when grown. Its work will, however, be confined almost entirely to the fields: its presence on the roads, except in transit, will not be tolerated.

The word "tractor" is, in a sense, a misnomer, and the authors sometimes wonder whether the mere habit of calling this agri-

cultural machine a tractor has not, to some extent, been responsible for the industry's persistent attention to the one type to the exclusion of other possible forms. It seems to have been taken for granted, too much, perhaps, that a "tractor" was wanted. Some groping after a really applicable name for this agricultural substitute for the horse was, no doubt, at the back of the minds of the editorial staff of the "Commercial Motor," with which paper one of the authors was at one time connected, when they suggested the word "Agrimotor" as being more suitable for the purpose in view. The same word, it may be noted, is used by Mr. Crawley in describing his self-propelled plough, which is named the "Crawley Agrimotor." The opinion is here ventured that the tractor, after all, may not be the ideal machine. It is doing very well at present—uncommonly well, no doubt many will be inclined to interpolate here—as a mere passing phase in the movement, but it is quite possible that it may prove not to be the final form.

The whole business is really so very new, as such things go. We know that steam agricultural tractors were made upwards of fifty years ago, but for all practical purposes the agricultural tractor is a war-time product. It appeared on the scene as a tractor, and, apart from one or two exceptions, designers have been content to accept that form as the correct and, presumably, ultimate one. Now, one of the things the authors wish to do to-day is to throw some sort of philosophic doubt on the matter; philosophic doubt is, perhaps, the best term to use, as they are far from any definite conclusions on the subject themselves. A little discussion on the matter may help. What really will happen in the long run, the authors think, will be that the tractor, and the extensive use of it, will so change all our settled convictions of farm routine and procedure, and will so alter the methods of cultivation, seeding and harvesting, that it will run itself out of existence, and in that process it will be assisted very considerably by the motor car and motor lorry, especially the latter, equipped particularly for farm haulage, and for supplementing the work of the "agrimotor" (not tractor) in the field. At present there is a tendency to concentrate on a machine of more or less universal application, one which shall be as useful for hauling goods on the road as for working in the fields. So long as that idea is held, so long shall we be prevented from achieving full success in either department. The two sets of requirements are practically incompatible. The road tractor, to haul the fairly considerable weights with which the farmer habitually deals, and to do so on the extremely poor road surfaces, and in some cases through the familiar morass which so frequently exists where field and road adjoin, must have weight. Yet such weight, although not in every case detrimental to a field machine, is nevertheless sufficiently so, in the general run of cases, to make it preferable that comparatively light machines should be the rule.

In the opinion of the authors, the tractor should be so designed

that it is geared to the ground, its weight, wheels and spuds being so proportioned and adjusted to the surface that it propels itself almost without taking advantage of the frictional adhesion between the rim or wheel and the ground surface. One of the main points on which the authors would lay stress is that a field machine should be entirely different from a road machine. The agrimotor should be set apart for farm work, and the motor lorry, equipped, if necessary, with traction lugs for soft land, employed for haulage work.

None of these peeps into the dim future of agriculture is likely to be of much direct use to us, at least not for some years. The authors will therefore come down to earth and discuss the present type of machine, which in itself, as they have said, is quite enough of a problem to go on with. For the time being, at least, whatever the future may bring forth, the practical proposition of the moment is the tractor, and it is therefore necessary for us as practical men to consider this type of machine rather than to spend too much time on speculating as to its subsequent development.

Considering, therefore, the present most popular type of machine, the authors think that the mistake has generally been made of considering the design of the tractor independently, and subsequently casting around for implements which it could conveniently draw. The mistake is, perhaps, a natural one, for the tractor was, in the first place, intended as a substitute for the horse, and in the beginning was conceived merely as hauling an implement discarded by, or perhaps it would be better to say reluctantly relinquished by, the horse. Subsequently, as makers grew to a realisation of the existence of the tractor, which they did but tardily, tools were made which, more or less, fitted the tractor. The result has not been altogether what could have been wished, and one of the principal difficulties yet to be faced in this connection to-day, is that of efficiently coupling the tractor to its implement. As an example may be cited the urgent and extreme need of some simple means of hitching a multiple-furrow self-lift plough to a tractor in such a way that, on the one hand, too much side draught is not thrown on the tractor, which in such a case evinces a tendency to turn into the furrow which is ploughed, nor, on the other hand, too much of that same side draught passed on to the plough, greatly increasing the power necessary to haul it, and causing broken and uneven furrows as well as rapid wear of plough parts.

Now this difficulty arises entirely from the fact that tractors have, in the main, been designed by people whose experience had been chiefly with motor cars or traction engines. Having, seemingly, little or no imagination, they set to work to make field vehicles on precisely the same lines as those to which they had been accustomed. The *modus operandi* is a simple one, well known to the designer. A more or less satisfactory petrol engine was selected, and this, usually, was partly ruined by saddling it with a paraffin

vaporiser of sorts. A gear-box and a back-axle, generally in keeping with the power unit, were then chosen, and the whole mounted on four wheels, which were disposed, not with any particular regard for the work which they had to do, so much as in order that they might hold up the four corners of the tractor machinery. Even those few makers who, for some reason or other, decided that three wheels were sufficient, nevertheless stuck to the main scheme as regards the arrangement of the wheels; at any rate, they missed the main essential, that of considering the wheel track in relation to the implement or implements which the machine was intended to haul.

The inevitable result of this haphazard method of arriving at a suitable layout was that the width of the tractor came, as it were, just anyhow, and consequently when it was set down in a field with a plough behind it, it was generally found, in all but exceptional cases, that, even with the offside wheel of the tractor running in the last completed furrow, the plough was still many inches out of line, being to the offside of the tractor. Hence the afore-mentioned difficulty about alinement of the tractor and the implement. There can be no need to point out to an assembly of engineers such as this is, that a piece of mechanism which starts out by being thus fundamentally wrong is very unlikely ever to become that perfectly satisfactory job for which an engineer presumably always works, consequently the problem which still confronts the tractor user of to-day is—whatever the maker may say—how is he going to get his men into the way of invariably coupling the plough to the tractor so as to involve excessive side draught on neither, and at the same time make it reasonably practicable for good, even ploughing to be effected.

Now, suppose the tractor—if the temporary assumption that it must be a tractor may be continued—had, in the course of its design, been considered from the implement end. It would, in the first place, inevitably have been the plough that would have had prior consideration, principally for the reason that the most arduous work is undoubtedly that of ploughing.

Now, although mechanical tillage is not by any means new, it is nevertheless a fact that the commonest method of ploughing a field is by horses, and in the majority of cases a single-furrow plough operated by two animals is used. The implement in any case is guided by hand, and, with the usual arrangement, namely, that of one horse travelling in the bottom of the furrow, and the other on the land, the pull on the plough is practically dead in line with the centre of draught of the share, which centre of draught, by the way, is not the centre of the furrow, but is, practically speaking, a line through a point one-fifth of the distance from the wall of the furrow to the other side. The tractor is a long way from being so conveniently disposed, and before going any further it may be best to consider how far it falls short of this ideal.

