

FARM MACHINERY
IN
NORTH AMERICA.

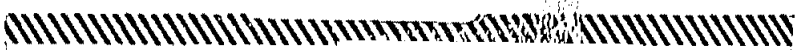


AGRICULTURE
OVERSEAS



REPORT No. 3

Farm Machinery
in
North America



H.M. STATIONERY OFFICE

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A Report submitted to the Ministry of Agriculture and Fisheries and the Department of Agriculture for Scotland by the Members of the Farm Machinery Mission following their investigation in the United States of America and Canada during May, June and July, 1945



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BRITISH MISSION TO STUDY FARM MACHINERY DEVELOPMENTS IN U.S.A. AND CANADA.

In April, 1945, acting on the recommendation of the Agricultural Machinery Development Board, the Ministry of Agriculture and the Department of Agriculture for Scotland arranged for a small party to investigate the general trend and state of mechanization, and the methods by which the development of agricultural machinery is carried out, in U.S.A. and Canada. This Mission comprised :

Major T. K. JEANS	}	Members of the Agricultural Machinery Development Board.
Mr. T. A. WEDDERSPOON		
Mr. S. J. WRIGHT	..	Director of the National Institute of Agri- cultural Engineering.

The Mission visited farms, factories, research centres and colleges, and discussed with those concerned, the various machines and methods in use, the latest developments in agricultural machinery and the part played by trained agricultural engineers in American practice. Its findings are now published for the benefit of farmers, manufacturers, agricultural engineers and others interested.

INTRODUCTION

Objectives of Delegation. The general object of the delegation as a whole was to study the machines and methods used in some sections of American and Canadian farming, and the present trends of machinery development, with particular reference to equipment which might be adaptable to the more outstanding problems of British mechanization, including root and potato growing and dung handling. Special attention was also to be given to the general mechanization of ordinary-scale mixed farming. The results of this enquiry are given in Part I of this report.

Within these general terms of reference, Mr. Wright was also particularly concerned with a more detailed study of the actual methods by which manufacturers carry out machinery development, and the part played as regards both Education and Research by the State Colleges. The results of this study are given in Part II.

Itinerary. The delegation landed in New York on May 5th, spent a preliminary week visiting U.S.D.A. Departments and the Federal Research Centre in and near Washington, D.C., and then proceeded to Ontario for visits to the Massey Harris Co. in Toronto and the Ontario Agricultural College at Guelph. Mr. Wright also paid a short visit to McDonald College, near Montreal, and had discussions with representatives of the Dominion Experimental Farms Service. The next five weeks (until June 23rd) were spent in the Middle West and included visits to the State colleges in Michigan and Iowa, the Universities of Illinois and Wisconsin and several manufacturers, including I.H.C., John Deere, Massey Harris, J. I. Case and Allis Chalmers. Major Jeans and Mr. Wedderspoon spent the next week in Minnesota and N. Dakota, while Mr. Wright visited Saskatoon, Swift Current and Lethbridge in Western Canada. The party joined up again on July 4th at Fort Collins, Colorado, where Federal work on sugar beet machinery is carried out. For the remainder of the tour the party separated, Major Jeans going to Kansas and Cornell University N.Y.; Mr. Wedderspoon to Maine for enquiries about potatoes; and Mr. Wright to California and Nebraska. The party met again in Washington D.C. on July 19th for final discussions with Professor Rae, the U.K. Agricultural Attaché at Washington, and sailed from New York on the return journey on July 28th.

General Farming Circumstances. As the above itinerary indicates, the greater part of the time of the delegation as a whole was spent in and around the Middle West, the solid agricultural centre of the U.S.A. so far as main crops and finished livestock products are concerned. There are two main regions: the Corn Belt around Iowa where maize is predominantly important, and the region nearer the great cities of which Wisconsin and Michigan are typical. Southern Ontario, the immediately adjoining part of Canada, is very similar to much of Michigan.

The predominance of maize in the Corn Belt is illustrated by the fact that in Iowa it occupies something over half the total cropped area, and accounts for two-thirds of the crop income. The other main crops in order of importance are oats, legumes (notably lucerne) for hay and silage, and soya beans; with maize, they account for over 95 per cent of the cropped area. Almost the sole purpose of livestock in this region is to turn maize into meat. Pigs are the most important enterprise, with cattle and sheep brought in from the ranges

INTRODUCTION

for finishing in summer. These are handled on what might be called "chore-free" lines. The pigs, for example, are pastured on lucerne with access to water and dry feeders filled with maize.

In the cities region there is much more dairying and rather more diversity of cropping—for example, peas and beans for canning, and here and there sugar beet and potatoes. But the main Corn Belt crops are prominent here too, with the difference that a higher proportion of the maize is grown for silage, and of the soya beans for both hay and silage, while there are barley and other small grains in addition to the oats.

In relation to these areas it has sometimes been suggested that "mixed" farming is carried on with much less labour than in this country, and that the reason may be found in a greater use of labour-saving appliances in and around the farmstead. In fact, although many of the farms visited had no more than one man per 200 acres or so, there were a variety of contributory factors. In the first place, American farms as a whole are more compact and regular in shape than ours, being based on mile-square "sections" of 640 acres with some kind of road on all four sides. An 80-acre farm, for example—and this was the original one-man unit in most areas—will almost certainly be an exact rectangle half a mile long and a quarter of a mile wide, and will involve much less transport and general running-about than most British farms of comparable size. Again, circumstances of soil and climate make cultivations, and especially weed control, easier than they are here. Yet again, there are no fodder roots and the ordinary farmer's row crops are widely-spaced above-ground crops, like maize and soya beans, which are comparatively easy to cultivate and harvest. There are no outstanding appliances in general use for harvesting potatoes or sugar beet and where crops like these are grown, additional labour is necessary on very much the same scale as with us. Finally, there was none of the close association between livestock and arable farming in the interests of fertility maintenance that we are accustomed to.

To sum up, it is certainly true that the Middle West farmer manages with much less labour than we need, but the reason lies, not so much in particular labour-saving appliances, as in the general circumstances outlined above—and in the fact that in most cases the two or three men on a farm were the farmer and his sons—or some similar partnership not generally involving hired labour. There was no escaping the conclusion that at busy seasons they put in abnormally long hours and, by comparison with our standards, get through on amazing amount of work.

PART I—MAIN TRENDS OF MECHANIZATION

Tractors. Throughout the Middle West, practically all field work is done by tractors and, due to the relative importance of maize, the great majority of these are 3-wheeled machines on pneumatic tyres. Inter-row cultivations of maize are generally carried on until the crop is far too high to pass under any normally designed four-wheeled tractor. Due to a variety of circumstances, pneumatic tyres are rarely at a disadvantage in these areas. Cultivations can nearly always be done in dry conditions; most of the land is ploughed in spring when the soil, naturally light in any case, is friable after heavy winter frost; the work is relatively shallow and can be done at high speeds. Due to the large number of wheeled tractors used in the Middle West, tracklayers make up only a small proportion of the total U.S. tractor population. Track-

layers are, however, in keen demand in other districts, notably in the potato growing areas of the State of Maine, where the land is undulating and deep ploughing is practised. There is also a great preponderance of tracklayers in California where nearly all crops are irrigated, so that much contouring and levelling has to be done while thorough subsoiling is practised for each successive crop. There is no frost to speak of in the Californian valleys, so that this work is heavy and demands the full powers of a large tracklayer.

