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OF THE
INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

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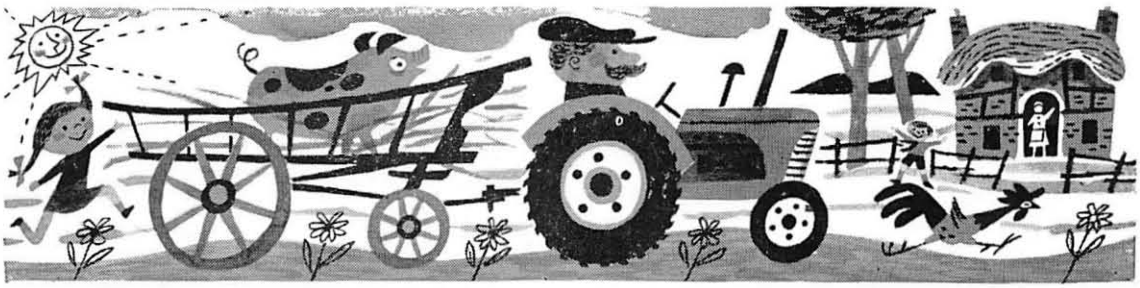

JOURNAL AND PROCEEDINGS OF THE INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

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CONTENTS

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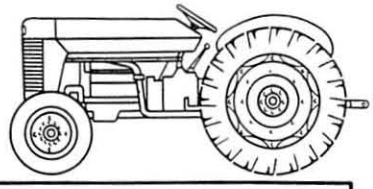

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INSTITUTION NOTES

Open Meetings

AT the Annual General Meeting on 5th May it was decided that the time of Commencement of Open Meetings in London would in future be 2.15 p.m. This decision was taken following an experimental period of two years, during which these meetings were held in the evening. Attendance figures had shown that afternoon meetings were, on average, better attended than those in the evening.

Graduate Membership Examination

The first examination for entry to Graduate Membership of the Institution was held in July, taking place concurrently with that for the National Diploma in Agricultural Engineering. Successful candidates will become eligible for Graduate Membership, and those with sufficient practical experience may be elected to Associate Membership of the Institution.

Lectures for Schoolboys

The Council has decided to continue with the provision of lectures designed to interest schoolboys in careers in agricultural engineering. Following upon the initial talk delivered in London in November, 1957, consideration has been given to the form and content of the lectures with a view to them being presented in London and the Local Centres, and possibly in Schools throughout the country.

N.D.Agr.E. Scholarships and Bursaries

The " Dunlop " Scholarship has this year been awarded to Mr. Derek C. Farnes, who has recently taken his B.Sc. (Agric.) at Reading University. Mr. Farnes will proceed to the Essex Institute of Agriculture for the final course of study for the Diploma.

"Shell-Mex" Bursaries were awarded to Mr. D. A. Sims and Mr. J. B. Underwood, both of whom will also complete their training at the Essex Institute.

ELECTION OF HONORARY MEMBER

AT the Annual General Meeting held on 5th May, 1958, the President announced that the Council had elected Mr. J. C. Gough an Honorary Member of the Institution.

The President said that Mr. Gough, elected a Member in 1945, had rendered quite outstanding service, having held office for a consecutive period of nine years, being a member of Council 1948 to 1951, Honorary Treasurer 1952 to 1954, and Vice-President 1954 to 1957.

During all of this time Mr. Gough had been most active and was largely instrumental in the introduction of policies which had increased the standing and influence of the Institution, in particular the improved financial position revealed by the 1957 accounts.

The gratitude and thanks due to him could adequately be expressed only by the award of the highest honour the Council had in its power to bestow—that of Honorary Membership of the Institution.

The President's announcement was received with acclamation.

Mr. Gough, after Army service in the 1914–18 war, joined the Staff of the Education Inspectorate of the Ministry of Agriculture in 1920.

In the early part of 1939 he was appointed Tractor and Machinery Inspector, with responsibility for the examination of machines then being stored against the possible outbreak of war.

From this evolved the Machinery Inspectorate, which he headed throughout the war, until, in August, 1956, after the passing of the Agriculture (Safety, Health and Welfare Provisions) Act, he was appointed as Chief Inspector (Safety and Wages) to the new Inspectorate set up at that time, and continues in this post.

JIG AND FIXTURE DESIGN FOR BATCH PRODUCTION OF AGRICULTURAL MACHINERY

by P. W. LESTER, M.I.B.A.E.*

A Paper read at a Meeting of the Institution on 11th March, 1958

THE production of nearly all agricultural machinery may be classified under three headings. At one end of the scale we find machines which can be sold at the rate of hundreds per day. Most tractors come under this heading. At the other end of the scale will be found one off or special purpose machines, such as storage or refrigeration, seed dressing and washing plants, in which each set of equipment must receive individual attention from a designer.

Between these two we find the production of machines which can be sold at the rate of a few thousand or in some cases a few hundred a year which lend themselves to a system of batch production. There is a distinct difference between mass and batch production. Mass-production results in high turnover, which on the output of large numbers of a single machine may amount to £100,000 per working day. Production at this speed is only made possible by the installation of specialised production machinery to obtain the high turnover which makes the installation financially possible. But in the case of batch production there are small factories working successfully on an annual turnover of about £100,000—in other words, the same kind of turnover in a year as the large factories have in a working day.

The small agricultural engineering factory will produce machines to meet a demand of a few hundred per year. To produce these small numbers highly specialised production machine tools are not necessary. Good general-purpose machines such as centre lathes, drills, oxyacetylene cutting plants and electric welding generators, hydraulic presses and so on will by the use of jigs and fixtures be temporarily turned into specialised production tools. Thus the production of a batch of quite different parts can be obtained by the use of a different set of jigs while using the same machines.

It is characteristic of batch production that the specialisation of the machine is temporary, whereas in mass production the machine specialization is permanent. It is the object of this Paper to consider the jigs and fixtures necessary to use general-purpose machines for specialised batch production of agricultural implements. It will be appreciated that however small the number of implements or component parts that it is proposed to make a jig, fixture or master form must be used to ensure interchangeability.

* Managing Director, Bomford Bros., Ltd.

In modern mass production the toolroom can be considered as one of the most important foundation stones, for the accuracy obtained in repetition engineering is derived through the skill of the toolmaker. The construction of the present-day mass production automatic machines and lathes fitted with tracer control mechanism is designed to produce one item for long periods. These machines have all the devices required to retain the components in position for machining, together with the necessary cutting tools and guides which, in turn, result in machine shop automation.

There are fundamental differences of approach to the problem of jig construction. In mass production a machine is designed to do one job and is in itself a jig. In this illustration a multi-drilling machine for extension shaft holes in various camshaft and crankshaft gears is shown. The multi-head, which is, in fact, a gearbox with spindles at the required centres, carries drills that pass through a spring-loaded bush plate. The base or table is four-station indexing. Gears in three positions are drilled simultaneously, whilst the fourth position is unloading and loading. In the first position four bolt holes are drilled ; in the second, one dowel hole ; in the third, the dowel hole is reamed. The table is fitted with removable adaptor pieces to enable the different size bore gears to be drilled.

In mass production these machines have superseded a considerable number of the jigs and fixtures which used to be necessary. In batch production the approach to this problem is very different. The terms jig and fixture are often used somewhat loosely ; it is therefore difficult to distinguish precisely between them. A jig can be regarded as a device to guide the cutting tool into the work that has to be machined, a fixture to hold parts rigidly together during assembly or when they are welded. One of the most common forms is that which is used for the drilling of holes. These are of frame or box construction and components can be loaded in stacks into them. The drill is guided through hardened steel bushes, which are inserted in the top face of the jig. A fixture will generally come into use after the components have been machined, the holes and machined areas being used to register the work-pieces to form the unit under construction.

In the batch production of agricultural machinery, particularly implements, machining is kept to the absolute minimum. A look at the products of the small works will emphasise this. These workshops contribute a substantial number of the implements in use on farms today. The implements will be manufactured in batches of 50 to 100 at a time. If the components are to mate with one another with a reasonable fit and they are to be chosen without selection when assembled, then each individual part must be made to within a defined limit. It is at this stage that the demand for jigs must be met to speed production and ensure accurate work.

In the approach to this question a small firm will have more freedom of action than the large organisation with its set-up of designers and project engineers, who in designing these jigs think first of castings in iron. This, in turn, will of necessity entail a considerable amount of machining, and because of the limited machine availability the small works freely use electric welding in the construction of devices to aid their production. This will result in a substantial saving in weight of material, a reduction of machining and a considerably reduced time lag between the prototype and the production implement. The devices will be made from the stock steel angles, channels, flats and rounds that can be found in any steel rack. The secret of good machining is accurate setting up of the work that is to be machined.