The first tractors ran along the top of the unploughed land. The ploughs they hauled were of what is called the steerage type, that is to say, they were actually steered by the ploughman as distinct from the tractor driver. The former was accommodated with a seat on the implement, and guided it by the manipulation of suitable levers. The connection between the tractor and the plough was a flexible one, so that neither tractor nor implement was made to suffer much inconvenience as the result of the considerable non-alinement which inevitably resulted with a tractor running some distance to the left of the furrow. The connection, being long, reduced the angularity of the pull on both machines; moreover, the steerage plough was usually fairly long from its front wheels to its rear, and in consequence the side pressure between the guiding wheels and the wall of the furrow was not very great. Very soon, however, it was appreciated that if the tractor was to make headway with farmers, it would have to do so largely as a labour saver. In consequence of this realisation, and of the resultant desire to eliminate the extra man on the plough, the self-lift implement was introduced, one which could be operated by the tractor driver without there being any necessity for him to leave his seat. This novel introduction at once involved two things: close-coupling of the tractor and the implement, doing away at once with the convenient long flexible connection to which we have referred, and the steering of the implement by the tractor itself. The effect, in the beginning, in all cases except those in which an expert was employed to operate the combined outfit, was disastrous. Some wretched ploughing was the result, and it was seriously thought at one time by many that return would have to be made to the steerage or riding plough, and endeavours put forth to compensate for the extra man in other directions, the said directions not being, as a matter of fact, named. As this was obviously a counsel of despair, it goes without saying that it did not get much of a hearing, and the upshot was our old friend "Compromise." A special type of hitch was designed, triangular in formation, which provided for the plough being held fairly rigidly as regards lateral swinging, and thus permitted of its being steered by the tractor, while its peculiar formation and the provision of a number of holes in the three limbs of the triangle allowed of ample means of adjustment laterally, by altering the positions of the ends of the sides of the triangle, provided that the uses of that adjustment were appreciated by the operator. As a matter of fact, however, even this apparently ample provision for adjustment proved to be inadequate, and in nearly every case now it is supplemented by means of a lever and quadrant, a ratchet and pawl, or a handwheel and screw, which allow of ultimate adjustment of the alinement within fine limits.

All these various types of hitch are illustrated in Figs. 1 and 2, and Figs. 3 and 4, Plate III. The last named is, in the opinion of the authors, the best type, as it puts the adjustment on

to the tractor, taking it from either the plough or the plough hitch. Its disposal there renders it available for use in connection with all the various implements which the machine may be called upon to pull from time to time. Even the best of these adjustable hitches, however, is only a compromise, and still leaves the main trouble—lack of alinement of the tractor and implement—entirely untouched, and it is the belief of the authors that if the design

FIG. 1.

of the tractor be tackled from the implement end some means will be found of eliminating this wrong alinement entirely.

The position of the present-day designer of a tractor is that he sits down to lay out a machine which will be capable of hauling a two- or three-furrow plough, according to circumstances. It must, therefore, be capable of ploughing a width of from 20 to 30 in., perhaps, at one stretch. The extreme limits may even

FIG. 2.

be further apart than this. It should have 10 in. wide rear wheels, certainly those wheels on the furrow side, with which we are concerned, should be no wider than this, otherwise they will be too wide to travel along the bottom of a furrow of that width, which is most popular in this country. Figs. 5 and 6 show graphically the position of the offside furrow wheel, the location of the two or three furrows which are being ploughed, and the centre line of draught of the two- or three-furrow plough. For purposes of

comparison, the centre line of draught of a tractor, 5 ft. 6 in. wide over the rear driving wheels, is also indicated. An examination of the dimensions on the sketch will make it clear that our tractor, if it is to be properly in alinement with the implement

FIG. 5.

FIG. 6.

in the extreme circumstances named, must be 46 in. wide overall in the first case and 56 in. in the second.

It would therefore seem that, if our tractor is to be ideal in this respect, its wheel track must be adjustable. The question is, is

this practicable, or are we going to create more trouble by its adoption than we shall save by the elimination of the non-alinement of the plough and the tractor? From the mechanical point of view it presents small difficulty. The engineer has the choice of wheels with offset rims, reversible so as to give different tracks, or wheels with rims split circumferentially, the halves being interchangeable, or a combination of these two methods might be adopted. Alternatively, the axles might be telescopic, with the length rapidly variable by manipulation of a handwheel and screw, or similar device. Other means of attaining the same end will suggest themselves. Even so, however, there might be some doubt as to the advisability of adding even this small complication to the agrimotor with merely this one object in view. There are other occasions, however, when this feature of adjustable wheel track would be advantageous, and those, in conjunction with the one the authors have so specifically indicated, may be sufficient to make it worth while. Practically all those operations which necessitate the tractor's traversing fields of growing crops involve the need for some adjustment of the track. Crops are planted in rows the distance between which varies not only according to the crop but even with the same crop, depending also on the soil and the method of cultivation, i.e., whether the rows are ridged or on the flat. Mangolds, swedes, and potatoes, for example, may be set in rows which may be anything from 18 in. to 30 in. apart, while rows of carrots, parsnips and turnips may be from 12 in. to 18 in. apart. Corn crops are sown 6 in. or 7 in. apart as a rule to-day, and therefore present more of a problem, since it is rather difficult to steer a tractor with wheels of one-half that width with sufficient accuracy to avoid crushing the growing crops. It is quite likely, however, that the provision of economical mechanical methods of hoeing, making the continuous cultivation of corn fields practicable, may effect yet another alteration in method, and bring about the practice of sowing our wheat and oats in rows a foot or more apart. It has already been established that, provided adequate hoeing and weeding is effected, a better crop results from half the expenditure of seed, than by the method now common.

It is in this direction that the agrimotor must develop. The field is practically, but not quite, unexplored. Designers who direct their efforts towards making the tractor useful in the field, and ignoring the road, are more likely to be successful in the long run than those who, in aiming at a so-called universal machine, really produce something which is not properly adapted for efficient use either on the road or in the field. The ultimate agrimotor will be a universal *field* machine. As an instance of the methods adopted by one maker to meet requirements of the kind just referred to, Figs. 7 to 10, which illustrate various models of the Avery motor cultivator, are of interest.

It is pertinent in discussing possible changes in methods of

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cultivation which will result from the wide-spread employment of power-driven machinery in the fields as well as about the farm yard to make some reference to the speed of ploughing. It has frequently been urged, as is easily understood, that the tractor would show to a much greater advantage if ploughs were to be so designed that they could be operated at a higher speed than is now generally regarded as permissible. Five to six miles per hour has been suggested instead of the present two to two-and-a-half miles per hour. Plough makers have, as a matter of fact, accepted this view, and some of them have carried out experiments with the object of being able to put an implement on the market which could be operated at speeds which, if not so high as those named above, are at least higher than those at present regarded as practicable. Success, however, has not yet

FIG. 7.—60-inch Avery Motor Cultivator.

This illustration shows the 60-inch width cultivator as used for cultivating rows 28, 30 and 32 inches apart. When so used, the cultivator is furnished with the regular single front wheel.

been attained—an important obstacle being the fact that however fine, within the limits of practical construction, the front edge of the plough breast may be made, it is still sufficiently blunt to pulverise soil at any speeds higher than approximately two miles per hour, thus destroying the even unbroken furrow-slice to which the British farmer is still wedded, and which seems still to be desirable under certain conditions of soil, weather, and intended crop. This difficulty of plough construction with this end in view is, perhaps, to some extent a problem which will solve itself as time goes on, and as newer methods of cultivation and cropping enable us to dispense with any considerable dependence on the action of the weather in disintegrating the soil for cleaning purposes. When this becomes possible the need for an unbroken furrow-slice will be eliminated, thus removing the principal objection on the part of the farmer to high-speed ploughing. It

may be, however, that by that time the plough share as we know it will itself have died out, to be superseded by some form of rotary disturber of the soil. Meantime, there does appear to be a risk that the tractor designer, by 'setting, as he may think, an example to the plough maker, and designing his machine to operate on its ploughing gear at from three to three-and-a-half miles per hour, may do himself and his machine harm, and the industry no good. To illustrate the authors' meaning, and at the same time point a moral, the experience of a well known British firm of

FIG. 8.—60-inch Avery Motor Cultivator.