As regards future developments in tractor manufacture, most firms appeared to be giving considerable attention to hydraulic lifts, both front and rear, and to direct-attached implements. Self-starters and lighting sets have come to be regarded as standard equipment. Synthetic rubber was in plentiful supply, and appeared to be giving quite satisfactory results. Most firms are developing still smaller models with a view to the new market represented by the so-called "one mule farms" of the South. Finally, although there is no definite information on this point, most manufacturers seemed to be experimenting behind the scenes with completely new and unorthodox models, incorporating such things as 4-wheel drives, rear steering-wheels and even divisibility.

One very striking point regarding tractors generally was that in fully-mechanized areas the number of tractors was very much smaller in relation to acres cropped than would be the case in this country. This was evidently due to a combination of circumstances already referred to: easier climatic conditions, simpler cropping, and more compact farm layouts.

Silage. The importance of silage is fully recognised by American farmers in all the dairy and stock feeding regions. Notable exceptions are Western Canada, where rainfall is insufficient for growing bulky silage crops, and the irrigated regions of California, where the climate makes successful haymaking practically a certainty. Throughout Southern Ontario and the Middle West, practically every farm has its tower silo or silos: further west, pit silage is common. Maize silage predominates but good clover and alfalfa crops are also being ensiled.

As in this country, the chief problems are the labour and transport involved in cutting heavy, bulky crops and getting them to the silo, and the provision of suitable arrangements to avoid bottlenecks at the silo. The development of forage harvesters has gone a long way towards overcoming the first problem. The typical machine can be driven by power take-off from a medium powered tractor, and can be fitted with cutter bar, pick-up, or corn picker head as alternative attachments. With the cutter bar fitted, clover, lucerne and forage crops can be harvested direct for ensilage, while with the pick-up, the same crops can be harvested from the windrow in dry or partly dry condition. With the corn picker attachment maize can be harvested as a standing crop. In either case the crop is cut or picked up, chopped and blown or elevated direct into a trailer. It seems likely that the machines could fairly easily be adapted to harvest kale. They can also be used to chop and distribute straw behind the combine. All the main firms have at least one new model of this kind in or near production. They differ in the variety of attachments available, in the type of chopping mechanism, and in the means of conveying the crop to the vehicle. Further research on this last point is needed, for although the machines fitted with blowers are more compact, they need at present more power than those fitted with elevators. Comparative trials of various machines working in the same crop would probably be advantageous.

A good deal of experimental work is evidently being done on the problem of avoiding a bottleneck at the silo. Only one special-purpose off-loading machine

was seen—a trailer intended for use in connexion with pit silos, with a power-driven conveyor bed which would unload the material automatically in the few seconds it took to pass over the pit. This was an experimental model made by Allis Chalmers and when seen in operation was being used in filling a tower silo in conjunction with an experimental blower made by the same firm. Used in this way, the trailer was not fully effective since the normal rate of emptying was far too fast for the blower. The unloading mechanism was therefore used intermittently to bring the material to the back of the trailer where it was forked off by two men. A 2-ton load was off-loaded and blown in about 6 minutes. The experimental blower had a feed hopper the full width of the trailer, with a twin auger taking the material straight to the fan, and a reversed auger to even-out the feed. There was also a separate hopper and feed for mixing-in the small quantity of maize or grain meal which is normally added, instead of molasses, to grass or legume silage (on this occasion 13 cwt. of dry meal were added to 5 tons of chopped grass).

American silage-making practice suggests two general points that may be worthy of investigation in relation to British farming. First, the fact that molasses or acid are not used to preserve their silage: maize needs no preservative and dry maize or grain meal is used with grass or legumes. Secondly, the ensiling of maize when the cob is well formed is clearly of great value to stock, especially for the production of milk. The inclusion of maize as a fodder crop would fit in well with the further mechanization of mixed farming in this country, and active experimental work on the development of suitable hybrids should be undertaken.

Hay. Two major developments in the mechanization of haymaking are exciting much interest in the States at the present time. The first is the advent of one-man pick-up balers, and the second is the mow-drying of hay. Of the two, the one-man baler is of greater immediate interest to British agriculture. All the leading firms have models in or near production. As well as the twine-tying model which has already been seen in this country, I.H.C. have a wire-tying model which is only partly automatic and needs the services of a second man. The John Deere Company has both twine- and wire-tying models, both automatic, although the latter needs a specially-prepared wire. The twine-tying models, like the New Holland, which has already been imported, need especially strong twine. An entirely new principle is incorporated in the Allis Chalmers one-man baler which rolls the material between two rubber belts into a very tight cylinder about the size of a 40-gallon oil drum. Tying simply consists of winding a spiral of 12 turns or so of twine round the bale. The starting end is automatically anchored by being wrapped into the bale, but the other end is left loose and would generally need to be pegged down later. There is no danger of the bales bursting apart—the object of the twine is merely to prevent unrolling. The output of the machine is said to be 4 bales per minute or up to 1,500 in a normal day, although it is not continuous in action. The tractor has to be stopped and put out of gear while the bale is being tied and ejected. The bales are, however, very dense, and experimental work on the keeping quality of the hay and on the general convenience of rolled-up bales in stock-feeding would be necessary before this kind of machine could be considered suitable for this country. This would be an excellent machine for baling litter straw behind combines.

Allis Chalmers are also making a one-man bale elevator which picks up the bales automatically from the ground and elevates them on to a lorry or trailer.

Other firms are also making the bale loaders ; one already on the market in California was a grab-type attachment for the side of a lorry.

The other major development—the mow-drying of hay with unheated air—is unlikely to be so important to this country. In all the tower-silo regions, every farm has its two-storied wooden barn, with accommodation for livestock below, and a large hay-mow above. A layout of ducts connected to a power fan is first laid out on the mow-floor, and then a layer of wilted and partially cured hay is blown in. Air is then blown through until the hay is fully dry. A considerable amount of work is being done on this project, but there is still uncertainty on many points. When first blown in, for example, the hay may be in any condition from just wilted to nearly fully made. Some people put in only 2-3 ft. at a time, while others put in 8-10 ft. Again the final depth of hay varies from 6-14 ft. In any case, the process is likely to be a long drawn out one by our standards : three or four fillings are generally put in, and each may need from 8-10 days blowing. Experience has shown that the hay which is put in first—and therefore adjacent to the air tunnels—dries most quickly and is usually of excellent quality ; but the upper layer tends to become mouldy through condensation. Professor F. W. Duffee of Madison, Wisconsin, who has been responsible for a great deal of work on this subject, said that the hay should be taken from the windrow with a moisture content of about 40 per cent, and should be chopped fairly long—say from 4 to 6 inches. If the material is too dry before it is chopped, much of the leaf is lost in the form of dust after passing through the blower.

Although unheated air is generally used at present, experimental work with slightly heated air is going ahead. Allis Chalmers are supplying a 20 h.p. engine (which could also be adapted by suitable design to be used as the power unit of combine harvesters or other farm machinery) for the purpose of driving the fan. This takes in its air through the engine radiator, and is said to raise the air temperature by about 6°F. The main reason for the popularity of mow drying in the States is that their chief hay crop is alfalfa, and if this "stemmy" crop is left in the field until it is dry enough to be safely packed into wooden barns, a great deal of valuable leaf is likely to be lost in the carrying process. There is therefore great advantage in getting the carrying done while the crop is still relatively moist. Finally, it is worth remembering that the dried hay is stored directly over the cattle, and can be dropped very easily into the feeding passages at the head of the cows. The overall costs for making and feeding are therefore very low.