When designing drilling jigs the possibility of so constructing them as to take more than one component should be very carefully considered. By this method the total number of jigs required on a project will be cut down. In addition, considerable time will be saved on production, for when the jig is once set on the drilling or milling machine various different components can be processed. If when planning the construction of the implement consideration has been given to using, where possible, the same size bolts, different dimension steel bars can be drilled in the same jig by the use of alternate positions for the register pegs and locking devices.

Other small aids to increased production are the methods used to retain the components in the jig. The most favoured will be the eccentric cam for ease and speed of operation. Where the choice is between the cam and the screwed set stud, the latter should have a swivel handle attached for quick application of the load. The use of the engineer's spanner cannot be allowed, because it will always be missing when wanted, and undoubtedly is a factor contributing to operator fatigue.

In the small engineering works the function of the toolroom is more often undertaken by one man with the assistance of the designer of the machine to be manufactured and only a limited supply of toolroom equipment. He often lacks the advantage of an apprenticeship, but possesses, however, an inborn skill and ability to work to fine limits, and his contribution to the design of the fixtures and jigs is considerable. He is invariably an all-round mechanic, capable of operating lathes, millers, drilling machines, oxyacetylene cutting and electric welding plant, and he will produce all the devices required.

The modern special jig boring machine which is common in the roolroom of the large engineering organisation, together with all the other aids to accuracy, will not be found in the small factory ; other methods will therefore be used to obtain the precise location of holes in the jigs under construction. The jig maker is repeatedly called upon to make a jig for drilling holes in predetermined positions, and the accurate position of the holes is of the utmost importance.

When accurately-spaced holes are required, the popular method of obtaining them in the small factory is by the use of what is known as toolmaker buttons. A set consists of an accurately machined hollow cylinder and a set-screw. The internal diameter of the cylinder is slightly greater than the diameter of the set-screw. It will be appreciated that while the set-screw will hold the cylinder firmly on the face of a job, it will still be possible to move it in a radial direction within the limit imposed by the difference between the diameter of the set-screw and the internal diameter of the cylinder. Fig. 3 shows the use of buttons to obtain the fine limits required in the manufacture of a die and punch holder. The punch holder and die are first machined flat on their faces. The next step in the operation is to mark out the approximate centres of the five holes that have to be drilled. On these, centre holes are drilled and tapped for the set-screws that will hold the buttons on the face of the die. By measurement with a micrometer from the centre button to each button in turn on the circumference, and between the buttons on the circumference they can all be set at the predetermined positions of the holes. The set-screw is now tightened to hold the buttons rigidly in position. The die is mounted on to the lathe face-plate and adjusted with the aid of a test indicator for one button to run concentric to within a tenth part of a thousandth of an inch. The button is now removed and the hole bored to the fine limits required. The procedure is repeated for each hole that has to be machined. Great care must be taken in the operation to ensure that the holes coincide in the die and punch holder.

The most common form of jig for drilling holes consists of two mild steel plates machined on both faces and clamped together on to parallel distance pieces. Struts are then welded to the top and bottom plates to hold them together in parallel planes. It is an advantage to provide a clearance between the pack of components and the top plate carrying the guide bushes to give the swath a free passage from the drill other than through the drill guide bush. Projections are welded to the plates and the necessary holes are drilled in them. These holes are for the register pegs and the bolts which hold the jig on the lathe face-plate for the boring of the predetermined holes for the drill guide bush. The true position of the guide bush hole is obtained by the previously described method by the use of toolmaker's button. The drill guide bushes are obtained from manufacturers who specialise in this equipment. A jig for boring a mower con-rod consists of a mild steel plate, machined on one side, which is then fixed to a lathe face-plate, with two bolts which act as registers for setting the jig. The lathe face-plate is, of course, used for many other purposes. The centre portion of the mild steel plate and the pitch circle are machined to a common face. The plate is recessed concentrically with the lathe face-plate to allow the outside of the hydraulic tube forming one end of the con-rod to enter. On the machined pitch circle with a radius corresponding to the centre-to-centre dimension of the con-rod, two holes are bored and recessed to the same depth as the hole at the centre. Dowels are fitted into these two holes. One will fit the hydraulic tube before it has been bored, the other after. The quick release clamp secures the rod for machining. The con-rod is positioned on the plate with one end secured by the smaller dowel and the other by the recess at the lathe centre. The latter is bored and the con-rod is reversed with the bored hole secured by the larger dowel. The other end is then bored.

Fig. 7 illustrates a drilling jig that will accommodate eight different shaped work pieces. Seven drill guide bushes are fitted into the top face—two $\frac{3}{4}$ in. and five $\frac{5}{8}$ in. size holes. The 4 in. channels are drilled in pairs back to back. The other six profiles are loaded into the jig in stacks of eight. Each piece is located by the different positioning of the register pegs. Alternative positions are also provided for the eccentric cam. Four differently dimensioned and shaped components were drilled in this jig, which is fitted with two sizes of drill guide bushes. Permanently fixed register pegs are used and only the cam is moved. This drilling is done in stacks of eight. In Fig. 9 is shown a jig that will take four differently dimensioned stock flat bars. Two drill guide bushes $\frac{3}{4}$ in. and two $\frac{1}{2}$ in. are used.

Fig. 10 shows a drilling jig for a quadrant. The base and centre pillar started life as a steam engine winding drum spindle. The pillar was machined to take the rotating arm, which is a steel fabrication. This arm was then bored a working fit to rotate round the centre pillar. At the determined radius, two holes are bored in the rotating arm—one for the drill guide bush, the other for the register peg. A pack of six quadrants is loaded. The first hole is then drilled at one end, the arm rotated, the peg inserted in the hole just drilled. Another hole is drilled and the procedure repeated round the quadrant. All the components that have been illustrated are in course of preparation for fabricating into units by electric welding. All are from mild steel stock bars, angles, channels and flats.

When designing fixtures for welded work, consideration must be given to the following points : There should be freedom of access to all joints that have to be welded ; ease of loading and unloading is of great importance, for it will have a considerable effect on the daily output ; the fixtures should be designed so that components can only be inserted in the correct position, in which case semi-skilled labour can do the loading.

The behaviour of components that are to be welded in the fixture cannot always be foreseen. Clamps should be so positioned that they will control distortion of the product, for it must not lock in the fixture and hinder removal after welding is complete. The arrangement of the clamps must not impede the uninterrupted deposit of the electrode. They should be quick-acting toggle or cam clamps, or best of all the cheese-headed slotted pin and wedge to facilitate quick and accurate assembly of the components. The fixture must be mounted on bearings to enable the operator to rotate it at will. The three reasons for this are all important : Firstly, the welder should always work in a downhand position ; secondly, he should always have the easiest possible access to the weld ; thirdly, his working position should be as comfortable as possible. The rotation of the loaded fixture should be carefully balanced for ease of movement and to ensure that it will stay where put. Two types of quick-acting cam clamp are used. In the first the stud will fit the hole in the fixture and register the components into the correct position, the cam locking the component during welding. The other has a cam on a swing arm. The arm is attached to the fixture and the register stud in this instance permanently fixed. The two or more components can be quickly assembled and the cam clamped down. The advantages of the cam clamp are : Firstly, no loose separate parts ; secondly, can usually be operated with one hand ; thirdly, when attached to the fixture is always where it is wanted. It has, however, one disadvantage, in that it will in certain positions impede the deposit of the electrode. These illustrate three of the methods used to retain components in rolling fixtures for welding of implements in batch production. The use of screwed nuts and bolts should be avoided for retaining components in a welding fixture. The splatter from the electrode is bound to fowl the thread and lead to loss of time when removing the unit from the fixture.

It is essential that the fixtures should be constructed in the most economical manner. Fixtures designed for and constructed by electric welding will have a simplicity not possible with other methods. By welding small factories can use material which would otherwise be scrapped. The ability to fuse together parts of a unit eliminates machining which is required when other methods are used. In a few hours fixtures can be produced from stock bars, angles and channels which will give years of trouble-free service. In constructing fixtures by welded fabrication, the saving in material and the consequential reduced weight is an advantage. Mechanical aids will not be necessary to enable the operator to rotate the fixture for the correct welding sequence of the components. The easy manipulation of the fixture by hand will aid the welder to work for long periods without fatigue.