This illustration shows the Avery Motor Cultivator as used for cultivating beets and other crops planted in rows 20 inches in width. A two-wheel front truck is required in place of the regular single front wheel, as the front wheels must straddle one row. This cultivator is furnished with the standard attachment for cultivating beans, peas, etc.

tractor manufacturers may be quoted. They recently declared in public that by an alteration in the transmission gear on their tractor they had increased its *power* by 'some 30 per cent, using the word "power" in its proper academical sense. What really had happened was this. The tractor had been designed and turned out to deliver its rated power when ploughing at two-and-three-quarters to three miles per hour. In actual practice the farmer, looking to the condition of his ploughing rather than to the convenience of the tractor, refused to run the machine at more than

two to two-and-a-quarter miles per hour. He was in consequence not getting the rated power from the tractor, nor was the fuel consumption so good as it would have been. In a good many cases the machine, instead of being, as was intended, a satisfactory three-furrow tractor, proved itself to be only capable of hauling a two-furrow plough. The alteration in the gear ratio so that the engine revolved at its best speed with the machine travelling at two miles per hour instead of two-and-three-quarter miles effected the 30 per cent increase in horse-power at the actual ploughing speed. The moral, the authors think, is fairly obvious.

On the subject of the design of tractors as such, there is another point wherein designers have failed to distinguish between the requirements of field work and those of the road. We refer to the provision of a differential gear. Not only is there, in the

FIG. 9.—70-inch Avery Motor Cultivator.

This illustration shows the 70-inch width cultivator as used for cultivating rows 32, 34 and 36 inches apart.

authors' opinion, no need for a differential gear in a tractor, but, as a matter of fact, it is generally better off without such a component. Nearly all the actual work of tillage is carried out while travelling in a rigidly straight line. The first essential of the furrow is that it should be straight, and the same requirement is a feature of cultivating, harrowing, seeding, and indeed of all field operations. Freedom for turning is only requisite at stated intervals, and provision for that can be made in another fashion, as will be indicated later. The disadvantages inherent in any ordinary differential gear, disadvantages which have not passed unnoticed even on the road, are more prominent than ever in connection with ploughing. In that operation one driving wheel is frequently arranged to run at the bottom of a furrow, the other being on the unploughed land. The one is on solid earth at the bottom of the furrow, the other may be on loose soil or wet,

slippery clay. With a differential gear present, so soon as the draw-bar effort required becomes excessive, one of the driving wheels, generally that one on the land, immediately commences to slip, and if the soil is at all loose, rapidly digs a hole for itself, and not only stops any immediate progress but makes it difficult for the tractor either to proceed or recede from the position in

FIG. 10.—93-inch Avery Motor Cultivator.

This illustration shows the 93-inch width cultivator as used for cultivating rows 40, 42 and 44 inches apart. This is the width of cultivator most generally used.

which it then finds itself. Similar difficulty is even encountered at the end of a furrow on the headlands, which more often than not have to suffer the passage of the tractor many times over. The ground is, in consequence, badly scored, and a further tendency to slip is frequently observed.

The ideal arrangement is one in which both wheels are positively driven. This is only possible so long as the tractor or agrimotor

is moving in a direct line, as in the case when ploughing or engaged on some other tillage operation. When the headland is reached, some means of differentiation is required. The ideal is that in which the driving wheels run together until the steering gear is operated, as, for example, when turning at the end of a bout of the field: movement of the steering gear should liberate the inside driving wheel and transfer the whole of the drive to the outer one. Such a provision is a positive advantage, as it helps the tractor round at a critical point when the front wheels are, as is frequently the case, on ground which has already been traversed many times, and which as a result is either soft, broken up and loose or slippery, and consequently is frequently unable to afford sufficient grip for the front wheels of the tractor to enable them to steer the vehicle round. This inability to turn causes it to be necessary for the width of headlands to be increased, a necessity which should be avoided so far as is reasonably possible.

History is repeating itself in regard to the battle of the cylinders. We started with single- and twin-cylinders, just as did motor cars. There are a few twins left, but they survive not as motor car engines, not even as petrol engines, but rather as oil engines, built after the pattern of the farmer's engine. Most tractor engines have four cylinders and are of the orthodox type. There are one or two "sixes," and a strong feeling exists in many quarters that there ought to be more. On this point the authors would like to learn the opinion of other members.

To sum up,—the tractor is only a passing phase of the movement sufficiently permanent to merit a good deal more attention than it has yet received from automobile engineers. Extensive use of the tractor is the only way along which the farmer will progress towards the real agrimotor. He will never pass in one stride from present methods to complete mechanical tillage. Immediate development of the tractor should be in the direction of increasing its scope of employment in the field. Designers should abandon the prevalent notion that a tractor must of necessity be both a field and road machine.

THE DISCUSSION.

Colonel R. E. CROMPTON, in opening the discussion, said: Many of the matters that we are discussing to-day as to educating the farmer up to the advantages of machinery, and the criticisms which have been raised by the farmers themselves, remind me that it is just fifty years since we had a very similar discussion at the time the R. A. S. E. Show was held at Wolverhampton. We then ploughed the land for the first time with rubber-tyred Thomson engines made by Ransomes, which drew the plough direct, and the discussions that took place about the waste of time on the headlands, the farmers' objections and the farmers' difficulties were all put forward fifty years ago exactly as they are put forward to-day. I have always felt that the extended application of power-driven machinery to cultivate the soil was one of the matters which must come, and which always gave a fruitful field of investigation to the young engineer. I therefore made it the subject of my Presidential Address to the Junior Institution of Engineers two years ago.

Our work of fifty years ago was dropped for various reasons, chiefly because those who wished to forward the interests of direct traction were few in number, so that we have had an intervening period during which little progress has been made. We have now so many men, manufacturers and others, interested in the industry, that I believe it will go forward without further delay. The fact that the cost of labour is now so high will be a powerful factor in helping on this good cause. Although it is hard on us who worked at that time to feel that so many good years have been wasted, perhaps the great progress that we are now making would not have been possible so long as we had to use steam engines and boilers; I do not say that we could not have done it, but with the internal combustion engine the problem is a much easier one. In those days we were told that it was impossible to develop direct traction for ploughing on account of the difficulty of getting the pull sufficiently in line with the plough furrow. Greig, of Fowlers, who did more than anyone else in developing the endless-rope system of steam ploughing, used the argument of the damage done to the land both by horses walking in the furrow and by the wheels of the tractor compressing the soil. He then said that this fact alone must condemn any idea of taking tractors over the land itself. From the papers under discussion we see that this difficulty has been met. We have yet to learn how much can be done for England by the proper cultivation and aeration of the soil, and by getting it into condition at the proper time of year. It is well known how much the farmer can benefit by every inch of extra

(Colonel R. E. Crompton.)

depth of soil that he brings up and mixes with the soil that has been previously ploughed and stirred for years past.

I hope I may be allowed to put forward an idea of my own, as a landowner, or, rather, a life tenant. The net income from the estate, after the rates and taxes have been paid and sufficient sums allowed for repairs, is so small that it is insufficient to pay the succession duties. My case is a very common one, and the only practical suggestion I have to make is that we landlords should now be the real heads of our property, and have sufficient business engineering knowledge to enable us to be of real assistance to our tenants. I believe that each estate should be self-contained, the landlord keeping a central store of machinery for use by the tenants in turn as they require it, and maintaining a repair establishment which would deal with all estate repairs of all kinds, not only those to buildings and fences, gates and so on, and charging the tenants with the cost. I am sure every business man will agree with me that this would effect vast savings and greatly facilitate the use of machinery.

I quite agree that the agriculturist must have roads, and that he must pay in one form or other for their upkeep. I may be a dreamer, but I foresee the day when the present cumbrous manual processes of hacking out a road, spreading stone, rolling it down, subsequently tarring it, spreading chips over it by hand and tarring it and rolling it a second time will be all condensed into a road train of vehicles passing over a worn-out road and by one passage completing it into a finished new surface. Such a train might consist of six or more vehicles, all power-driven, which would by five or six consecutive processes convert an uneven worn-out road into a new surface which would last for many years.