The chopping of hay during the carrying process is an essential part of mow drying, but is also being practised quite apart from drying, as a means of saving labour by making the hay capable of being blown. Two alternative methods are being used. The first is to pick up the hay in the normal way with a hay-loader, and to carry it to the barn, where it is fed through the equivalent of a silage cutter-blower, and blown into the mow. The alternative method is to pick up the hay from the windrow with one of the silage harvesters previously mentioned, which chops the material, and blows it into a vehicle alongside. It is then taken to the barn and blown again into the mow, in exactly the same way as grass is put into the silo.

Research and experimental work is being carried out at Cornell University on hay crushing as a means of making natural drying more rapid and uniform. The John Bean Manufacturing Company have produced a machine for the purpose, which is an adaptation of an ordinary hay mower. The grass passes through a

pair of heavy rollers situated immediately behind the cutter bar, and this crushes some of the moisture out of the larger stems. In a practical demonstration seen at Cornell, the crushed grass was ready to rick one day earlier than the uncrushed, but the cost of the machine is at present quite uneconomic.

In Colorado, the delegation saw lucerne hay being swept and stacked in the field with overshot stackers of the kind which were tried in this country about ten years ago. The stack is little more than a rough heap which is left unthatched, but the winter is very dry, and this probably accounts for the success of the stackers in this region. All the sweeping is done with buckrakes, which are lifting sweeps fitted to the rear of old motor car or truck chassis. The back axle is turned over so that the drive is reversed. They look vastly superior to our car or lorry sweeps, and drawings have been brought back so that a prototype can be made. "The Hydraulic Farm Hand" made by the Superior Separator Sales Company is an elaborated sweep which can be raised or lowered by means of an hydraulic oil pump connected directly to the power take-off of a tractor. A load of 750 to 1,000 lb. can be lifted 21 ft. in the air, and the device can therefore be used as a combined hay sweep and stacker. It can also be used for sheaves, and by fitting a special fork, for loading manure. This implement should be of great interest to farmers in this country.

Combines. It is generally assumed that, as soon as machines become available, combines will become universal, and some leading firms are thinking of giving up binder manufacture altogether in the not too distant future.

The trend of production is towards smaller machines—5 and 6 ft. cut—with greater sieving and separating capacity than any machines so far sent to this country. Allis Chalmers are preparing to turn out in large numbers the new Model 44—a very slightly enlarged version of the baby machine seen here before the war.

Some research and development interest is beginning to be taken in grain drying. In the first place, due to increasing labour difficulties, it is generally felt that the rice crop will have to be combined and this will not be possible without artificial drying. Again, some firms are thinking towards a maize combine which will shell the cobs in the field, and here again drying will be necessary if the crop is to be safely bulked. With these possibilities in mind, I.H.C. already have a grain drier in process of development. It is said to be automatic in that it measures the moisture content periodically and adjusts the flow accordingly. A case of more immediate importance arises with soya beans which are being widely grown in the Middle West and are combined with the equipment already available for oats and barley. Some storage difficulties are being encountered and several State colleges are undertaking experimental work on the problem, but none of them has got very far up to the present.

An interesting experimental machine seen at the Michigan Experiment Station was a vacuum-type harvester for white clover seed. The machine was built round an International H tractor, and the clover was picked up with a large vacuum hood and blown into a covered trailer attached to the rear of the tractor. It will probably be some time before the machine is perfected for practical use.

Potato Machinery.

Planting. The bulk of the potato crop in America is planted mechanically, mainly by picker-type planters. In the potato crops seen, however, particularly in the State of Maine, the regularity of stand was not impressive.

Spraying. Potato spraying is more generally practised in America than here, as calcium arsenate (or Paris green) is used along with the Burgundy mixture for the control of Colorado beetle, and this in itself involves more frequent applications. The high pressures at which their wet sprays are applied are very impressive. In view of the long spraying season, many growers seem to prefer to build a spraying unit on to the tractor, thus securing a more manoeuvrable outfit. Films and catalogues of various types of machines have been brought back.

Harvesting. More potatoes are grown in the County of Aroostook, in the State of Maine, than in any of the other 47 States, and a careful analysis of potato harvesting methods in this County reveals some most interesting figures.

In September, 1945, 677 barrels, each weighing 180 lb., were harvested per day off $6\frac{1}{2}$ acres by 13 men with a 2-row elevator lifter. This works out at 54 tons (or slightly over 8 tons per acre), and the piece work rate is 18 cents a barrel, or 9d. per 180 lb. (If the crop drops below 7 tons an acre, or the ground is very dirty, the piece work rate is 20 cents per barrel.) The astonishing feature is that 13 men can clear $6\frac{1}{2}$ acres in a day, since with the average type of British labour, the number required would be nearer 40. During this season, a 70-year-old man has averaged 80 barrels a day, or slightly over 6 tons of potatoes picked off the ground and put into barrels. Last year one girl for eight days picked an average of 116 barrels per day on a 160 barrel per acre crop. This equals 9 tons 7 cwts. per day. The growers in Aroostook estimate that the average for all workers is about 60 barrels (approximately 4 tons 17 cwts.) per day per worker. The average figure for this country (leaving out the Holland Division of Lincolnshire) is approximately 2 tons of potatoes picked off the ground and put into baskets per day per picker.

It must be remembered that the power-take-off elevator digger has only been introduced into this country within the last seven years, and many growers are still having difficulty in getting the best results out of their machines. For this reason it has not been considered advisable to introduce the 2-row elevator digger; but the foregoing figures make it quite clear that the use of this machine can very considerably increase the tonnage of potatoes handled per worker per day—particularly when the piece work system is employed. It is therefore very strongly recommended that immediate action should be taken to make a number of 2-row elevator lifters available for trial during the 1946 season at 6 or 10 centres throughout the country, in the hands of operators who are thoroughly experienced in the use of single-row machines.

Dung Handling Machinery. The annual loss of fertility and manurial value from farms in England by the necessity of drains in cow sheds, and the daily washing away of all liquid, and most of the solid manure dropped in them, must amount to many thousands of pounds. The low fertility of many of our dairy farms makes this very obvious. At Cornell University there are no drains in or from the cow houses; all the liquid manure is absorbed by litter straw or, if this is not available, wood shavings. This is, of course, removed daily, the floors are brushed out, and granulated superphosphate of lime is sprinkled over them. This is collected with the litter and manure on the following day and carried out into the fields, where it is required on land that is deficient of phosphate. The success of this "no-drain" system is reflected in the very low bacterial count in the milk.

Most stall-type dairy farms had overhead runways and carriers with which the dung could be run out for tipping into the spreader. One or two of the

newest barns had no overhead runway inside, although a similar type of dung carrier was used on a 3-wheeled rubber-tyred chassis. When full, this was pushed to the doorway and lifted by slings on to a short outside runway for tipping into the spreader. A number of mechanical gutter cleaners were seen in operation; they are arrangements of chains and slats lying in the bottom of the gutter behind the cowstalls, one end of which is taken up over an outside ramp to a winch. When the winch is set in motion all the dung in the gutter is automatically scraped along and up the ramp into the loader standing at the other end. Under most conditions the cost of this equipment compares favourably with the cost of installing a litter carrier system. Those seen were home-made, and a Bulletin has been brought back giving descriptions and directions for farmers.