Fig. 14 shows a rotatable fixture loaded with components and the finished product after removal. The fixture is used in the welding of a mount to carry an implement fitted to a well-known tractor. Here we have a stand with a bearing on the top of the upright to carry the shaft on the vertical face of the fixture. The base of this fixture is a reproduction of the side members of the tractor. Stock channels, angles and plates are formed at right-angles to this base, and to them are fixed guides to take the units which comprise the mount, which are then clamped into position for welding. The mount when complete weighs 100 lb. In this fixture the operator can assemble the units and manipulate it with ease to any position of the clock for down-hand welding. Fig. 15 illustrates another welding fixture. In the top illustration the components are loaded in the fixture and welding is completed. The lower illustration shows the finished product after removal. The fixture is suspended on trunnions from two tripods ; this enables the operator to manipulate the fixture to any position for down-hand welding. The holes in the angles are jig drilled before assembly into the fixture for welding. Because the holes are the only machined surface, they are used to position the angles in the fixture. Permanently fixed registering dowels are provided to receive the angles. The construction of the fixture is from heavy section angles and channels, and with the correct positioning of the component retaining pins and wedges the fixture will prevent welding distortion. When loaded it is balanced and will stop at any angle to which the operator rotates it. On completion of the welding the unit, which is a sub-assembly of a cradle to carry a 2-h.p. engine, is quickly and easily removed from the fixture.

Designed for the production of threadless joints for irrigation spray-line pipes is a table consisting of a R.S.J., 16 ft. long, planed on one web and erected on legs fixed to the shop floor. At one end a male and at the other end a female column or upright strut are fixed at right-angles to the machined face and parallel in two planes one to another. A $1\frac{1}{2} \times 16$ in. gauge steel tube is inserted between two flanges, which are carried on the columns.

First the flanges are spot welded to the tube, thereby fixing the flanges in their correct angular relation to each other. The tube is now removed into an intermittent rotary apparatus, shown in the lower illustration, to enable the operator to put down an uninterrupted weld round the whole circumference of the joint. In this intermittent rotary apparatus an internally-geared $\frac{1}{3}$-h.p. electric motor with a shaft speed of 50-r.p.m. drives by way of a 5 to 1 reduction a countershaft to which is fitted a steel disc on which pegs can be bolted on different pitch circles. The pegs contact an arm near the top of their arc of travel, imparting a rise and fall motion to it. A spring keeps the arm in contact with the pegs. A link transmits the motion to a ratchet ; the link is adjustable on the pawl carrier arm. Speed of travel can be varied by an alteration of the pegs on a pitch circle, which in turn selects the number of teeth engaged by the pawl on the ratchet wheel ; thus the peripheral speed of the pipe can be kept constant, irrespective of pipe diameter. With the selection of the correct electrode welding deposit will be uniform.

When the flanges have been welded the pipe is returned to the fixture. This is now used for drilling and tapping holes at fixed intervals in the pipe. The table carrying a pillar to which an electric drill is fixed slides along the machined face of the R.S.J. ; V-blocks position the pipe ; a drill guide bush is fitted to a swing arm. This swinging of the arm is necessary so that the pipe can be loaded into the jig. A spring-loaded plunger registers the drilling station. With this set-up a throughput of 80 completed pipes—welded, drilled and tapped—per $8\frac{1}{2}$-hour working day is obtained with one man and one boy. Approximately 900 ins. of fillet welds are deposited, and during cold water test to 100 lb. p.s.i. pressure on the pipes porosity is never found.

Fig. 18 shows a fixture for the fabrication by welding of a beam for a special-purpose mower. Six completed beams are produced in nine working hours by one man. There are 20 separate pieces of tube, flats, angles and rounds to be welded to the main tube. In all, 134 ins. of fillet weld is put down. This rolling fixture is constructed from a R.S.J., and mounted in bearings on two stands. It allows the operator to move it when welding so that the deposit of the electrode is uninterrupted. By this method he will always be welding in the down-hand position—a most important point with fillet welds, for tubular constructions do present some difficulty. The loading of the components into the fixture in this instance is done by the welder. It is only by using this balanced rolling fixture that the operator can deposit in all 90 ins. of fillet weld in one hour. Payment for this job is by piece-work at the rate of 10/9 each. Where possible, the cheese-headed slotted pin and wedge is used to retain the components. It was necessary, however, to use quick-release clamps to retain the tube. Left and right-hand beams are produced. This entailed two different fixtures, since it proved impossible to accommodate both in the one fixture. The right-hand beams are produced to meet export demand. The mower is for the special purpose of road verge maintenance. There is an advantage in a welded construction for an implement of this kind, because it will allow slight changes in design that may become necessary to be done without expensive alterations to patterns as would be the case with iron casting.

The illustrations have shown a few of the devices designed and manufactured by one small batch production factory. Although many of them would be considered unorthodox in design and construction, they have proved increasingly profitable in use for a number of years and a high standard of accuracy has been maintained. The policy has always been to avoid dependence on outside assistance in the construction of any jig or fixture and only specialised products are obtained from manufacturers of this equipment. The small factory must be constantly on the alert to use any new idea to aid production, and it should be possible for suggestions from the shop floor to be communicated direct to the designer draftsman. Attention has been called to the difference between mass and batch production. The effect on personnel should not be overlooked. The competition for labour between the two systems is constant, but the man who wishes to retain his ability to use initiative will more often choose the smaller factory knowing that the conditions of employment are similar and there is little difference in pay, pension schemes and holidays. In the small factory engaged on batch production the operator will often use different types of machine in the course of the working week. This, together with the extent to which he must use his own initiative and accept responsibility, provides him with the variety that is essential to maintain the interest in the work he is doing. The small factory is usually free of labour trouble because of this interest and because of the free and easy contact with the management, who are often on the shop floor and working with the men on a machine or project. This gives mutual understanding of each other's problems and will lead to a contented and happy relationship.

DISCUSSION

MR. J. E. NICHOLSON* : We have heard a most interesting discourse on jigs and fixtures and I do not feel myself very well qualified to open the discussion, since my experience is not nearly so great as Mr. Lester's. I understand that Mr. Lester served for many years in the jig and tool industry where jigs are really jigs. He has shown us how he has been able to adapt his vast experience and ingenuity in producing jigs for making agricultural implements in the smaller firm.

My firm is a smallish one and I am very pleased, and also comforted, to find that our methods are very similar to those used by Mr. Lester, so that I do not think we shall cross swords on many points. There is no doubt that in producing implements in the smaller firm jigs can make or break a job. If you become too enthusiastic about jig making and make them too complicated you can spend a lot of money on producing a beautiful-looking jig which in the end helps to produce a hole which costs, perhaps, only ¼d. when it comes to the piecework price.

That brings me to the question of accuracy in jig making. Mr. Lester has demonstrated a very neat way of producing holes accurately spaced without the use of a jig borer. The question is what accuracy is required of a jig for drilling holes in a cultivator frame ? The holes may be $\frac{1}{32}$ in. larger than the diameter of the bolts, so there is no need to spend a lot of money to get an accuracy of half-thou. I put that point because one can sometimes spend much time and money on making a jig more accurate than is necessary.

There is a great advantage which we smaller manufacturers have in jig making, and that is that very often the person who designs the machines designs jigs also, and as he goes along designing a machine he has jigs in mind. That is one of the ways in which the smaller firm maintains flexibility. If one has to change the design to meet the demand one can design the jig according to who is going to use it. You know that Bill Jones is going to use it and you know that he is left-handed, so the jig must be left-handed !

I think most of the jigs mentioned have been for fabricated parts or parts for incorporation in fabricated assemblies. I will deal now with castings and the jigging of castings. In addition to those which Mr. Lester has shown us, there is a type of jig which I find very useful for handling castings. I am referring to a casting which might, perhaps, form part of a gearbox where you have a number of holes in bosses in the casting which probably have to be drilled and faced both ends and in some cases reamed or tapped. Where there are a lot of operations of this type on one casting we produce, in our factory, a turn-over jig on which all these operations can be done at one set-up. This consists of a jig-table which is mounted with trunnions so that it can be turned over 180 degrees in the horizontal plane. The back side of the table contains clamps so that you can turn the jig table over on the trunnions, load the casting and clamp it, and turn the jig table back again to expose the jig bushes. The table is then clamped and all the holes are drilled. If you have bosses that side to face, large slip bushes are used which can be taken out to expose the bosses for facing. The jig is then turned back 180 degrees to expose the back side of the casting free of all bushes and you can face again or ream, and you can also tap any holes which require to be tapped.

Mr. Lester said that spanners were anathema to him, but I think that sometimes they are necessary. I am thinking again of castings requiring heavy machining operations. Sometimes there is no room for a toggle or an eccentric clamp. One cannot always afford to put in an air or hydraulic clamp and one has to come down to a nut and spanner. I like a big one so that the operator can see it and get hold of it, and it is also useful from the point of pressure on the thread of the stud. From the point of view of wear, studs or bolts less than $\frac{5}{8}$ in. diameter are not satisfactory.