Mr. D. A. GILCHRIST: One point that must be dealt with is the question of the ease of replacement of parts. If a part of an agrimotor breaks down, then that part should be easily replaced. That is a very important point indeed. I want to say a word for the horse. I should not be satisfied if on a farm six horses should only plough two acres a day, and, as the agrimotor must be worked in the most efficient manner, so also the horses must be worked in the most efficient way. I would also like to say that the two-furrow plough drawn by three horses can, when conditions are suitable, do very good work indeed, and I have figures here showing that a plough, going at the rate of two miles an hour, with a furrow 9 in. wide, and allowing 50 per cent loss of time for turnings, to clear the plough, etc., could in $8\frac{1}{4}$ hours plough one acre. I am not saying this to argue for the horse plough as against the agrimotor, but I cannot but think that the horse plough will still have a very important place in the future, and that the place of the agrimotor is to get work forward at a time when it cannot otherwise be accomplished on the farm; not only that, but there is other special work to be done which cannot well be done by horses.

There is a very important point in connection with the "Once-Over" Tiller and the Somua Rotary Cultivator. The main objects of ploughing are to turn over or invert the soil as thoroughly as possible, so that it may be exposed to weather conditions, and to bury stubble and other materials. For that purpose it is necessary to turn the furrow over so that the surface comes well over to the under-soil. The Institution as a professional body must keep in mind that the object of ploughing is to turn over the soil completely, exposing it to the oxidising agents of the atmosphere, because there is a great difference between that and simply breaking up the soil. There is the action of the air during the winter time, and, further, no matter how a clay soil is ground up, if it is out of tilth, nothing will pulverise that soil better than frost, and it is also desirable in ploughing to turn the surface weeds completely down. I was very much struck with the remarks in the paper on the necessity for alinement in ploughing. The Royal Society of Arts dealt with agriculture from the beginning, and the first three volumes of their Proceedings were called Dossie's Memoirs of Agriculture. One of the papers in these volumes was by Mr. Cuthbert Clark, of Northumberland, showing how horses should be attached to a plough so as to get not only horizontal alinement but also vertical alinement. It is interesting to find that these problems have been exercising agricultural engineers and plough engineers for a very long time indeed. I have seen, during the war, a plough taken from being drawn by horses and attached to a tractor without any adjustment whatever, yet the tractor draws at a much lower level than horses, and the parts of the plough need adjustment in order that the plough may be so set that it just grips the soil sufficiently. Otherwise the plough grips the ground too deeply. With a swing plough there is no difficulty, but many of the tractor ploughs have got too much grip of the soil and there is a great loss of power. I would like to quote the following extract from a letter that I have received from a farmer who ploughed a large amount of land during the war and who has used tractors and also oil ploughing tackle. He says: "Farmers who have land suitable, and capital to stock farms, intend scrapping what implements they have and go in for stock farming only. It is quite impossible at present costs for them to carry on, and you know once a farmer puts his land to pasture it will be very difficult to change back to tillage." He then goes on to say, that unless prices for tractors come down very considerably, as horses are now a very great deal cheaper, as well as their food, the tractor will still have a competitor in the horse plough. Perhaps I may put it in another way. We are faced with the change of prices, probably a still further change, but as the tractor improves, I am satisfied it is going to take a large part in our agricultural work, especially on large farms, but we will want a tractor with easily replaceable parts, and a tractor that has proved its efficiency in every way.

(Dr. W. R. Ormandy.)

Dr. W. R. ORMANDY: Very many people forget that agriculture is by far the biggest industry in the world, and that when a colliery brings up, say, 5,000 tons of coal a day, it is all brought up at one spot, whereas the agriculturists who bring up 5,000 tons of crops, bring them up over a very wide area, so that the question of transport is much more vital to the agriculturist than it is to the industrialist. Yet the fact remains that we are practically now in the same stage with regard to agricultural machinery as we were with the road motor twenty years ago. If there is any one industry which is waiting for development, it is the application of motor traction to agriculture, not here, particularly, in this country—though greatly desired here—but in the Empire and in our broad lands overseas. In my connection with the Empire Motor Fuel Committee, I have constant communications with people who have farms of 10,000 and 20,000 acres in British East Africa, British Guiana, Australia, Borneo and in all parts of the world, but there is the one constant cry, "We can do nothing for lack of labour." Of course, people say we ought to educate the native. What we are trying to do is to get the native to work for five days for half a day's pay in order that he shall produce stuff cheaply for the white man, and the native to-day will not do it. He is gradually waking up to the fact that he has not been fairly treated, and as a matter of fact his wives work two hours a day for two months of the year and produce enough food to last the household for the rest of the year, and yet we want them to work ten hours a day to produce cheap food for the white man; naturally, they won't do it, and I don't blame them. But what are we to do in countries where the white man cannot dig or the cost is too great? We have to devise special machinery for special purposes. I get letters from all parts of the world saying, "We would and could plant thousands of acres" with this, that or the other crop. "We can get more or less workable tractors, but it is the weeding that is our trouble." They sow a crop and in three months there are weeds a yard wide and a yard high, and we have got to remove those weeds. There is a great industry awaiting us, and there is no competition because the industry, as such, does not exist at present, and if the papers under discussion have forced our attention to the fact that there is awaiting us one of the greatest industries in the world, even at least as great as the great motor traction industry as we know it to-day, with no competition, then this meeting has served a very useful purpose.

Taking up the matter now from what we may call the broad Imperial standpoint, my connection with the Imperial Motor Transport Committee has proved to me that the most varied crops can be produced in enormous quantities by men who have the capital and the land and are willing to plant if the motor industry will provide the right and proper means to do it. In the early days of railway development, the main object of the railway engineer was to make a coach which was as like the horse coach as possible,

but there is a vast difference between the early coaches on railways and the dining saloon of to-day. The motor car went through exactly the same stage of development, and now we are practically attempting the same thing; we are attempting to make an engine to do just what the horse does. But the engine is not intended to do just what the horse does. It is something which can do vastly more than the horse does or ever can do, and it is up to our engineers to design machinery which is suitable for the purpose for which it is required, and if it would be of any use, I am perfectly sure the Imperial Motor Transport Committee, which has working arrangements with the Colonial representatives, would be willing to work in harmony and give every help to the motor engineers in this country. One of the main difficulties is that we do not know exactly what is required, and if we could get the information from farmers in all parts of the world—I mean men who are working 2,000 to 10,000 acres—as to what they require, I am sure it would be a very great help to designers. They can design if they know what to design, and I suggest that it is possibly worth our consideration that there should be some attempt at co-operation between the Institution of Automobile Engineers and the designers of agrimotors and the official representatives of the Colonies, perhaps via the Imperial Motor Transport Committee, who are vitally interested in this subject of agriculture for the production of cheap starch crops; such co-operation is desirable, and could be brought about.

Mr. C. DAVIES: The first point I should like to mention is the difficulty of obtaining good drivers. So far as the farmer is concerned, I think this is one of the greatest difficulties that he has to contend with. The present procedure is as follows. Farmer A has a tractor. His neighbour, Farmer B, also decides to invest in a tractor, and he finds an intelligent farm labourer, who knows nothing at all about internal combustion engines or tractor machinery, and he sends him over to Farmer A and asks if he may be permitted to work with his driver for a certain time. Farmer A's tractor driver can drive the tractor. He has learned to drive it, as the advertisements often say, in half an hour. He is shown where to put the fuel in and which levers to pull to make the tractor go forward, etc., and that is all; and then Farmer B soon finds that his bill for repairs is very high indeed. I really think that if some school or centre of instruction could be organised where prospective tractor drivers could learn the job, many farmers who at present are looking for skilled drivers would buy tractors, whereas at present they are afraid to do so. There is another point. I think that in the future arable farmers will have to cut down their hedges; the fields are too small and too irregular. In certain cases this would involve filling in ditches and draining in other ways. I hope that next month at Lincoln we shall see some machines which will do draining operations economically and expeditiously, and I gather that the majority of modern draining machines can be hauled by tractors.