Practically every farm has its dung spreader and the aim is to put the manure straight into the spreaders and spread it on the land right away. This is evidently a policy of perfection, however, and plenty of instances were seen in which there was a heap of dung accumulating near where the spreader stood. It is questionable whether daily spreading would appeal to British farmers who would probably prefer to compost the manure first.

The only dung loaders seen on farms were buck-rake appliances attached to the front of tractors, and only a minority of farmers had them, although there seemed to be a fair number on order. They have the same disadvantage as has been encountered with similar appliances in this country—the front overhang reduces the weight on the rear wheels of the tractor so that there is a good deal of slippage about the heap.

John Deere is developing a rear-attached manure loader which seems sounder in principle. It is roughly on the lines of a contractor's "navvy" excavator, but is light and easily manoeuvred. It is power-take-off driven, and the seat of the tractor is turned round so that the driver is facing backwards. The tractor is reversed up to the heap or into the yard, and the 8 ft. boom can clear all the manure within a half-circle of 10 ft. radius. One of these machines in actual practice can keep four rubber-tyred spreaders carting, up to a distance of half a mile.

Generally speaking, American farmers are not very interested in dung, in the sense that they are more concerned with getting it out of the way than with making efficient use of it afterwards. In Iowa it was said frankly that they did not need to bother with it. In other places it was put on the pastures at any time that the weather allowed in the autumn and winter.

Miscellaneous. A very high proportion of the farms visited had a supply of electricity and this obviously made for convenience and tended to reduce chores. The cost to farmers in America, both of installation and supply, is believed to be considerably less than in this country.

Research and experimental work in the placement of fertilizer in relation to the sown seed is being carried out at several Stations, and very interesting results have been obtained. Experimental combined drills constructed for this purpose are being made.

PART II—AGRICULTURAL MACHINERY DEVELOPMENT

General Considerations. Before any description of the detailed activities of either experiment stations or manufacturers is attempted, it seems desirable to note certain factors which generally facilitate machinery development in the U.S.A.

The first and most obvious of these is the relatively enormous home market represented by nearly seven million farms. This is far more important to American firms than their export market, impressive though the latter may seem. Over the three pre-war years, 1937-1939, exports of agricultural machinery and equipment of all kinds amounted on average to only 13½ per cent of total sales, while of the machines exported nearly one-third went only over the border into Canada. Total sales of equipment over the three years averaged over 500 million dollars wholesale value annually.

A second factor is the strength and completeness of the organization of the larger companies. Through their branch houses, full-line dealers, and so on, they maintain a permanent network of intelligence, sales and service throughout their home territories and in the main export fields as well. Moreover, working in co-operation with the sales and engineering sides and with the branch house network, each firm has its own "consumer relations" or "product research" organization. The exact title varies but the general object is always the same: a sort of continual feeling of the agricultural pulse with a view to knowing in advance what will be wanted in anything up to ten years' time.

A third factor is the wide range of climate and conditions available on the American continent for preliminary trials. In the first week of May, Massey-Harris were sending their experimental combine harvesters off to start work in Southern Texas. They could have been sent out even earlier, and by moving the machines gradually northwards, development staffs could get in many months of continuous testing under almost every imaginable condition in a single season. This third factor has a definite bearing on exports: for example, tractors and equipment which are to be sold in S. Africa can be tested somewhere in the South Western States under conditions of soil and climate closely resembling those which they will be required to meet abroad.

Finally there should be mentioned the broader outlook on mechanization which exists everywhere in the U.S.A. In this country, until quite recently at any rate, mechanization has been regarded almost as an unfortunate circumstance forced on farming by high wages, shortage of labour, etc. In America it is part of the national tradition to mechanize everything. Whatever the product, industrial or agricultural, there is a general urge to cut down the man-hours involved in producing it. Owing to their shorter agricultural history there are fewer traditions of good husbandry than there are here; but even where these exist the mechanization urge often over-rides them. For example, a maker of cultivating or harvesting equipment for row-crops in this country may meet half-a-dozen different row widths in a single parish. In America one could travel hundreds of miles, be always in sight of maize fields, and quite possibly find the row widths identical in every one. Moreover, when the Middle West took to growing soya beans no one worried about the optimum row width from the crop husbandry standpoint; they planted them the same distance apart as the maize so that they could be cultivated with the same equipment. With sugar beet, row widths are being widened—again regardless of agronomic considerations—so as to facilitate work with machines. Standards are being lowered; the average beet field to-day has at least 30 per cent of doubles; an average American sample of mechanically harvested beet would certainly be refused by a British factory—and so on. Potato seed is cut almost universally to uniform size for mechanical planting and both the danger of virus disease and the effect on plant population ignored. There are already

indications that America has gone too far in this direction and is having to call a halt. But there is on the other hand no doubt that the process has favoured machinery development; and one cannot help feeling that a little more give and take in British agriculture (e.g. over things like one- or two-inch variations in row widths which do not rest on scientific foundation) would help our manufacturers in the same way.

Two odd incidents are also of some interest in the same connexion. When the President of John Deere was asked to give a specific instance in which the work of experiment stations had helped machinery development, he answered without hesitation that the breeding of maize hybrids with more uniform ears had greatly facilitated the development of the corn picker; and that the perfection of mechanical cotton pickers would depend, to an even greater extent, on the success of plant breeding work now in progress. It would be surprising to find a typical British manufacturer who felt that the N.I.A.B. had anything particular to do with his job. The other instance arose from a visit to one of several commercial firms engaged solely in the growing and sale of seed maize, where all the seed was being graded and put through planter calibrations. The label on each bag of seed sent out gave a list of the commercial planters most commonly used by farmers with the number of the seed plate recommended in each case. It is doubtful whether any British seed firm would regard the farmer's drill and its calibration as being any concern of theirs. Although these incidents are trivial in themselves, they seem to indicate a unity of purpose beyond anything experienced in this country, farmers, manufacturers and scientists, all appreciating what the others are trying to do.

EXPERIMENT STATIONS

State Colleges. All the American colleges visited were what are called "Land Grant Colleges", i.e., they were originally set up with the aid of Federal grants of land to undertake agricultural education and experiment only. Nowadays their field of activity is wider, including in addition to agriculture and engineering such divisions as home economics, applied science, veterinary science, liberal arts and so on.

As mentioned later, the educational syllabus for agricultural engineers would normally include a fair proportion of purely engineering lectures, so that in this respect there was co-operation between the agricultural and engineering divisions of the colleges concerned. In all other respects, however, the typical agricultural engineering department was a part of—and its work would lie entirely within—the agricultural division of its college.

The work of the agricultural division would take three main directions—teaching, experiment station, and extension (i.e., outside advisory work, education and propaganda). The teaching and experiment station sides work closely together and depend to a considerable extent on the same permanent staffs. The extension services, on the other hand, are separately staffed, and their work lies rather outside the scope of this report. It should be remarked, however, that these services keep American farmers much more practically informed about machinery developments, and much more closely in touch with the results of experimental work, than British farmers have been up to now.