Again, on welding jigs, Mr. Lester mentioned that if you have a stud and nut the splatter from the electrode sometimes makes it difficult to get the nut off. We often use a cap nut which covers the stud, and sometimes we weld a T-piece on to the nut to make it easier for the operator to manipulate without a special spanner. We use that type cap nut for holding the feed plate bearing bracket on our fertilizer distributor. We found that farmers were apt to break wing nuts, so we produced a cap nut with a square piece welded across the top. No one has broken that yet, and in addition the cap nut protects the thread of the stud from corrosion by the fertilizer.

One item we find very useful when incorporated in a welding jig is the screw jack. You do get distortion, and sometimes it can be counteracted by prestressing the part in the jig by means of a screw jack. I find that if you use a screw jack and bend the tube in the opposite way to the distortion when you have welded up it comes out straight. The amount of pre-stressing is found by trial and error, but it is a useful trick. The screw jack we use is the 1 in. square thread screw as used for depth control on a cultivator.

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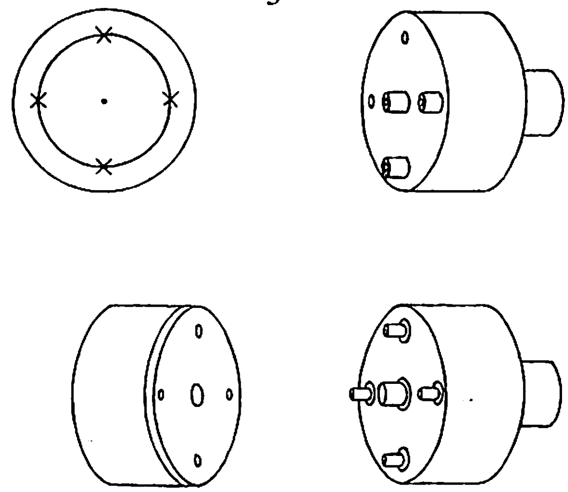
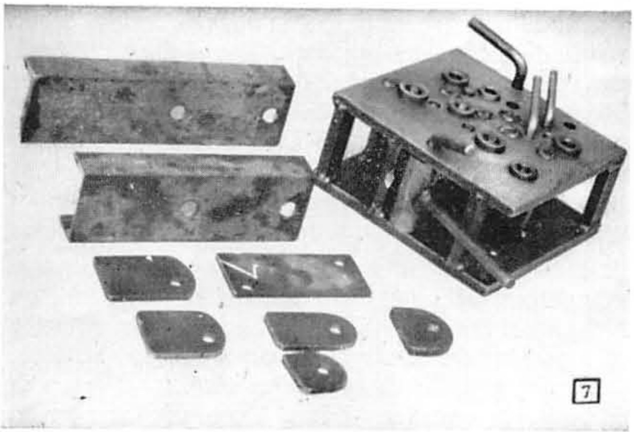


* W. N. Nicholson & Sons Ltd.



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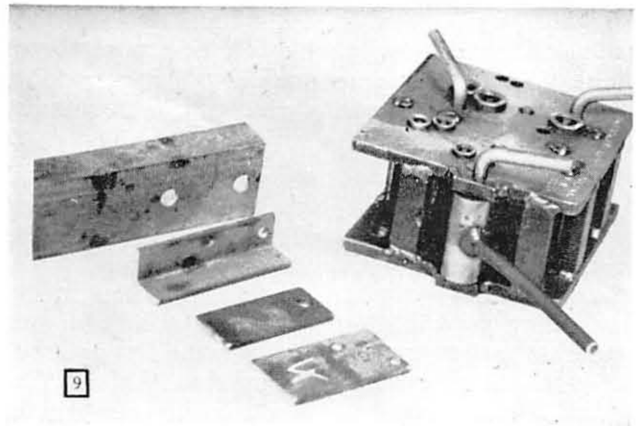

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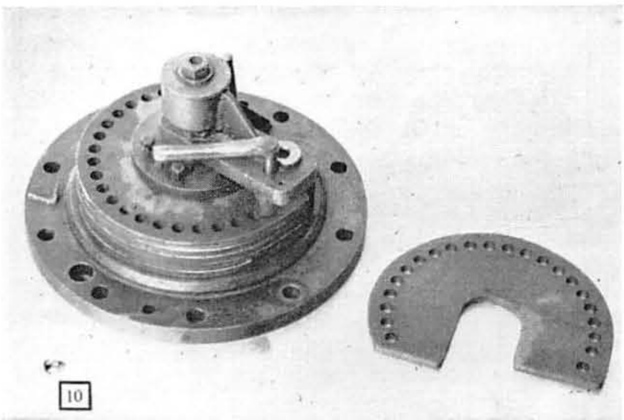

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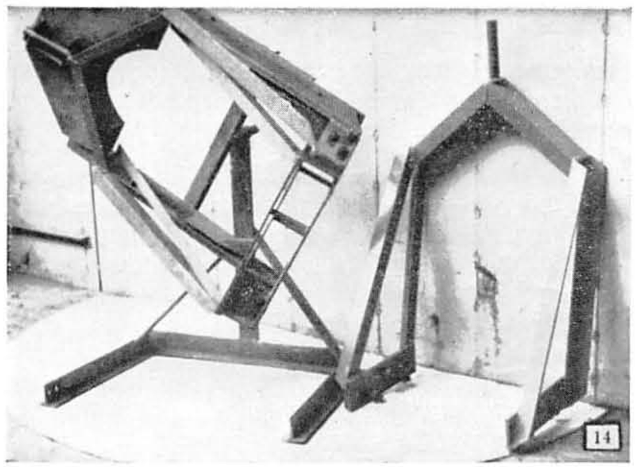

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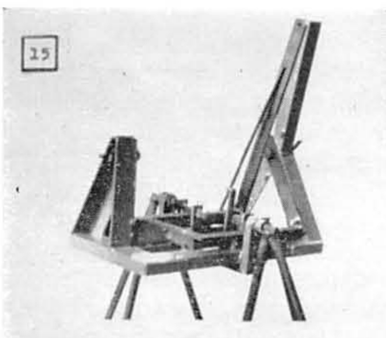

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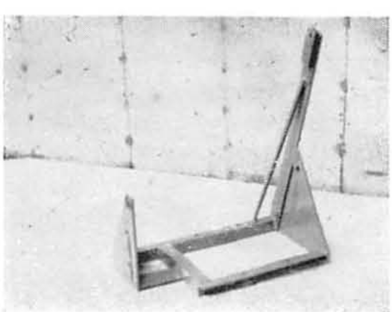

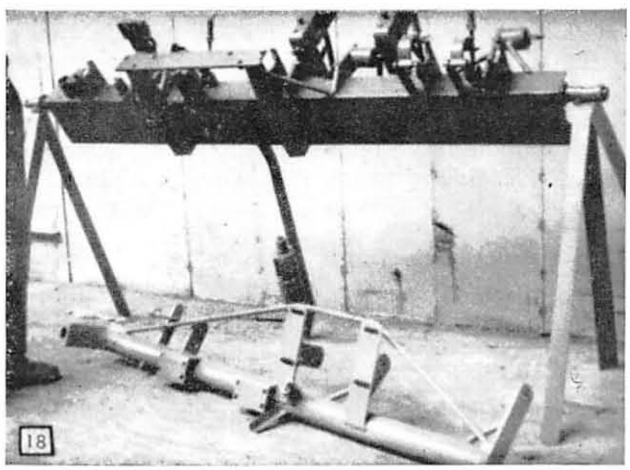

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I was pleased to see Mr. Lester stress the use of bits and pieces to make up jigs without having to go " down the road " to buy an expensive clamp. One can do a lot of improvising, especially when only short runs are required from the jig.

With small castings and small parts on which several operations are to be done, perhaps drilling and reaming or tapping, quite a high output can be obtained from one operator by means of a number of standard single-spindle drill heads mounted on pillars at about 15 ins. pitch, using one drill table. You can have a jig for each operation so that you put a casting in the first jig at one end of the line and set the drill in motion. While the first operation is in progress you take a casting on which the first operation has been carried out and put that in the second jig and set its drill going, and so on. Thus you can do a simple " transfer machine " type of operation by hand, using, say, four drill heads. Very often you do not want more than four operations on a small casting.

I have a question in relation to a rotating jig. I wonder if there is any means of clamping it in any particular position ?

MR. LESTER : It is so balanced that it can be rotated and the welder, while welding, will rotate it to produce a continuous fillet weld.