(Mr. C. Davies.)

Until the time comes that the fields are made much larger than at present, I do not agree that the differential should be done away with on tractors. I admit that the majority of tractor farming operations should be done in a straight line, but where the fields are of irregular shape the differential is still necessary. I think that too much stress has been laid on the question of alinement, and that, judging by results, implement makers and tractor designers have not neglected this point altogether. I have seen tractors drawing two-furrow ploughs, which have been set by the driver, so that he can walk alongside, and the work turned out has been very good. I think it will be a long time before the heavy-land farmer will adopt rotary cultivators; he does not want his land just loosely kicked up, especially for winter ploughing. He must leave it up in a solid furrow, to be broken down by the frost and rain throughout the winter, and I think too much has been made lately of the rotary cultivator in general, though the plough, as it exists to-day, could certainly be improved, but not entirely replaced by the rotary cultivator.

The type of literature which is sent out is in the majority of cases much too technical for the average farmer. It is not a bit of good talking to him about drop forgings and babbitt bearings and vanadium steel, though a brief technical specification is all right. There is another point which has militated against the adoption of tractors, or prejudiced farmers against certain types, and that is the habit of overloading them. Very often a tractor will pull a two-furrow plough comfortably, and it should be called a two-furrow tractor, but I think that it is a great mistake that because when in skilled hands it will pull a three-furrow plough, perhaps on heavy land, it should be advertised as a three-furrow tractor. I do not think it would be advisable to do away with the high-speed gears on tractors, because various implement makers have realised that high-speed tools—by that I mean ploughs, etc.—will be introduced, and in that case it will be necessary to have a high gear on the tractor. I agree with the author of the first paper in his condemnation of the lubricating system on paraffin engines, which is undoubtedly one of the great troubles of to-day. The paraffin undoubtedly does get past the pistons and dilute the oil in the sump.

Sir DOUGLAS NEWTON: I am sure that the closer the co-operation that can be developed between those who make and those who sell machines, and between the makers and sellers and the agriculturists, the better will be the results for all concerned, and on that account I am very glad to have been invited as representing the Farmers' Club to take part in this Conference. I think that the statement that much of the work of agriculture in connection with tractors is rush work is perfectly true, and that is, I should imagine, one of the strong selling points of the tractor. I feel, too, that there is a great need for the development of machines to go with the tractor. At present we have not got a single drill which is the least suitable for the work so far as heavy land is concerned,

and I do not except the wide disk drills, which only work satisfactorily on free-working land. It is the same with harrows and many other implements. Deep ploughing is referred to in one of the papers, but that wants to be done very, very carefully. In the district in which I reside and farm, a heavy land district, an enormous amount of damage was done some sixty years ago by deep ploughing, by bringing up the cold and sour land to the surface, and it took years before that crumbled down and became of any use for growing substantial crops. What we do want, however, is deep *subsoiling*—shallow ploughing, with a deep stirring of the soil underneath, and I would like to direct the attention of those who have to deal with these matters to the study of this point. Personally, I agree that the tractor has not yet reached finality. Everybody has been talking about the all-purpose and general-purpose implement. That was tried with cattle. We have dual-purpose animals now, animals that are fed for food, and animals that are milked, and in some countries they work them as well, but we cannot hope to develop the all-purpose animal, that will do ploughing, and then give milk, and then provide beef. I equally do not believe that we shall succeed in getting a really satisfactory all-purpose tractor. I believe the tractor will have to be built to do the particular work which the farmer has in mind. Of course, it will be able to do many more jobs, and it will be more of a general-purpose machine than the illustration I have given of the animal, but at the same time, it will not be able to do everything. The general position now is that farmers are alive to, and sensitive of, the advantages of the motor. Still, there are a great many of them that have not used tractors yet, and there is an enormous undeveloped field. One horse-power is still one horse-power, but horses, if properly managed, tend to grow into money and not out of money, and in that sense the farmer gets the work of the horse for nothing, although, of course, he has to pay the driver's bill. The tractor must be able to do practically everything that horses can do, and a great many things that horses cannot do, such as pumping and threshing, and other operations of that kind.

I hope that running costs will be carefully studied, and that machines with wearing parts which can be easily renewed at the end of the season will also be developed to a greater extent. I have always felt that spuds might be very much improved. I cannot see why they should not be mounted on a kind of eccentric, so that the spud is out when a section of the wheel is pressing on the ground, and is thrown right back when the same section is on the top. The spuds would thus be absolutely clean every time they were wanted for service in the ground. At the present time the spuds get choked and half their surface is lost from the point of view of adhesion, particularly in heavy ground.

I feel that we must look to the use of machinery for greater production from the land. Experiments have been carried out

(Sir Douglas Newton.)

at Rothamsted extending over a long period of years. It has been found that when we get, with 200 lb. of fertiliser an additional yield of 10 bushels, 400 lb. would only give an additional yield of 18 bushels, while 600 lb. of fertiliser would only give an additional yield of $19\frac{1}{2}$ bushels. In other words, the law of diminishing returns operates very rapidly, and therefore it seems to me that if we want to increase our net returns in agriculture, we must look to other means of obtaining them, by using labour-aiding machinery, by doing our operations in the right way, at the right time, in the shortest possible time and thereby getting a bigger yield from our land. After all, if I may say so, this is a labour question, and if it is handled wisely we shall get labour to a great extent on our side. At the present time, it requires on a normal farm about six men for every 200 acres of arable land. If that land is laid down to grass or tumbles down to grass, it only requires one man in place of the six to every 200 acres. Therefore, I say that the development of machinery which will tend to keep this land in arable cultivation must inevitably mean a greater measure of employment, and therefore a greater gain to yourselves, a greater gain to the farmer, and a greater gain to the State. A few years ago it was said of the average machine that it used to rust out rather than wear out, and I think there has not been a great measure of progress since that observation received currency. But the way in which we have got to stop what I call this butchery of motors is by technical education, by giving facilities for training the young men in the villages. That would be a great benefit, because it would help to keep our brightest boys in the country instead of driving them off to the towns. It is in that way that we shall be able to get better results out of our tractors, and more of them will be used throughout the country. Even now, I suppose it is not untrue to say that the life of the tractor depends as to practically 80 per cent on the man and 20 per cent on the machine; at least, that is my experience after a considerable use of tractors. I am sure we all desire to do all we can to further this most important industry, and one of the ways in which it can be done, I think, is the way in which you are doing it here to-day, by bringing us all together. I hope, too, that the question of agricultural machinery will also receive your attention more than it has done in the past, from the point of view of balance between the different interests concerned. I was Chairman of the Agricultural Machinery Committee which was set up by Lord Erle in the days of the war to consider what steps might be taken to promote the development of agricultural machinery. The report of that Committee, before which Mr. Burford was a very able witness, has not yet been fully acted upon, but I believe that steps are likely to be taken by which a number of the recommendations in the report will be given effect to, and I hope that if it comes your way you will give it your most careful consideration to see whether you cannot

lend your aid and assistance in the direction which I think must ultimately redound to the great benefit of the farmers and the machinery trade as a whole.