Generally speaking, there is one college of this kind in each State, i.e., there are over 40 of them in all. In addition many of them have experimental

sub-stations in areas where special agricultural problems arise. The agricultural outlook of any one college is generally rather narrower than that of any corresponding institution in this country, for each is concerned only with the agriculture of its particular State. And while most of the States are large—all those mentioned below are larger both geographically and agriculturally than the British Isles—they have for the most part considerably less diversity of soil and cropping. There is in fact a tendency for colleges to concentrate on one aspect of farming or even on one crop. The University of Wisconsin, for example, concentrates on dairy farming while, until quite recently, the Iowa State College has devoted a great proportion of its interests to maize. *Agricultural Engineering*. At most colleges a very wide interpretation is placed on the subject. It would include such sections as "farm structures", "rural electrification", "land amelioration", "processing of farm crops", and so on—in addition to "farm power and machinery", which itself might include everything done or contemplated at Askham Bryan.

The experimental work of American colleges on farm power and machinery differs from our own mainly in that they do no testing to speak of and comparatively little research development. They concentrate on the other hand on crop husbandry problems—of the kind which we regard as outside the scope of agricultural engineering—and on studies of new techniques and methods. As crop husbandry examples, one may mention that in Iowa they were experimenting with different methods of cultivation in preparation for the maize crop; at various places they were studying fertilizer placement; in Colorado they were working on the spacing and inter-row cultivation of sugar beet; elsewhere they were studying planting depth for various crops. Technique studies included the work in Wisconsin on hay chopping, and in Iowa on silage making. Studies of the labour required for haymaking by ordinary methods led Wisconsin experimenters to the idea of chopping the hay during the picking-up process so that in the field it would be blown into the carts and at the barnyard into the hay mow. The method was tried out by lashing together some suitable combination of pick-up, chaff cutter and fan. The work has led directly to a practical machinery development (in the shape of the pick-up hay choppers which several firms are now putting on the market) but all the development work has been left to the manufacturers. The college itself did not go beyond lashing up something to demonstrate the possibility of the method.

The Iowa work on silage making was concerned with the technique of using modern silage harvesting equipment so as to reduce labour to a minimum. Using one of the most up-to-date commercial silage harvesters in the field, with an up-to-date blower at the silo, they set out to find the combination of vehicles and method of unloading which would give the highest possible throughput per man employed. For these experiments, a winch-operated unloading device and an extension of the blower feed-hopper were rigged up. The work is still going on and the practical outcome of these new features cannot be foreseen, but it is likely that unless they are suitable for farmers to make for themselves—in which case they will be publicised through the Extension Services—the college will be content to have demonstrated the method and will leave manufacturers to develop auxiliary equipment on the same lines if they think fit.

The earlier statement that American colleges do no testing to speak of, referred not to commercial testing—which is a rather special activity—but to

the kind of testing commonly done at Askham Bryan for the N.I.A.E.'S own information and as a starting point for research development. If the N.I.A.E. had done the hay chopping work, for example, it would almost certainly have gone on to test several blower arrangements in comparison with one another, in the hope that the resulting data would enable a still more efficient outfit to be designed. Again, in the silage harvesting work, it would have tried not one commercial harvester and blower but several on comparative lines with the same kind of object in view. The fact that American colleges do not ordinarily carry out research testing of this kind is certainly not due to any feeling that the work would not be worth doing. Professor Duffee (who is in charge of agricultural engineering at Wisconsin) expressed quite spontaneously the opinion that comparative tests of hay blowers ought to be carried out and would almost certainly lead to a general improvement of performance; he regretted that his department was not in a position to do the work. On a quite different occasion the head of another agricultural engineering department expressed much the same view, this time in connexion with beet harvesting. One reason, at least, why more of this work is not done is shortage of full-time experimental staff.

Staffs. All the colleges were at a disadvantage when they were visited. There had been no reservation from military service for agricultural students or graduates so that after 3½ years of war both staff and activities were seriously curtailed. Nevertheless, judging from pre-war staff lists, it would seem that agricultural engineering is something of a Cinderella subject at most colleges. For example, at Iowa (generally regarded as being particularly strong in agricultural engineering) the staff list includes (under teaching and experiment station together) only 7 agricultural engineers—although the same lists included 23 agricultural economists. At Wisconsin the corresponding figures are 8 agricultural engineers with 26 agricultural economists and journalists. At Michigan and Nebraska there are 5 and 7 agricultural engineers respectively. Moreover, most of the men concerned have to combine experimental work with teaching; the 4 colleges mentioned seem to have between them only 4 full-time agricultural engineering experimenters. It is true that in normal times the experiment stations will have a considerable number of graduate research students, but these are almost exclusively concerned with "one-year projects" capable of being started, completed, and written-up into a master's degree thesis within 12 months. Research development with machinery can rarely be brought to fruition in one year, nor can it satisfactorily be handed on from one man to another at one-year intervals. It is not surprising, therefore, that there is concentration on crop husbandry and technique studies, which can more easily be carried out intermittently.

The University of California. This State, and its agricultural college at Davis, are exceptional. California grows an extraordinary variety of crops, and many of them, like melons, tomatoes, walnuts, asparagus and so on, require equipment right outside the ordinary range. Moreover, most of the land is irrigated, and even with equipment for ordinary purposes, this often imposes limitations which make a standard type of machine unsuitable. In consequence, the State has many local firms who manufacture special machines in small numbers. Indeed, the manufacturing position resembles our own more nearly than in any other part of America although, since the farms are large and the products mainly in the luxury class, the first cost of machines is less important than it is here.

EXPERIMENT STATIONS

These circumstances probably account for the fact that the agricultural engineering department at Davis has a larger staff and undertakes machinery research development as a major activity. Much of the work is financed by the various "industries" into which Californian farming divides itself. For example, the walnut growing industry provided funds for research into its particular machinery problems. The sugar industry (in this case extending well outside the State boundaries) provided funds in the same way for work on beet mechanization. Generally these grants of money are arranged on a dollar-for-dollar basis so that an appropriate measure of independence is maintained. In any case, subject to the occasional advice of a consultative committee, the College would be given a free hand to carry on any work which might lead to further mechanization of the crop in question.

As an illustration of the work itself, it may be mentioned that after research on components—very like that at Askham Bryan, but more extensive since it has been in progress for a much longer period—the College has just built a prototype beet harvester. Like the N.I.A.E.'s machine, the prototype is a combination of components chosen after research tests, some of them original and some copied from other machines. During a long discussion with the head of the department on the principles underlying this kind of work, he was asked whether a "hybrid" machine of the kind would ever get manufactured, however successful it might prove in the field. His answer was a natural one in the circumstances; it was roughly that their job was to carry out research and if possible to demonstrate from the results how beet harvesting *could* be done mechanically. If there was a demand for beet harvesters and the machine or any part of it was the most efficient in sight, then it might be left to the common sense of manufacturers to get it produced.

When the University of California accepts grants of money for research development, it is usually subject to the condition that the industry providing the money must itself take care of patent complications, and has the right to dispose of any new invention arising from work done with the aid of the grant. In the particular case of the beet harvesting work the industry's policy on the latter point was both interesting and practical. The College was instructed to give I.H.C., John Deere and Allis Chalmers equal access to all the results and to leave them to make whatever use of them they liked without patents or royalties. (The I.H.C. beet harvester, now in the pre-production stage of development, has a "Davis" topping unit, while the John Deere harvester includes a part of the same mechanism.)