MR. NICHOLSON : We use that kind of jig, but on some jigs of this type, until all the parts are in place, they are not always fully balanced, so we put a circular plate with suitable locating holes on the end of the channel, and a spring-operated plunger is fixed to the trunnion housing so that the operator can lock the jig from turning or rotate it to a convenient position for welding. We put a catch on the plunger so that the jig can be rotated slowly if necessary after it has been loaded. We have found that sometimes these jigs are not fully balanced until you have everything in, and a lock plunger does help, especially when the jig is being loaded or unloaded.

Instead of having a manipulating jig in some instances I would suggest using a manipulating table, which you can buy or make yourself on which to bolt the jig. We use them for small jigs which have to be manipulated two ways. The jig can be bolted on to the table, and it saves time and money because each does not need to be capable of being manipulated individually.

MR. C. J. PADWICK* : I find myself in some little difficulty in speaking this evening, because although Taskers are now producing agricultural machinery once again they have been out of this market for some time, and their line of business has been trailers of all sorts, shapes and sizes. I am their Foreman Toolmaker and am responsible for the design of jigs and tools as well. For many years we have been making tools for use on contracts with the various Ministries and Government Departments. They wanted to see a good finished, workmanlike job because they were paying for it. The tools we made then, and still do when required, were of a better standard than we now find acceptable for the agricultural industry, and I find it quite difficult to lower my standards. It is mainly a question of price ; I don't want you to think that we do not try and make them as accurately as in the past, but we have to use different methods and materials ; we have to cut our cloth to suit the price, and the price ultimately is the amount of money the farmer will pay for the implement. Tool costs must therefore be in proportion.

In the main, I agree with the majority of points made in the Paper, although there are one or two things on which I must disagree. I do not like clamping with the slotted pin and drift, except on extremely heavy sections. With a heavy part it is as good and quick to clamp as it is possible to get, but whoever has to use them has to drive out the drift with a hammer, and once a man has a hammer in his hand he is inclined to use it on something else to the detriment of smaller and lighter jigs and components. On smaller work I advise another type of clamp altogether and there are many to choose from. You can, for example, use a cam-operated clamp. These are quite useful on welding fixtures, but not extremely satisfactory on drilling jigs. We use toggle clamps to a very large extent on welding fixtures ; they are adjustable and can be obtained in a large range of types and size. They are expensive, but once you stock them you have always one at hand when required, and you know beforehand exactly what you are going to use, thereby saving time all round.

I suggest it is a good thing to try and standardise your clamping. Even if you have to go outside and buy your clamps, drill bushes and dowels, they can prove cheaper in the long run because you do not have to stop a job on the lathe to supply the urgent needs of a man who is waiting for a couple of studs for his jig. It is equally important to standardise on drill sizes wherever possible. Do not design a component with one hole of 33/64ths in. dia. when all the other holes are 17/32nds in. dia. Make the clearance between bolt and hole standard so that you do not need such a big range of drill bushes. This should also apply to special studs or nuts used. In jig making, standardise whever possible.

One of the biggest difficulties in using stock angles, channels and tees in the manufacture of components or jigs is the variation in the sectional dimensions. Although the Drawing Office may call for a 4 × 2 channel, when you come to use it it is $4\frac{1}{8} \times 2\frac{1}{16}$. If you have made your welding fixture it may accept only 4 × 2 and the components cannot be assembled. You must design carefully to allow for over-sized material, and the preparation of that material must be considered. When you crop off a piece of 4 × 2 channel there will be a rough edge somewhere—it will not go into a 4 ft. space if you have a $\frac{1}{32}$ burr in the way. Persuade your Drawing Office or Planning Department to call up the material slightly short or be prepared to make your jig $\frac{1}{32}$ oversize so that the welder can assembly the details easily.

Another point on which I differ with the speaker is the question of multi-part jigs. These are all very well on occasion, but, unfortunately, you frequently find that you have made a jig to accept eight different components and the Drawing Office comes along with a ninth similar

* Taskers of Andover Ltd.

component. If you have adopted the design suggested by Mr. Lester you have welded the top plate of the jig to the bottom plate and so the extra detail cannot be accommodated. I suggest that you do not weld your drill jigs together, but use bolts and distance pieces so that you can remove the top plate from the bottom plate to make that extra adjustment.

If you have a press in your shop you can often replace a rolled steel angle or channel with a plate profiled and drilled before bending to the required shape. You are not then tied to a stock size off the rack and a 4 × 2 angle can become 3¾ × 1¾ with a saving in weight and material cost. Profile the plate to the size and shape required and then drill 8, 10, 12 or 16 plates at a time and cut the drilling cost to a point which will more than pay for the bending operation. You cannot always do this, I agree, but wherever possible try and get the draughtsman to say : " Let us make a pressing of this " ; it will save weight and frequently save production costs ; it will mean a much easier drilling jig to make and will be a typical " sandwich " jig. " Sandwich " is a good name for it, as the piece you are going to drill is held between two plates. This jig would cost less than if the component was made from channel or angle, as the jig would then have to be used in two or more planes. I use many socket head cap screws, even for clamping ; they can be kept quite small and you ensure that the operator has to use the key wrench. This will give you sufficient holding pressure, but less than that obtained with an equivalent size of spanner, and so minimising distortion of the jig.

Location points in drill jigs have to be carefully thought out. They should be no bigger or wider than absolutely necessary because nine times out of ten they are a perfect swarf trap. They must be made so that the swarf can easily be removed by air pressure or hand brushing. If difficult to get at this operation is too often left undone ; the driller will load the next batch into the drill jig without cleaning away the swarf from the locating stops and faulty drilling results. It is a good idea on sandwich jigs to relieve the bottom plate in line with the holes so that any little burr left on the bottom of the drilled hole can be cleared when the part is removed from the jig. The burrs can be quite large and the relief becomes essential. You too often find the operators driving the component from the jig because the designer has forgotten to machine the all-important slot in the bottom plate.

I hope I have not tried to set too high a standard. If you have a reasonable size of job coming through with a good chance of repeating orders try to make as good a jig as you can possibly afford. I find that the operators take more care and trouble over a jig well made and looking workmanlike than over something made out of odds and ends and looking like it. I am not suggesting that they cannot be made from odds and ends, but try to cover it up so that the tool does not look like something from the scrap heap.

I have no jig borer, so have to do practically all hole spacing on a milling machine, and I get by very well indeed. The use of toolmakers' buttons is quite sound, and in some cases you must use them. If your milling machine is calibrated on all its feed screws and you take care of any backlash between the screws and their corresponding nuts you can obtain pretty accurate results. An accuracy of ·005 in. on hole centres is acceptable if you are drilling 33/64ths in. for ½ in. bolts. When jigging for, say, the gearbox location, it is a different matter and greater accuracy will be necessary.

I do advocate making the jig as good as you can with the tools available, as it will be expected to last, and if your machine is in production for any length of time the accuracy of your tooling must be maintained and the operators will take more care in using it.

I fit all my large turn-over welding fixtures with a circular drilled plate on one trunnion. A spring-loaded plunger fitted to one end stand can give me several fixed positions and this is admirable for loading when the jig is out of balance. I think the fact that you have six or eight positions, while not equivalent to a continuous movement when making a circular weld, is a great help if other positional welds have to be made at the same time.

I standardise on several different sizes of trunnions and end stands obviating separate end stands for every turn-over jig ; switching from one jig to another is a simple operation. You should make sure that all turn-over jigs are properly earthed. I have found to my cost that unless the jig is well earthed shorting can take place between the trunnion and the bearing and a " seize up " results.

I want to stress that I do not necessarily buy these standard parts. I set my own standards and the parts are made by my own toolmakers. Our bought out and standard parts are confined to dowels, drill bushes of the smaller sizes and clamps and jig hand nuts. Large drill bushes can be made more cheaply than we can buy them. I do advise people to make their own standards ; the toolmaker knows at once what you want him to use.

MR. G. STREETER* : On the subject of welding fixtures, my Company's material is considerably smaller than Mr. Lester's—it is a smaller gauge. We find that quite a lot of jobs can be done more quickly and with less fatigue to the operator by making small templates first and then spot welding them into position. This is done on an impeller, which is a large circular disc with three plates. We spot weld them in position with a light template, which can be handled by a man all day long. The spot weld assembly goes to the arc welder, who puts a fillet weld round. That gets away from heavy welding fixtures. The man is handling the components and not the jig.