Dr. WM. GOODWIN: My experience differs from that of Mr. Davies on the question of drivers of tractors, and I have found that there are men in almost all localities who very quickly make themselves not only efficient tractor drivers, but take pains to understand the mechanism of the tractor they are working. I am primarily engaged in educational work and I get a considerable number of young men—farmers' sons and others—and as a result of my observations, I should say that there is not likely to be any falling off in the future generation of farmers so far as interest in mechanical traction goes, and I am perfectly sure that when the right tractor comes along there will be no difficulty in getting farmers to take it up. I have in my immediate vicinity four or five farms on which the farmers' sons have from the very early days been working tractors most successfully, and some of these tractors are very ancient pieces of machinery nowadays. At the same time there are undoubtedly criticisms which the farmer will always make with regard to the tractor, and rightly so, but I am perfectly sure that on our own farm, if we had not had a tractor a couple of years ago, we could not have succeeded in getting through anything like the work which we have done. We have not, however, found that by using a tractor we have been able to employ fewer horses, but that work has been done more satisfactorily. I think that the engineer should not insist too much that the tractor is going to replace the horse, but that it will allow more work to be done, and in the long run, when all things are taken into consideration, it ought to mean a reduction in the working costs of the farm, especially when labour has settled down. Mr. Davies raised a very important point, namely, the small size and irregular shape of the fields in some counties, which cause a huge waste of time and bad work for which the tractor is unjustly blamed. If the smaller fields could be thrown into one the tractor would have a clear run, and would be able to do very much more satisfactory work. So far, then, I agree with the view that the prospects in connection with the use of tractors on a farm are good. The whole question, however, will need careful consideration; costs will be a factor, but I do not myself think there will be any serious difficulty in getting a thoroughly satisfactory tractor taken up, and if the right machine comes along, then I am sure we can trust the younger generation of farmers to see that it is worked properly.

Mr. HENRY DECK: We have before us a three-fold combination; first, there is the tractor and the supplier of the tractor; second, there is the implement and the implement manufacturer; and, third, there is the agriculturist, and I am particularly in-

(Mr. Henry Deck.)

terested in that part of the tractor outfit which is behind the drawbar. As a representative of an agricultural implement firm, closely allied with farming, I must say one thing, namely, that nature cannot be "gingered." The farmer has to look to nature to do a great deal of work for him, and to illustrate my meaning I will exaggerate the picture drawn for us by Col. Crompton in connection with roads. He said he dreamed of the day when a finished road would be formed simply by the passage of a train-load of machinery. I think his intention was to make us think that in the agricultural world the same thing might apply, and that the farmer would simply send out his tractor with a plough coupled behind it, then behind that his heavy harrows, his cultivators, then the light harrows, followed by the drill, the harrows to cover after the drill, and then the roller and the hoe, the tail being brought up by the cutting machine, the rake and the binder, and the threshing machine, the complete crop being produced in one operation. I have, of course, exaggerated the picture in order to emphasise the point which I desire to make, namely, that the farmer has to look to nature to do a great deal of his work. I do not wish to criticise what is said in the paper about the question of side draught, but I would mention that to eliminate all the side draught in a tractor, and in a plough, the ideal would be for the tractor to be powerful enough to pull a plough cutting furrows equal to its whole width. It is difficult to achieve that in this country, although it has been done abroad. A 60 h.p. engine can pull twelve ploughs, and I believe twelve ploughs with 12 in. bottoms are wide enough to cut out the full width of the engine. I am afraid that is impossible in this country, because fields are too small, and the heavy engine is not suitable for the ground. I would like to give a definition of ploughing taken from some old records, which I consider is a very apt one, namely, "the cutting of a succession of slices from the soil and laying these over at a determinate angle, exposing the greatest extent of the surface to the action of the atmosphere, covering the old surface and forming a number of parallel seed beds or rows." That is a definition with which a large number of agriculturists will agree to-day, especially those who are dealing with heavy land, because it is necessary for the furrow to be left in such a form that it will receive the full benefit of the atmosphere, and also in certain cases to obtain a seed bed.

Touching the question of the form of the present plough, some fifty or sixty years ago a paper was read on agricultural machines and engineering, in which the following comment is made:—"This defect (the formation of a hard crust or sole, caused by the slide of the plough sliding over it) is held by its opponents to be a very serious one, and in the following terms it is alluded to by one of the most graphic exponents of agriculture:—"I see that

the plough has a sentence of death written upon it, because it is essentially imperfect. What it does is little towards the work of cultivation, but that little is limited by a radical imperfection—damage to the subsoil—which is pressed and hardened by the share in an exact ratio with the weight of the soil lifted, plus that of the force required to effect the damage and the weight of the instrument itself. Were there any other reason for saying it than this, this alone would entitle the philosophical machinist to say and see that the plough was never meant to be immortal. Although the advocates of the plough admit these defects and admit them to be important, they do not admit that they outweigh the good qualities of the plough; on the contrary, they assert that by no other implement and by no other mode of working can the land be prepared in so good and efficient a way for the reception of seed and the future growth of the plant. In short, that the plough, with all its defects, is the best implement, and that the method in which it prepares and leaves the soil is the best under all circumstances."

I quote this because at that time people were turning their attention to the same problems that we are discussing now, and they were trying to find some substitute for the plough, and yet the rotary cultivator has never yet taken its place. I think that the evidence which was given by Mr. Wyles before a Committee, of which Sir Douglas Newton was the Chairman, has led Mr. Burford to make reference to this implement. Mr. Wyles said:—"There was a further idea that had occurred to him, namely, why was it necessary to plough at all? The plough was an effort to convert the horizontal pull of an animal into rotary motion, but the horse was being replaced by an engine in which the motion was rotary to begin with. The tendency of the manufacturer, therefore, was to convert the rotary power of the engine into horizontal pull, thereby getting great weight, difficulties in regard to grip, etc., and then to re-convert the horizontal pull into rotary motion." This affords a good deal of food for thought, but I will not express an opinion upon it. The rotary cultivator may or may not be a very useful implement for a farmer. I say it may not, advisedly, because I do think there are many cases where it would not be useful. In my opinion, it would not take the place of the plough, for the reason that with it the land cannot be set up in such a form as to receive the goodness that nature will put into it, during, we will say, the winter months, particularly if the land happens to be heavy.

The next point I would like to deal with is that of the speed of ploughing. I propose to read some abstracts from a paper which was read by Major Oliver B. Zimmerman at a meeting of the Society of Automotive Engineers in Kansas City on

(Mr. Henry Deck.)

February 19th, during the week of the National Tractor Show:—

“The question of what happens to the power being delivered at the drawbar is a most important one, and it is necessary to assume certain standard conditions. To simplify our analysis, let us take two well-designed outfits—the first to travel at two miles per hour, and the other at four miles per hour—these to draw four and two bottoms respectively. If we assume for the moment that the drawbar horse-power is equal, and the acreage accomplishment in the same time is equal, the following conclusions can be drawn from the comparison:—

- (a) That the tractor must move itself, and the ploughs, over the ground twice as far in one case as it does in the other;
- (b) That the number of turns at the ends is 'double in one case that of the other;
- (c) That the strains due to striking hidden obstructions are greater at the higher speed.

Then is given what happens at the rear of the drawbar, which is accompanied by charts, and the conclusions come to are as follows:—

- (1) That, placed on a comparable basis with reasonable assumptions supplementing the carefully prepared and conducted experiments used herein, the most economical ploughing speeds are unquestionably below three miles per hour, the cost rising rapidly from around two miles per hour;
- (2) If ploughs were designed to meet higher speeds they can help only in reducing the greatly increased costs at the higher speeds, but cannot by any means veer the economical point above three miles;
- (3) It is evident that the argument for better breaking up of the soil at the higher speeds is heavily paid for, and that it is more economical to perform the operation of harrowing either separately or behind the ploughs than to try to accomplish it by rapid ploughing;
- (4) That to attain the very best results with the outfits, speed-ratios of ploughing gear should cover the ranges from $1\frac{3}{4}$ miles per hour to three miles per hour. This would permit the most flexible ranges to meet the various soil resistances;
- (5) It would appear that in heavy land and ploughing up to 8 in. deep with small tractors, greater acreage would be attained by the use of 10 in. or 12 in. bottoms instead of 14 in.;

- (6) The time required to plough one acre can be tabulated thus in relation to the number of ploughs pulled:—

			Heavy Land hours.	Light Land hours.
Number of ploughs	 2		1·212	 0·643
„	 3		1·095	 0·565
„	 4		1·000	 0·506
„	 5		0·926	 0·462
„	 6		—	 0·426
„	 7		—	 0·400

- (7) The low limit of ploughing speed is obviously that speed which will permit of scouring of the mould-board. This speed will be dependent on soil conditions.