Federal Research Work. So far as agricultural machinery is concerned there is little done directly under Federal auspices. The main function of the Agricultural Engineering Department at the Beltsville Research Centre was obviously to provide an administrative and co-ordinating headquarters for outside staff. Its workshops were rather smaller and less fully equipped than those at Askham Bryan; their main purpose was to construct equipment for experimental work, e.g., planters of various kinds fitted with special hoppers and coulters for fertilizer placement studies. A sub-station at Toledo was mainly concerned in the same way with rigging up special equipment for spraying researches. The outside staff referred to above would be attached to, and the actual experimental work would be done at whichever State college was most appropriate for the particular subject concerned. Except that they would be completely free from teaching duties, the work of these men would not differ from that of the ordinary experimental staff.

The number of Federal workers attached in this way so as to strengthen the colleges' experimental work in this or that particular direction would depend to a considerable extent on political circumstances; for example, there have never been more than two Federal workers on sugar beet machinery, although over the last few years there have been some hundreds working on soil conservation.

Canadian Institutions. The Canadian colleges are similar in general conception to the American institutions except that they are smaller and rather less fully equipped. So far as agricultural machinery is concerned, however, they have virtually no experimental side. Indeed, agricultural research in Canada seems to be mainly confined to the 30-odd Dominion Experimental Farms and their sub-stations. A booklet on this organization opens with the words "The Dominion Experimental Farms stretch across Canada from the Atlantic to the Pacific Ocean and constitute the most comprehensive system of its kind to be found in the world." The claim is very probably justified.

One of these farms—at Swift Current, Saskatchewan—is particularly associated with agricultural machinery. Much of its work—like that of the American colleges—is concerned with the crop husbandry aspects of machinery and its use, but, in addition, a great deal of straightforward testing is carried on. None of this is commercial testing and no separate reports are issued. But in principle any implement of potential importance in the agriculture of Western Canada is acquired (by purchase) and tried out. The results are incorporated in annual reports to the Central Experimental Farm in Ottawa and form the basis of the advisory work on machinery that is done throughout the Dominion.

Swift Current obviously has a good reputation as the place which really knows about machinery, and manufacturers seem very willing to co-operate with it.

COMMERCIAL MACHINERY DEVELOPMENT

General Organization and Outlook. (It should be pointed out that this section represents a considered, but personal, estimation of what happens in American machinery development; and that, being based on information picked up in different places at different times, it presents a composite picture rather than one applicable to any individual firm.)

There is little that is speculative about machinery development by the American companies. It is for the most part a coldly calculated process in which all three of the main branches of the organization—sales, engineering and production—take part. Sales in this connexion can be taken to include consumer relations or product research. At any given moment "production" will be turning out the present "lines" of equipment as fast as "sales" can dispose of them. But with each item "sales" will have forecast the time, possibly several years ahead, when, owing to diminishing demand or new requirements, new "lines" will have to be introduced. "Engineering" (which in America practically means "development") will be developing these ready for production at the appropriate time, having been given a lead in the directions to be followed by product research. Product research in the meantime will be looking still further ahead for fresh subjects for the engineers to tackle when their present development efforts have reached fruition. There is close co-operation at every stage; the results of the engineers' development work must be in accord with what the selling side estimates the customer wants

—or can be persuaded to want. They must also be in accord with what the production side can turn out economically, or the customer will never get them. In one of the largest companies the final decision on any development question is made—in the shape of a recommendation to the directorate—by a standing committee of three, including one representative of each branch. There is one such standing committee for each major line, i.e., one for tractors, one for harvesting machinery, and so on.

An important part of the above process is the timing. The chief engineer of one very large organization emphasised this point as one of the main differences between commercial and institutional research. He pointed out that commercial organizations could not afford to devote much time or energy to long-term research with no definite end point, or to trying to evolve ideal machines. They had always to keep in mind the quite definite moment at which (to avoid slowing down output) the new model must be ready; and they had to be content with the best machine they could accomplish by that time. Most firms would be prepared to foster some long-term research—either inside or outside their own organization—but it must be kept within bounds and must not obscure the definite shorter-term objectives.

Once the subject for development (e.g., sugar beet harvesting) has been set up by product research, the most usual starting point for development work would be a farmer's "invention". The John Deere beet harvester, for example, started in this way; so did all three of the cotton pickers now in course of development by I.H.C., John Deere and Allis Chalmers respectively. At least one of these companies has its own "inventing" department at work in the background but, so far as could be made out, it was concerned with tractors, engines, transmissions, etc.—i.e., with things which would be separated from their agricultural context and developed on purely drawing-office and laboratory lines. It would apparently be exceptional for this department to "invent" anything agricultural, but if it did so it is reasonably certain that the "invention" would be handed over to the engineering department for practical development exactly as if it had originated outside the firm.

In connexion with a farmer's "invention" taken over in this way, it is rather important to emphasize that the typical large firm is not *primarily* concerned with its absolute merits (so long as it makes some semblance of doing the job in question); nor yet with whether it is patented or patentable. To the firm it represents essentially two things—additional concrete evidence that demand for something of the kind exists, and a definite starting point for their own development work. Having regard to the time factor already mentioned a definite starting point is almost essential. The management of a firm could hardly say to its engineering department (out of the blue as it were) "develop a beet harvester by such and such a time". But it can, and does, say "take this invention and, by such and such a time, develop it into something which can be produced and sold". In one large firm at least, to find and bring inventions to notice is a function of product research, and this probably applies fairly generally, but representatives of both engineering and production branches will no doubt help choose one for development.

One or two instances in illustration of the general outlook can be given. As mentioned already, three firms are developing cotton pickers and each started with a different farmer's invention. No doubt the first firm in the field saw all three and chose the one it liked the best. But all the large firms are too well informed as to what is going on for anyone to get far ahead in this sort

of connexion ; and it seems that the subsequent course of events would have been much the same if the three of them had drawn lots for the machines in the first place. Again, it has been mentioned that, in the particular case of beet harvesting, three firms are drawing proven ideas from a common source. Yet again, a well authenticated account of recent developmental progress with one particular type of equipment—silage harvesters or something of the kind—specifically mentioned that rival firms were pooling and inter-changing ideas. Finally, there may be mentioned an example which cropped up in California. As the result of technique studies the University rigged up and publicised a simple form of bale lifter of which some hundreds were made by small local firms for neighbouring farmers. Eventually one of the main firms decided that it was time they included something of the kind in their range of equipment, and approached the University with a view to purchasing their prototype. The firm was not at all put off by being told that there was nothing exclusive in the design and that several (small) firms were already making it. They paid for and carried off the prototype and in due course their bale lifter, in principle exactly like all the others, came on to the market. The firm obviously relied more on production and selling efficiency than on patents or on being first in the field.

Practical Development Work. The actual development process is a long business of trial and error with production requirements in mind at every stage. First, anything up to half a dozen successive prototypes will be made, tested and modified. This will be done on the firm's own experimental land or, if special conditions are required, at some outside location closely under the firm's control. The proceedings will be under a veil of secrecy at this stage, not so much to prevent competing firms from knowing what is afoot, but because rumours of things to come might check sales of present lines. In the next stage of development a relatively small number of copies of the selected prototype will be made and put out for wider-scale testing, probably in direct association with the main branch houses. But it is in what might be called the immediate pre-production stage that the real strength of the development process lies, and it is here that the general factors mentioned earlier combine to give the large American firm an advantage. Where our manufacturers make two or three copies of a pre-production prototype for final testing, the Americans may make anything up to two or three hundred. They can make a large number for testing because they have a large market and large production volume in mind. They can handle a large number because their branch house and dealer network is there to place them, keep them under close observation, and send in co-ordinated information about performance and shortcomings. Finally, they have at their disposal the wide range of soil and climate conditions which extends both the season and scope of the tests.