On the making of holes, we have seen from the slides that a lot of the work is drilled, but I would suggest here the use of a tool which I know is heavy, but, I think, not too heavy. Much time and jigging can be saved by using a press. We use quite a lot of standard punches and dies which are interchangeable, and with very simple location strips we make a hole in one-tenth of the time it

* J. E. Shay, Ltd.

takes to drill it. Press work in our shop is 50 per cent. of the total. We find it quicker and easier to handle and money is saved on jigging. We do make some of our press tools, but we also find that we can standardise a lot by using the standard press tool sets which are on the market. You can buy dies and stripper plates and punch plates already made and only have to cut the holes. Considerable time is saved by this method.

Another point that I noticed from the slides was that there were a number of parts which were strips of metal with holes in and so on. It is not difficult to design a press tool with piercers and crop strips of varying widths and holes, which can be made adjustable for length.

MR. LESTER : The reason why I did not mention machining jigs is because we avoid them like the plague. We design machines which are made up of stock steel bars, angles and so on by cutting and welding. We do very little machining. Mr. Padwick, as a toolmaker, considers our tool making unorthodox. He gets his cast-iron or piece of steel and drills four holes and then has machining to do for distance-pieces. I think that would be the orthodox way of making a jig. We approach it in a slightly different way.

I think Mr. Streeter was talking of smaller things altogether when he spoke of cropping and punching, but this can never be quite as accurate as cutting and drilling.

Mr. Padwick said that he had a job to get down to our standards. I do not like that, but I appreciate his attitude. He has been making gearboxes and that requires some real jigs. But even with those jigs the electric arc should be used a lot more than it is. I have been privileged to go round big works and I found that they were doing things as I did them 30 years ago. In our case, we are batch producing certain implements—100, 200 or perhaps 400 a year. For that it is necessary to get the cost of jigs down to the lowest possible level and, although it is interesting to hear how other people approach the job, we do avoid the screw, nut and bolt in a drilling jig if we possibly can. We use the register peg and locking clamp.

MR. R. H. HODGKINSON : Surely, as far as drilling is concerned, every job should be tackled on its merits. Obviously, Mr. Lester did not mean that every job must be set down to 10 thou. Certain jobs, by reason of their assembly, have to be set out in that manner for real accuracy, but others can be laid out by hand with dividers with a reasonably good operator. It is possible that the drills will be even better if they are done accurately by an experienced operator.

MR. NICHOLSON : It may be that I did not make my meaning clear when I spoke of the use of a four-spindle machine. The machine consisted of four standard single-spindle drilling machines set in a row using one drill table. You could have the heads at a certain centre, it does not matter whether 2 ft. or 18 ins. apart. When dealing with small castings there are two different ways of getting high production with one operator using all four spindles with different sized drills, reamers or taps in each spindle. You have a casting which has to go into four different jigs for four different operations. You start off with the casting in the first jig at one end of the table and put your first hole through, take it out and put in into the next jig, where it has to have a tap put through it, and so on. All these standard single spindle drills have a trip and self-return so that the operator starts off drill No. 1, and while that is operating he can be loading jig No. 2, and so on. The point is that you get a high output from one operator in the case of small parts, and without any special tooling of the drills, which makes for flexibility, especially on short runs.

Another modification is to have the same jig for different operations, but have different tools in the drill heads. You can hold the casting in the same jig and slide the jig along the table under each head successively and have it returned at the back of the table at the end of the cycle. There, again, in this particular application you can get quite a high output, especially if more than jig is used, so that one jig can be loaded while the other is in use, depending upon the time cycle of the various operations.

I support what has been said on the question of accuracy. I was not implying that one does not need to have accurately-spaced holes, but sometimes a high degree of accuracy is not necessary. When drilling out a jig plate on centre dots previously marked out the drill sometimes runs and the holes do not come out true to centre. An eccentric bush is useful in this instance ; it can be used to bring the drill guide hole back to its true position, and so makes the scrapping of the jig plate unnecessary.

MR. L. R. BOMFORD : As a farmer, I congratulate Mr. Lester on making a complicated matter sound simple. How glad we are, as farmers, that these jigs are being used. Years ago we had trouble in getting spares to fit but in these days, as a general rule, even with batch production, the spares will go straight in.

Nuts and bolts have been mentioned. I wish we could get back to one thread. The Whitworth B.S.S. and this new thread cause awful trouble on a farm. If some arrangement could be made to standardise on one thread or the other it would be an enormous advantage.

MR. LESTER : I should like to refer to a point which Mr. Streeter made about welding. He said that he took a template and tacked up the article and then it was transferred it to the welder proper. Surely the thing we want to watch is this transference of one component to a new situation for the next operation. We try very, very hard to carry out all the welding and complete it in the jig so that when the component is removed from the jig it is a finished product. We do that wherever it is possible.

ANNUAL LUNCHEON, MAY 1958

The following address was made by the Guest of Honour Mr. Lionel Harper, President of the Agricultural Engineers Association

MR. PRESIDENT, LADIES AND GENTLEMEN,

Allow me to thank you, Mr. President, and through you all members of the Institution of British Agricultural Engineers, for your kind invitation to attend this Annual Luncheon. May I thank you also for your very generous hospitality.

Over the past five years the 10 leading firms in the British Agricultural Machinery Industry have spent an estimated £13 million on Engineering—an average of £2,600,000 a year—and numbered amongst our gathering here to-day are the men who have spent it ! Have we had value for our money ? I feel that we have ! ! The vast strides forward that have been made by our Industry over the past 20 years—typified by the advance from the horse and the single furrow to the tractor and the five-furrow plough—are attributable to a major extent to you and do great credit to all British Agricultural Engineers. You have every right to feel proud !

It reminds me of the story I was told recently by an overseas visitor to one of our factories. Four farmers died and went up to Heaven. At the gate they were met by St. Peter, who asked the first farmer " What kind of a tractor did you own down on earth ? " " Oh, a German tractor," said the farmer. " Come on in," said St. Peter. Then to the second farmer : " What kind of tractor did you own ? " " A Russian tractor." " Come on in." To the third the same question—" Oh, an American tractor." " Come on in." Then to the fourth, who had a British tractor, " Go down below," said St. Peter. At this the owner of the British tractor complained bitterly. " Why do you allow three farmers through the gates then send me down to Hell ? " Replied St. Peter : " You owned a British tractor—you had Heaven on Earth."

Now I do not think it is as good as all that, but our Agricultural Engineers have indeed done an outstanding job, and I should like to congratulate your President, Mr. John Chambers, who last Friday celebrated his quarter-century in agricultural engineering, and all members of your organisation on their achievements over the past two decades and on the attainment of the " Number One " position in the world in agricultural engineering.

As I have said before, " You can be proud, or even cocky, about what an industry has done, but it is where it is going that really counts." There is an opportunity for even greater progress in the next 20 years and our engineers must set their sights high. Let us be more far-seeing, more imaginative, more original. Because a method is old and tried does not necessarily say we should carry on with it. The horse and buggy were old and tried. Let us not copy others ; to copy is the cheap way, but it is also the lazy way of engineering. Let us continue to lead—not be content to follow. There is a great challenge here and I am sure that you, who have accomplished so much in the past, will be fully equal to it.

One of the problems I should like to see tackled energetically by our engineers is the elimination of belts and chains and even augers, and of dispensing with grease guns and at least a few of the wide variety of spanners we use on our machines to-day. What a boon this would be for our farmers and contractors, and how much better our machines would look.

We congratulate Mr. Cashmore and Mr. Hawkins of the N.I.A.E. on the elimination of the share and apron chain—those inefficient and costly items respectively on potato harvesters. I hope we shall continue to persevere with this problem so that the next time one of our leading organisations sponsors a demonstration or competition for one of these labour-saving machines they will feel justified—unlike 1956—in presenting a First Prize.

The one-way plough is quickly coming to the fore, and it is not before time that we are seeing the gradual elimination of the dead furrow. I would suggest to the British Ploughing Association that they take the lead and sponsor a class for this type of plough. I predict that it will continue to grow in favour.

British engineers should hide their heads in shame that there are now 10,000 or more Dutch side rakes at work in British fields. All credit to the Dutch, but it is not good enough ! You men who are responsible for our haymaking tackle will have to do better.

Vast new fields are opening up for agricultural tractors. Between the industrial crawler, with its heavy excavation equipment, etc., and the small Lister or conveyancer type of truck as used around the factory there is a vast field and need in industry for the wheel tractor and appropriate mounted equipment, particularly in the building and construction trades. Here is a real opportunity for our engineers and a wide market which, I am certain, will make a substantial contribution to future sales volume, both at home and in export.

Eighty-five per cent. of our farms will be electrified by the end of 1963. Our engineers should take note of this and be ready with the right kind of equipment to assist our farmers to take advantage of this opportunity for further cost reductions on the farm.