From the particulars given here, it is pretty conclusively the opinion in the United States that the most satisfactory ploughing speed is that not exceeding three miles per hour. Supposing a tractor travels at two miles per hour, and the mould-board is 3 ft. long. In theory, if the speed of the tractor is doubled the length of the mould-board must also be doubled, making it 6 ft. long instead of 3 ft. Is that a practical proposition? Can a plough with three furrows having mould-boards 6 ft. long be used satisfactorily? So far as we are concerned, I refer to agricultural implement makers generally, we have done our best to keep abreast of the times by producing the machines necessary for working in conjunction with tractors, and I think that there never was a time when so many new implements have been introduced as in the last few years. We realise that the manufacturers of tractors, the manufacturers of implements, and the farmers must work together, and I hope the Committee appointed to deal with the question of research, which Sir Douglas Newton has referred to, will lead to the attainment of good results, helpful to the agricultural implement manufacturer by way of data useful to them, and helpful to the farmer by its application in regard to his soil, and the power required for dealing with it.

Mr. MAX LAWRENCE: I believe that the true solution of this question will be that implements will be designed as entire entities, and that the practice of pulling a horse-plough and horse cultivating implements is just as wrong as trying to harness a motor into a horse-brougham, as was done in the early days. I think it is a wasteful way of applying power to use a 30 h.p. engine to turn over the soil by pulling ploughs through it and creating all the friction and so on. All driving difficulties would be overcome by driving direct on to lighter machines, and I am sure that if capital must be economised, it would be better to change the engine from a plough, for instance, and put it on to the cultivator, and then take it off the cultivator and put it on to the reaping machine. I think it is wrong to transmit the pull, as in a reaping

(Mr. Max Lawrence.)

machine, from the engine to the ground, and then back again to the knives.

The PRESIDENT: From my own observations, from many tests which I have taken, of the actual power required, not at the engine, but at the drawbar, I can support the view of one of the authors that at least two types of machine will be required. I think that if our machines were considered in the light of drawbar efficiency instead of attempting to make them of universal application, we should get nearer the farmer's requirements. The same author spoke of belt pulleys, and said that these should be from 20 to 24 in. diameter, but before deciding on that diameter the belt speed of the class of machine for which it is to be used must be ascertained. The universal belt speed all over the world for threshing machines is 2,200 ft. per minute. All English and American portable and semi-portable engines are made to give a belt speed of 2,200 ft. per minute; yet, in the tractors submitted at the recent trials—and in this respect I would like to point out that the American tractor builders, for some reason, are far greater offenders than those of any other country—the belt speed at normal engine revolutions varied from 1,900 to 3,980 ft. per minute. The question of dust has also been referred to. I should like to impress on all tractor designers the absolute necessity for efficiently filtering the intake air. It has become the practice of a great many tractor builders to incorporate either centrifugal separators or air washers, and the amount of dust that would otherwise go into the cylinders by way of the induction pipe and wear out the piston rings and the cylinders is simply appalling. With regard to spuds, I fear we have not made very much progress. We still see tractors with pieces of angle steel bolted on to the wheels, and expect them to give an efficient grip on the ground. In wet weather or on clay land, instead of gripping, they just bite up chunks of the clay and build up on the outside of the wheel, so that in a short time the wheel has no grips on at all. On the other hand, if it is hard land, they do not bite in at all. There were several excellent examples of the relative efficiencies of short independent spuds and long strakes during the recent tests. Several machines were tested, both with long strakes, long angle spuds, and with short ones, and although the makers of these machines claimed that the long and overhanging angle spud gives very greatly increased adhesion, under the hard conditions such as have existed throughout the whole of the past four or five weeks, it has shown no advantage at all. In fact, the broad strake gave less adhesion than the comparatively narrow and short strake. As regards the use of paraffin, I fear that is going to be one of our biggest difficulties, unless we re-design our engines entirely and start on the basis of the Ricardo engine, with independent cross-head and an entirely different arrangement of crank case, so that we can trap any paraffin passing from the main pistons. With existing designs we cannot get away from leakage entirely

it is there, and we have just got to put up with it, until by the process of evolution we find something better. The rate of leakage is not really so extraordinarily fast as to be a source of danger, and if only the tractor driver would change the oil periodically, not by putting fresh oil in, but by draining the old oil out and putting in fresh oil at reasonably frequent periods, he would find that although it may seem heartbreaking to throw away a good deal of oil, it would pay in the end, and possibly the oil that is drained off in that way could be used on the farm for other purposes.

The tractor has been referred to as a wartime product. It is true that it has developed more during the wartime than at any other period, but some twelve or fourteen years ago I made a continuous 24-hours' test of an agricultural tractor in Lincolnshire, and actually ploughed $21\frac{1}{2}$ acres in 22 hrs. 47 mins., so that I do not think that the tractor can be called exactly a wartime product.

With regard to hitches, I have never, until the recent tests, had any opportunity of ascertaining the seriousness of side draught, but there we had two particular machines, each of which was drawing two three-furrow ploughs with independent hitches, and it was necessary to put in two independent dynamometers. Both ploughs on each tractor were identical. The forward plough was held close up to the tractor drawbar, and the side draught was transferred to the tractor itself. In the case of the rear plough there was a coupling 10 or 12 ft. long, and that coupling, although it reduced the angle, could not transfer the side draught so freely to the tractor drawbar as in the case of the forward plough. The resistance registered on the dynamometer was 31 per cent greater on the rear plough than on the forward one in one case, and in the other it was 24 per cent greater. That represents the extra work spent in overcoming the resistance of the plough-breast bearing hard against the shoulder of the unploughed land. I was much interested in Sir Douglas Newton's remarks on spuds. He thought it would be advisable to have spuds which receded from the wheel rim as it left the ground, in other words, operated by an eccentric: nearly ten years ago I took out a patent for that very idea. A pair of wheels were fitted up and mounted on a tractor, shown at the Royal Agricultural Show, but the tractor itself was a very poor specimen of engineering, and I am not at all surprised that the eccentrically-operated spud did not show to advantage, but I do think that something of that nature, if properly developed on simple lines, would overcome many of our difficulties at the present time with spuds. A set of spuds of present-day design takes from one to two hours to fit. If it becomes necessary to move out of one field into another, across a highway, either the spuds have to be removed or the risk must be run of an action for extraordinary traffic damage.

(Mr. Burford.)

Mr. BURFORD, in replying on the discussion on behalf of Messrs. Arnott and Scott Hall, said: With regard to the President's ploughing test before the war, perhaps he would like to refresh his memory as to that $21\frac{1}{2}$ acres in 23 hours.

The PRESIDENT: That is quite correct. You will find the evidence on p. 306 of Vol. VI. of the "Commercial Motor," Dec. 5, 1907. The test was made with a Marshall tractor near Lincoln.