It should be emphasized that the overall development process is a slow one ; it is doubtful whether anything in recent times has got from starting point to production in as short a time as seven years. The John Deere beet harvester is said to have been on the stocks for something like 15 years. A crushing device for hay which was being developed by a smaller firm looked like something really recent and new, but the Nebraska invention from which it sprang was described in the R.A.S.E. Journal of 1932. One reason why development is slow is because everything must be tried and re-tried beyond all reasonable doubt before mass production can start. In any case, the firm is generally not in any hurry ; for example, if it has put something like a quarter of a million

pounds into tooling-up for a new baler (as is said to be so in one case), it will be in no hurry to have an even newer one available.

American implement firms do not seem to carry out much in the way of real research. For instance, although agricultural machines and methods are coming to depend more and more on blowing materials from one place to another, neither observations made in the U.S.A., nor general experience at Askham Bryan with American appliances, suggests that any general research work on blowing has been, or is being, done. One reason for this is that, up to the present at any rate, Americans have not been much interested in saving either power or fuel. One rarely sees a tractor struggling with its load on an American farm—it generally has power enough for twice as big an implement. If 3 h.p. is not enough for a particular purpose, an American engineer does not spend much time in finding out whether 4 h.p. will do; he is more likely to spend 10 h.p. and be quite certain about it.

On the other hand, American engineers do go to great lengths to save materials and weight. Their general practice in development is to make their machine light and flimsy to start with, and to strengthen it as required as they go along. This is, of course, sound experimental method; a machine which is not strong enough will soon tell its designer so by breaking; a machine which is over-strong gives no information on the point. In any case, the American designer does not set out to make something which will never break: he aims at reducing breakages to a definite small percentage of production output and leaves it at that. Nor are American machines made to last for ever. Engineers of more than one firm said that they would never again make tractors as solid and sound as those of 25 years ago—it was no longer good business to do so. In accordance with the general "timing" of production, machines to-day are made to last from five to eight years.

It has already been mentioned that the American engineer must keep production requirements in mind at every stage of his development work; and it may be worth mentioning that this is not the only thing, apart from sheer technical performance, to be taken into account. One example of a particular combine harvester clearly illustrates this fact. One might expect the size and shape of the main structure of a combine to depend on agricultural requirements or, at least, on what has to go inside it. In fact, the length of this particular machine is the maximum loading width permissible on the standard "flat car" of the American rail-road system, while its overall width is an exact sub-multiple of the length of the car. It is a long way from the manufacturing centres to California, Texas or Western Canada, and delivery charges on a bulky machine may run into hundreds of dollars.

Attitude to Inventors. None of the people in the manufacturing organizations visited had much sympathy for inventors. Certainly no one was in favour of doing anything to foster the emergence of more inventions. Far more were brought to notice already than they could possibly deal with, and at the psychological moment for beginning development, there were always "starting points" to choose from. In particular it would certainly not be desirable for experiment stations to go beyond the lash-up necessary to try out and demonstrate a new technique or to exhibit the results of research. When a firm takes up an invention it apparently prefers, and generally contrives, to buy up the whole thing and to eliminate the inventor as early as possible. As mentioned already, the "invention" is merely a starting point; it will be modified and changed out of all recognition before it gets anywhere, and in the modifying

process many things besides sheer technical performance will have to be taken into account.

Relations with Colleges and Experiment Stations. Through both branch houses and product research organisations, American firms keep in close and constant touch with what is going on at the colleges and experiment stations. A man fairly high up in the organization of one of the smaller full-line companies, who has been in this country several times, said that practically his sole job nowadays was to go around from one college to the next, keeping headquarters always informed as to what was afoot. But it is clear that the manufacturers' interest in the colleges lies mainly in two directions. First, they are the places where thousands of potential farmers are trained, and it is good business to do anything which keeps the oncoming generation informed about machines and mechanization progress. Secondly, the experimental work on crop husbandry and the studies of new techniques which go on there are very largely what keeps mechanization progress alive. It is mainly the work of the colleges which will create in positive shape demands for new types of machines in the future. Moreover, in this connexion the association between experimental work and education is important; by the time a new hay-chopper comes into production thousands of young farmers will be mentally conditioned to hay-chopping.

With this kind of thing in mind, American firms lend machinery very freely for instructional exhibition to students, and provide a good deal of other material in the way of films, models and so on. They also lend machines fairly freely for use in technique studies.

It would, on the other hand, be exceptional for a firm to ask a college to try out one of its products; for nothing which the average college could do in this way would count for much alongside the extensive pre-production trials which, as already mentioned, are carried out through the branch house networks. The words "average college" are used advisedly because it has already been pointed out that a rather different attitude towards machinery development prevails at the University of California, and it seems that manufacturers are also beginning to regard this institution in a special light. In one very recent case, for example, a large firm thought it worth while to send an entirely new tractor—still in the one-off hush-hush stage of development—all the way to California for an opinion on its possibilities. It was very easy to interest the men responsible (at the top) for development work in the kind of research-testing and component research which the N.I.A.E. is setting out to do at Askham Bryan, and it is likely that they would welcome an extension of the same kind of work in America. They would, however, probably want it to be kept quite separate from education.

Use of Trained Agricultural Engineers. On every convenient occasion the appropriate men in manufacturing firms were asked whether and how they used trained agricultural engineers, and what kind of men they wanted. I.H.C. said that they used 50 or 60 such men (i.e., men with something like a college degree specifically in agricultural engineering)—all of them on the sales side. Many of the younger men in the product research side of other organizations had also had a similar training. But it was clear that in the eyes of the executive heads of the firms concerned all these men were "experts in mechanized farming" rather than "agricultural engineers" in the strict sense.

The impression is, rightly or wrongly, that the agricultural engineering departments of the colleges are not yet producing quite the type of man needed

by firms for their development work. Remarks by the Heads of engineering sides on the kind of man wanted came to much the same thing in every case. They wanted, first and foremost, a good engineer—almost regardless of anything specially agricultural in his training. The second requirement—and the one which was difficult to fulfil was as wide a knock-about experience with agricultural machines as possible. In comparison with this practical knock-about experience, agricultural training (i.e., technical knowledge of crops, soils and fertilizers, etc.) seemed to be unimportant ; the proper place for that kind of knowledge was consumer relations or product research.

If the typical American young man with a degree in agricultural engineering has experience of the kind wanted, it is because (in nine cases out of ten) he has been brought up on a farm—he gets little of it in his college training. It was stated more than once that in choosing young men for the engineering side at least as much attention was paid to the (farming) homes from which they came as to the college department in which they were trained. Since a very high proportion of the purely engineering students at American colleges also come from farm surroundings, the men chosen were at least as likely to be graduates in engineering as graduates in agricultural engineering.

An engineering graduate who had had a couple of years' experience at a place where (as at Askham Bryan) there was everyday contact with tests and trials of agricultural machines of all kinds, should appeal enormously to the American manufacturer.