Make greater use of our agricultural contractors when carrying out your tests. They are men who are given the worst conditions in which to work and who have the practical field experience and the knowledge to assist you in producing better and more trouble-free machines.

(continued on page 115)

TESTING OF AGRICULTURAL MACHINERY, with special reference to ROOT CROP HARVESTING EQUIPMENT

by D. I. McLaren,* B.Sc., N.D.A., M.I.B.A.E.

A Paper read at a Meeting of the Institution on 8th April, 1958

Previous Papers to this Institution have dealt with the testing of green crop driers[1] and of tractors[2, 3], and accounts are given in them of the development of suitable testing techniques and of the scope of the tests for these two classes of equipment. In the present Paper the testing of field implements and machinery is discussed in general terms and some details are given of the testing procedures which have been developed at the N.I.A.E. for potato and sugar beet harvesting equipment.

PART I

1. Purpose of the N.I.A.E. Testing Scheme

WHATEVER the class of equipment concerned, the starting point for all formal N.I.A.E. tests is the same. The N.I.A.E. Testing Scheme is offered as a service to manufacturers so that the performance of their machines, or components of them, can be assessed under representative conditions by an independent body. The manufacturer's reasons for using such a service vary considerably and range from the need for information on the functional behaviour or suitability of construction of a prototype machine, to the desire for a published report to provide independent evidence in support of his claims for a machine in both the home and overseas markets. From the farmer's point of view, this type of service can be of benefit in either of two ways. In the first place, he obtains an indirect benefit because often as a result of a test an improved machine comes on to the market. Secondly, a direct benefit may be obtained if, when selecting new equipment, the farmer makes use of the reports which are agreed for publication by the manufacturers.

2. Standard Tests for Implements

Standard tests which follow a fixed procedure are obviously most desirable in any such testing scheme since they not only facilitate direct comparison of the merits of different machines, but also simplify the testing work because it can be done to a routine pattern. The value of drawing up accepted standard tests for each of the main classes of farm equipment has also been recognised from the international point of view.[4]

As is evident from the three Papers referred to earlier, considerable progress has been made with the standardisation of tests of certain features of the performance of both tractors and green crop driers. But the testing of most types of field machinery, where in the main their performance is directly dependent on soil or crop conditions, presents a number of problems which preclude rigid standardisation of procedure. Standard conditions for working on the land do not occur in practice, and, for the most part, laboratory or selected artificial conditions are unsatisfactory for obtaining a true picture of what the agricultural machine can do under its natural conditions—at work on the land. Again, there is such a variety of machines involved that the task of standardising methods of test for the 80 or more different kinds of machine that may be entered for test is one that will take an extremely long time to accomplish.

It might be argued that, ideally, no attempt should be made to test any machine at the N.I.A.E. until at least a provisional standard test for its type has been worked out. In practice, however, the demand for independent tests has been too great for this line of approach to be seriously considered as a feasible policy, and, instead, individual techniques have had to be worked out as requests for tests of different machines have occurred, improvements in technique being incorporated in successive tests of similar types of machines as experience accumulated and the methods of carrying out the work are investigated, improved and simplified. Details of N.I.A.E. testing technique studies undertaken for this purpose, and of the types of problem which have to be overcome in the course of them, are given in the appropriate sections of the Institute's Annual Reports.[5] Perhaps it is sufficient to re-state here that it is not the aim at the moment to produce a " standard " test for each class of field machine or implement, as has been done in the case of tractors,[6] because of the rather variable requirements of test entrants, the relatively wide variation of the different biological conditions which are encountered (*e.g.*, crop yield, crop height, soil type), and the need for carrying out tests under special or unusual conditions. Instead, the study of any one kind of machine is intended to arrive at a basic scheme which lays down (i) a recommended range of conditions for the test, (ii) the manner of defining the conditions, (iii) features of performance or construction to be measured or assessed, and, of great importance, (iv) a " preferred method " for carrying out each phase of the test.

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Obviously, there are limitations to the time that can be spent on a particular test, especially as the test results are nearly always wanted quickly by the manufacturer and, when published, are of mainly topical interest to the farmer, and the problem constantly arises where to strike the balance between prolonged and detailed testing to ensure accuracy and full information at one extreme and, at the other, perfunctory observation for the sake of a quick opinion. Furthermore, whatever basic recommended test procedure is decided upon for any one class of machine, it must be sufficiently flexible to cope with new developments in design or even with changes in the fundamental principles of operation.

Up to the present, detailed procedures of testing for two classes of field equipment (combine-harvesters[7] and sugar beet harvesters[8]) and one of barn machinery (hammer mills and other farm grinding mills[9]) have been published by the N.I.A.E., and the studies of four other classes of equipment (including potato harvesters) are well advanced.

3. Features of Performance or Construction to be Determined in an Implement Test

The scope of an implement test and the way in which it can be conducted are determined largely by the class of equipment involved, whether it is a production model or a prototype, and by the purpose for which the results are required. Since the results of a test may and, in the case of a production machine, probably will be published, it is important that they should present the farmer who reads the report with a reasonably balanced picture of the capabilities of the test machine. In practice, it has been found that a determination of some or all of the following features of the machine under an agreed range of practical conditions will normally meet the requirements of both the manufacturer and the farmer in the majority of cases :

Quality of work in whatever terms are appropriate or possible for the class of equipment involved.

Rate of work in terms of acres or tons per hour on both a net and overall basis, with, possibly, an analysis of wasted time.

Power requirement in terms of horse-power or fuel consumption.

Labour requirement, including an assessment of effort and skill required.

Handling characteristics, including ease of operation, setting and adjustment and the time required to do normal servicing and maintenance. The question of the safety of the operators may also have to be considered under this heading.

Construction in terms of avoidance of breakage or distortion, and length of life.

With most tests, features such as rate of work, power requirement and some aspects of labour requirement can be determined in a straightforward way by means of measurements or field records, using, where necessary, testing apparatus (*e.g.*, land measuring wheels, mobile weighbridges, drawbar and p.t.o. dynamometers) or techniques which have been developed specifically for the purpose. At the other extreme, assessments of such points as the ease of operation, setting and adjustment, or of the skill and effort required of the operators, can only be subjective in nature, and the value of the opinions given must depend to a large extent on the testing experience of the staff involved.

Assessments of the remaining basic features—quality of work and construction—pose several major problems with tests of most field implements, and these problems, together with the need for defining test conditions, are therefore discussed in some detail below.

Need for Definition of Test Conditions. Although it is never possible to include in any one N.I.A.E. test all the different conditions that a machine is likely to meet in various parts of the country, a reasonable knowledge of the farmer's requirements, coupled with previous testing experience, can usually be relied upon to suggest a realistic range of practical conditions under which the machine should be tested to give a worthwhile estimate of its capabilities. However, unless the various conditions chosen can each be defined or designated in some repeatable way, it is difficult to assess the merits of a particular machine or to make proper comparisons between the performance results of two machines tested on different dates or in different seasons. A description of a condition based on an individual judgment can be very nebulous and unreliable—it is difficult, for example, to describe how stony a field is or to judge how moist a soil is. On the other hand, any endeavour to measure all the factors of condition, even if measurements appropriate to a condition could be made (imagine, for instance, attempting to define, by measurement, the state of potato haulm in each of the fields used for a potato harvester test !), usually takes more time than that available for the whole test. In the circumstances, a compromise has usually to be adopted and such testing " devices " as the introduction of a comparison machine or a hand-method—which can be tried alongside the test machine as a check on a condition—are used to supplement brief descriptions, photographs and whatever measurements are feasible.

Particularly where the primary object is to obtain sound comparative information on performance, " series " testing can also be used. With this form of testing, a number of different makes of machine of the same broad type from the functional point of view are tested together in one season. Each machine is assessed in the same fields on the same days so that a series of comparative results can be obtained and the need to define each condition in detail is then less important. If published, the results obtained by series testing are of particular value to farmers who are usually more interested in comparative information on a range of machines in any one class than in detailed technical data about a single machine. However, especially with machines to do with soils and crops, series tests require such an organisation of farm arrangements and a concentration of tractor drivers, recording staff, tractors and other equipment that this form of testing can only be used on a modest scale (one series per year) at the N.I.A.E. without reducing materially the service in respect of " single " tests.

Assessment of Quality of Work. In many tests the finding of methods to determine objectively the quality of work done by a machine represents a major problem—for example, ploughs and most kinds of cultivation equipment are notoriously difficult in this respect. But even when the quality of work can be expressed in numerical terms, *e.g.*, the evenness of distribution of manure by a fertiliser distributor, the basic information required to interpret the figures—in this case the relationship between crop response and regularity of distribution—may not be available. These two types of problem can usually only be solved by testing technique studies on the one hand or by basic agricultural research (often of a type outside the scope of an engineering institute) on the other ; and, as each usually entails an extensive piece of work, it may be some considerable time before the final answers are available. In the absence of some means of measuring quality of work with implements such as ploughs, the introduction of hand- or machine-comparisons as an aid to the making of subjective observations by experienced testing personnel may be the only practical course to adopt in the meantime.