Mr. BURFORD: The comment I make upon Mr. Gilchrist's remarks is that in my judgment, and from my experience, which extends now over some twenty-eight years, it is impossible to compare the output of the horse with that of the worst tractor that was ever built, for this reason, that there is no horse that can work $8\frac{3}{4}$ hours a day continuously. On the other hand, the tractor can go on as long as the man will sit on it. The suggestion that Dr. Ormandy threw out is one that we all should welcome. We require as manufacturers, and we require as engineers, and this Institution particularly requires, the sympathy, support and co-operation of every party, in the world that can help us to bring agriculture to the front. In a speech I made at Shrewsbury I emphasised the fact that agriculture, being the principal industry in this country, must be restored to prosperity before the Empire can hope to retain its lead in the world, and to achieve that we must have the co-operation of such societies as Dr. Ormandy referred to. I welcome particularly Sir Douglas Newton's presence here, because he is not only an eminent agriculturist in the purely agricultural sense, but he has done a great deal to forward the mechanical side of the industry. He has referred to the committee of inquiry, and I believe the outcome of that investigation has already borne fruit in the setting up of a committee by the present Minister of Agriculture, to investigate many of the suggestions which have been put forward in the paper. Mr. Goodwin referred to the question of the right motor; there never has yet, to my mind, been the right motor. The position of the agricultural industry to-day is very similar to the position of the London streets about twenty years ago, when I had it in my mind that horse traction should be superseded by motors. In a very short time the motor omnibus development wiped the horse off the streets of London, but if we had waited then for the right motor for road traction we should never have reached this stage, and we should not have had cheap transport. The only practical course in agriculture, as in road traction, is to make the best use of the tools at hand, and with the help and experience of the agriculturists, and with the help of the younger men that are coming into the industry, we shall soon get a machine which, though it may not be perfect, will be one which will save the farmer from destruction, because, after all, if he does not use mechanical means, he must get out of the business. Without mechanical means there is no future for agriculture in this country. I will not reply in detail to Mr. Deck, but I will say this, and I say it advisedly,

that the few manufacturers in this country had, up to the war, and even afterwards, fallen asleep, and were satisfied with what they had got, and that the motor industry has not only brought them to life again, but it has quickened them, and during the last two years they have made more advance in design and in material than they have made in any similar period in their history. I am entirely in accord with Mr. Deck that subsoiling is a question that all farmers and makers of agricultural implements must deal with.

I would like to take this opportunity of congratulating the Institution on having a President this year who has done probably more from the scientific standpoint for the agricultural and engineering industries than any man in the country. His dynamometer has given us results which are probably more valuable than anything done in any other country in the world; I might, indeed, say that this country to-day leads even America in obtaining scientific results of actual work performed in the field. The dynamometer is an ingenious and practical device. We had one record of $4\frac{3}{4}$ hours continuous work, and it gave us the true work performed, and not only that, but a record of the work wasted, that is, the loss of time at the headlands. Another important feature which it records is the distance traversed by the plough before it got down to the desired depth after leaving the headland, a thing we had not discovered or thought of before.

Col. Crompton's suggestion that the larger landlords should set up establishments for the repair and maintenance of tractors and machinery is most ingenious. From the practical point of view, however, it would be preferable that the local agent, who has taken the responsibility of selling such machinery, should be equipped to effect the necessary repairs. He will be required to do so for those farmers who are not subject to the principal landlord, and he cannot set up a proper establishment on an economical basis unless he has a reasonable prospect of sufficient work to keep his department going. That prospect will only obtain if he carries out the repair and maintenance work of the majority of farmers within his district.

Mr. Gilchrist, in company with several others, referred to rotary cultivators as though we had in view the prospect of regular use of such implements instead of ploughs; that was not quite the idea which the paper was intended to convey. What we thought, and still maintain, was that much more extended use of such implements in the autumn for winter sowing and in the spring is likely to become popular and would be beneficial.

Dr. Ormandy's suggestion that the Imperial Motor Transport Committee would be willing to work in harmony with tractor manufacturers with a view to enabling the overseas farmer's requirements to be met, is a good one. We should certainly like something definite to develop from this.

Mr. C. Davies refers to the difficulty of obtaining good tractor

(Mr. Burford.)

drivers. It has to be admitted that he has touched upon a problem which concerns the majority of tractor manufacturers to-day in their efforts to induce more extended use of tractors. At the same time, it may be pointed out that it is one which has arisen in connection with other new machinery, and a parallel can easily be drawn between the present state of affairs in this regard, and those which existed during the early days of commercial motor vehicles.

We are not at all in agreement with Mr. Davies that the differential is necessary. Actually, the smaller the field the less desirable is the *ordinary* differential gear, since the usual construction makes turning more difficult. The design suggested in the course of the paper has a beneficial effect.

With regard to alinement between the tractor and the implement, Mr. Davies mentioned a case in which the work of an ordinary tractor and plough was well done and without the difficulty of alinement making itself apparent. It is impossible to answer this criticism without a fuller knowledge of the circumstances of the particular case; for example, the alinement may have been good, or, as is far more likely, the operator was a competent man, capable of making the necessary adjustment so as to reduce to a minimum the bad effect of non-alinement.

The habit which the farmer has of overloading the tractor can only be counteracted as his experience and knowledge of the ability of the machine grows. Every effort is being made by those responsible for the manufacture and sale of tractors to disseminate information which will be of value in this regard. From the technical point of view, his suggestion that an additional high-speed gear should be fitted to the tractor would, if followed, have the effect of aggravating the overloading trouble to which he makes reference, although in pointing this out we do not wish it to be understood that we are of a contrary opinion as regards the necessity for such a gear.

Sir Douglas Newton most usefully draws attention to the need for suitable implements for use in conjunction with the tractor. This is a matter which manufacturers of tractors and of implements have under closest attention. At the recent tractor trials, promoted by the Society of Motor Manufacturers and Traders, Ltd., a special class was set apart for tractor implements, mainly with a view to encouraging development in this connection. In future years it is hoped to extend the idea.

While agreeing with him that deep ploughing must be very carefully done, we deprecate the citing of such particular instances as that to which he referred, in which an enormous amount of damage was supposed to have been done about sixty years ago by deep ploughing. No good purpose can be served by references of this kind unless all the circumstances of the case are fully known and can be properly understood, so as to ascertain wherein the error lay which, as likely as not, was not that of ploughing deeply,

but of disregarding the other precautions which should be taken at the same time.

He is evidently in agreement with us that an all-purpose tractor is not likely to be useful in the long run. As regards the special type of spud which he mentions, spuds which are so fitted that they alternately project through the rim of the wheel and are withdrawn have been tried, and inventors are still busy with that problem. Up to the present success has not been achieved.

We would remind Dr. Goodwin, who repeatedly states his determination to "wait until the right tractor comes along," that our span of life here is but a short one, and that "To-morrow never comes."

Mr. Deck also, in reference to the question of implements, points out that the farmer has to look to nature to do a great deal of his work. We would point out that we are concerned with the operations which nature needs before it can get to work, and it is in connection with the speeding up of these operations that the tractor and implements will be found most useful.

In reply to his question *re* alinement, it is a simple matter to design a tractor which shall pull a plough cutting furrows equal to its whole width. The question of the power of the tractor does not arise in this connection. We have seen tractors which are already in production in this country, in operation with a plough that was but an inch or two short of cutting out the whole width of the tractor.

As regards his definition of ploughing, it is not invariably necessary that the operation should be carried out precisely as defined. We are of opinion that, as power farming develops, that necessity will diminish.

We do not see the point of his reference to the sentence of death upon the plough, unless he would have us believe that the present-day plough is not susceptible to improvement. Surely that is not what Mr. Deck would convey.

We are aware of the experiments to determine the best speed of ploughing, to which Mr. Deck refers, but would point out that those experiments were carried out on ordinary ploughs. Quite different data might accrue if ploughs of special design were used. Mr. Deck, in seeming to indicate the impossibility of constructing a plough to conform to some of the requirements of high-speed ploughing, actually shows the direction which investigators might very well follow, for, since it is impracticable to design a multi-furrow plough of the ordinary type with mould-boards six feet long, the alternative is to make an implement with short boards having a quick throw, but made to rotate in the reverse direction to the throw, so as to give the equivalent of a six-foot breast.

FIG. 3.

FIG. 4.