THE TRAINING OF AGRICULTURAL ENGINEERS

In most parts of the U.S.A. there are State laws providing for the registration or licensing of professional engineers on much the same lines as doctors, lawyers, etc. One condition of registration in nearly every case is "graduation in an approved curriculum of four years or more from a school or college approved as of satisfactory standing". Approval of curricula is given, in theory, by State Registration Boards, i.e., by a different body for each State concerned. In practice, however, since 1935 the task of accrediting curricula has been undertaken on a common basis for the U.S. as a whole by the Engineers' Council for Professional Development.

Agricultural engineering is being brought within this scheme for two reasons. First it is fairly widely felt that anyone who claims to be a graduate agricultural engineer ought to be as fully trained in straightforward engineering, and therefore as properly qualified, as any other kind of professional engineer. Secondly, even where this view is not so strongly held, educational institutions have been up against the practical difficulty that they cannot get students to enrol in their agricultural engineering courses, unless the resulting degree is one which professional engineering institutions will recognise. The E.C.P.D. has therefore included agricultural engineering in its terms of reference ; but of eleven curricula in the subject submitted by State colleges up to 1943, only three have been accredited. This means that only three out of 40-odd colleges (Iowa, Nebraska and Kansas) grant a degree in agricultural engineering which will entitle their holders to register under the State laws referred to earlier.

A first attempt at a standard curriculum tentatively put forward on behalf of the E.C.P.D. at a discussion last year will give a general idea of the ground covered. Of the lectures and instruction periods outlined, 26 per cent are devoted to basic science (mathematics, chemistry and physics) ; 29 per cent

to basic engineering subjects (mechanics, thermodynamics, hydraulics, mechanical drawing, machine design, etc.) ; and 11 per cent to applied agricultural science (farm crops, soils, farm management). Another 16 per cent of the syllabus is devoted to agricultural engineering (farm machinery and structures, soil and water conservation) ; 7 per cent to some applied engineering subject ; while 11 per cent is devoted to non-technical subjects like public speaking, and so on.

The straightforward engineering instruction at any one of the three accredited colleges—their curricula closely resemble the tentative one just discussed—is sound and practical, but corresponds rather to the better of our technical schools than to our universities. Agricultural instruction is probably very sound, subject to the limited outlook of the typical college and to the small proportion of time devoted to it. Judging by examination papers and similar material which were displayed, the standard of instruction in actual agricultural engineering is low—not much above what the N.I.A.E. manages in a six weeks machinery instructor course. It should be realised, however, that the teaching activities in agricultural engineering departments are mainly concerned with teaching what might be called “ farm mechanization ” to large numbers of purely agricultural students. A great deal of instruction in handicrafts is also given in the same connexion. At every college visited the most prominent feature in the department was a large shop with innumerable small forges for instruction in horse-shoeing and elementary smithing. These shops are however gradually being converted so as to concentrate mainly on instruction in welding. The total amount of instruction of farm machinery and its care and maintenance which ordinary agricultural students receive far exceeds anything yet seen in this country.

After something has been seen of the American system, the feeling remains that our future needs as regards agricultural engineering training will best be met by giving selected engineering graduates practical post-graduate instruction. The machinery advisers of the future can best be provided in much the same way, i.e., by giving agricultural graduates suitable post-graduate instruction in engineering. There is, however, some doubt as to whether any scheme of the kind can be put into effect quickly enough to meet the needs of the next few years, and we were specially requested to look into the possibility of covering the interim period by sending graduates to America (or Canada) for further instruction. It appears to be hardly worth while to send engineering graduates to an American college for the agricultural and agricultural engineering instruction necessary to convert them into agricultural engineers. They would already be better engineers (from the University standpoint) than corresponding American graduates, while the agriculture they would learn would be limited in scope and would have little reference to conditions in this country. This was also the opinion of all the American professors with whom the matter was discussed. There would, on the other hand, be far more to be said for sending agricultural graduates abroad to receive additional instruction appropriate for machinery advisers, and there would probably be little difficulty in fitting a relatively short period of instruction into the flexible American college system. All the colleges visited were keenly interested in the general idea of taking British graduate students of either class, and they would no doubt be willing to co-operate in any way desired. Opinion favoured sending one or two students to each of a number of institutions rather than a large number all to the same place.

CONCLUSIONS

One general conclusion to be drawn from this study is that American supremacy in agricultural machinery development is due far more to the economic and general factors than to the particular kind of men used or their developmental methods. As regards both production and design for production, the large firms are in a different class from anything in this country, but their methods cannot be imitated very closely in a quite different economic framework.

As regards research, there are no purely experimental institutions, and there is nothing quite parallel with the N.I.A.E. The college experiment stations obviously play a very big part in the overall result, although comparatively little of their work relates directly to machinery development. Their strength lies not so much in what is done at any one place, but in the fact that they are widespread all over the continent, and, through their extension services, penetrate into every corner of it. It is doubtful whether, in relation to the area concerned, there are as many men actively engaged in studying agricultural engineering problems in the States as there are here, but their impact on farming methods is obviously far greater.

As regards the lessons to be learnt, we are perhaps wrong to divorce crop husbandry experimentation from agricultural engineering research quite so completely as we do at present. By the time a new crop husbandry problem nears its solution in America, the machines necessary for the farmer to put it into effect are there waiting to be sold to him. In this country it seems often to be forgotten that the practical outcome of, say, fertilizer placement research, will depend to a great extent on whether suitable machines grow up, as it were, with the experimental work.

Nothing like American product research and their widespread testing of prototypes is easily possible when the industry consists, as ours does, of a large number of small firms. However, both the information and testing sides of the N.I.A.E.'s work at Askham Bryan can probably be extended to provide a very useful substitute in the circumstances, so long as the industry itself co-operates both in developing and in making use of it. Britain's future as regards agricultural machinery will clearly depend very largely on our success in export markets, particularly those in the Dominions and Colonies; and what Askham Bryan or any similar institution can accomplish will be limited unless its interests are extended into this field. It is not suggested that Askham Bryan should have overseas sub-stations, but leaving out the sheer research development side, the foundation of corresponding institutions throughout the Empire ought to be encouraged together with a regular exchange of ideas and staff.

Again, with the Empire in mind, advantage ought to be taken of the fact that Americans are not greatly interested in conserving either power or fuel, and partly in consequence of this, do comparatively little real research on machinery. Research might very well enable British manufacturers to offset by better performance the disadvantages arising from smaller-scale production.

RECOMMENDATIONS

We recommend the importation for practical trial in this country of a number of the machines which have been mentioned in our Report and have already submitted a detailed list to the Ministry. There are included a

RECOMMENDATIONS

representative collection of modern silage harvesting equipment, some typical automatic balers, and two devices for handling or loading dung and other farm materials, as well as two potato graders and one or two minor items of interest. We consider that more active experimental and demonstration work on the harvesting and making of silage should be undertaken in this country, with particular attention to the adaptation of modern machinery to our crops, including kale, and to the possible use of meal instead of molasses or acid as a preservative. We particularly recommend that attempts should be made to obtain or develop maize hybrids suitable for growing as a silage crop in our climate. We also recommend that the manufacture of a small number of two-row elevator potato diggers should be encouraged and that their labour-saving possibilities should be studied under practical farm conditions.

Finally we direct attention to the advantages which result, as regards both cleanliness of milk and maintenance of fertility, from the fact that drainage of cowsheds and dairy barns is not compulsory in America and so is very seldom practised; and we suggest that our own Dairying regulations should be re-considered in this aspect.

Signed T. K. Jeans.
 T. A. Wedderspoon.
 S. J. Wright.