Assessment of Durability. Another problem is the assessment of the durability of equipment submitted for test. The test machine is usually available for one season only, and although in practice a surprisingly large number of a machine's weaknesses are revealed during the 50 hours of field work which forms the basis of present N.I.A.E. implement tests, there may well be others which normally do not appear until after several seasons. Accelerated wear tests are a partial solution in certain cases, such as, for example, sprayer pumps and some soil working parts ; but before the use of such tests can be extended with confidence, more information is required on the correlation of the results of accelerated tests with those obtained in the field. In any event, it is probable that there will always be certain test subjects which can never be satisfactorily assessed in this way ; and in these cases resistance to wear and fatigue, as opposed to resistance to fracture (other than that caused by fatigue) or distortion, may have to be determined by means of a separate durability test, which could be done after the completion of the initial performance test.

4. Broad Method of Conducting Implement Tests

Since the basic aim of the bulk of N.I.A.E. tests of implements is to provide as much factual technical information as possible about the best performance of the test machine over a wide range of working conditions—as a reliable guide to designers and, if published in a suitably abbreviated form, to the potential user—greater emphasis is at present placed on assessments of functional behaviour and rate of work than on other features such as long-term durability. To reduce to a minimum variations due to the human element and other extraneous factors, all equipment under test is operated entirely by N.I.A.E. staff and is under the direct control of a test officer who is with the machine throughout the test period. The bulk of the measurements or assessments, however, are made on ordinary commercial farms selected by the Institute according to the test conditions required, and 50 hours of actual field operation forms the basis of all present tests.

This emphasis and broad method of conducting a test is not common to all testing stations in Europe. For example, in some cases[10] greater emphasis is placed on the need for a more general assessment of the test machine's reliability throughout at least a full season of ordinary farm work ; and for this purpose the bulk of the test is carried out by placing the test machine on selected farms chosen according to the crops and conditions on them. While on each of the farms the machine is operated under the direction of the farmer by his own men, frequent visits being made by a test officer for the purpose of checking the records kept by the farmer, inspecting the machine and doing periodic detailed measurements of performances as appropriate.

In Part II of this Paper reference is made to some of the testing techniques which have been developed at the N.I.A.E. for potato and sugar beet harvesting equipment. Some details of the methods being used for a number of other classes of equipment, together with comments on various aspects of N.I.A.E. tests of implements not mentioned in this Paper, have been given in several external publications[11, 12, 13] as well as in the Institute's Annual Reports mentioned earlier.[5]

PART II

The N.I.A.E. testing procedures for potato and sugar beet harvesting machinery can be used quite conveniently for illustrating many of the general points referred to in Part I. In both cases a " preferred " method for carrying out each phase of the test has been worked out and, as mentioned earlier, a detailed procedure of testing has either been published or is so far advanced that it can be used for routine tests.

In many respects potato and sugar beet harvesters are not the most difficult of test subjects since, broadly speaking, their performance in terms of rate and most aspects of quality of work can be measured quite readily. However, especially in the case of potato harvesters—where the crop is totally covered in soil—definition (as far as possible) of the conditions under which such measurements are made is necessary before comparisons between one machine and another can be regarded as valid. Furthermore, a knowledge of what was taken into the harvester in terms of potatoes, soil, stones, clods and plant material is essential in any attempt to assess the merits of a particular machine, especially as the proportions of these ridge constituents can vary considerably from one test site to another[14] and each field condition is never repeatable.

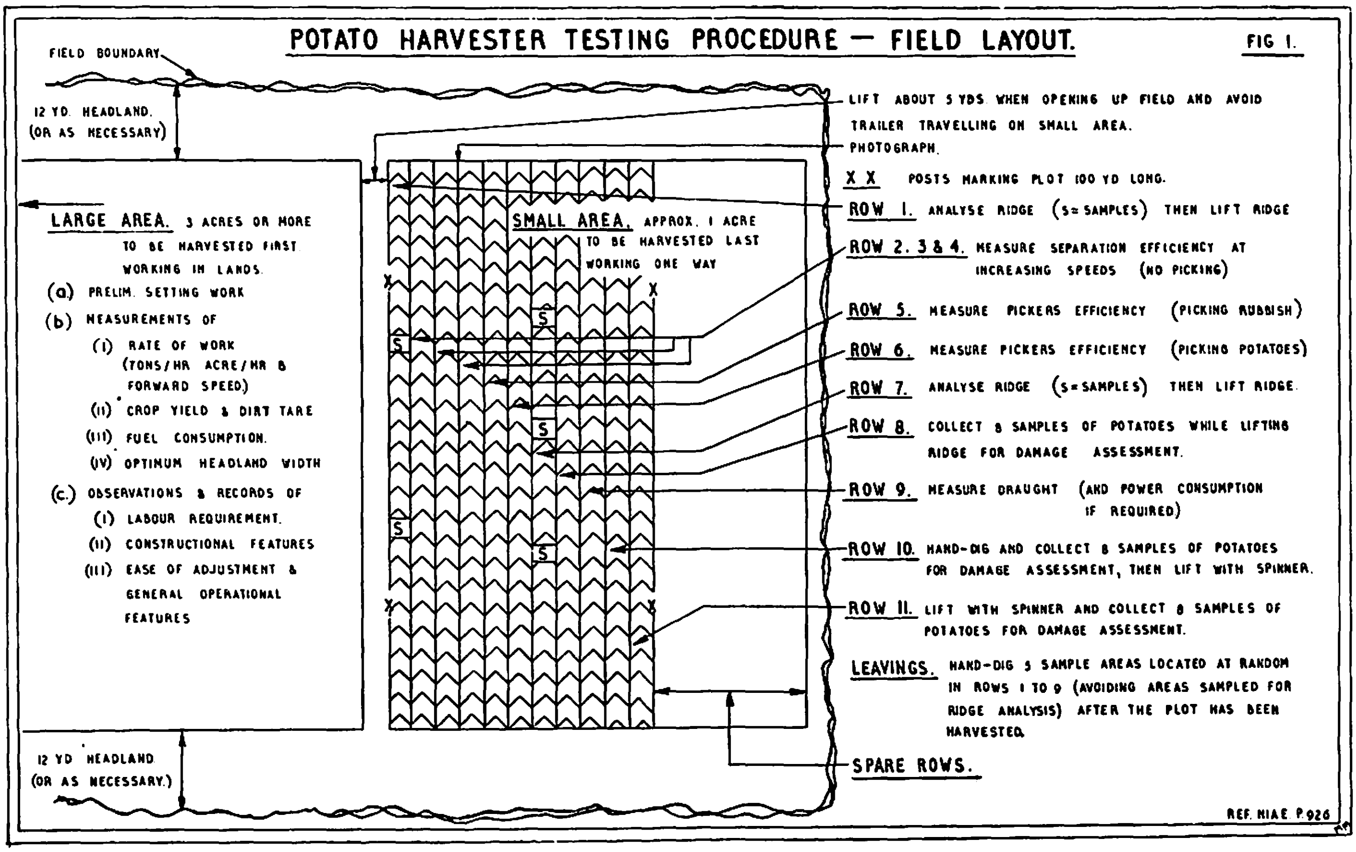
1. N.I.A.E. Tests of Potato Harvesters

Following a series of incidental studies to determine which of several methods of sampling or other procedure was the most accurate or practical, and after a complete harvester had been put through the proposed test under one field condition, the interim " Detailed Procedure of Testing for Potato Harvesters " given in the Appendix to this Paper was drawn up. Although there are certain minor phases of this procedure which require further study before it can be regarded as complete and ready for formal adoption, it has been used successfully with slight modifications for several routine potato harvester tests.[15, 16]

Much of the detailed procedure of testing given in the Appendix is self-explanatory and can be summarised in the form of a field layout diagram (Fig. 1). However, some additional information about certain aspects of the proposals, together with some details of the special apparatus and methods used, are given below.

Duration of Test. Taking into consideration the necessity to do the test work in the appropriate harvesting season and the available resources as regards staff, it was decided that, making allowances for weather, the field work for a potato harvester test must be completed within about one month by four N.I.A.E. staff (two recorders and two tractor drivers ; unskilled labour being drawn from farms where the testing was be to done). These limitations of time and labour obviously markedly affect the scope of the work that can be undertaken and the extent to which accuracy of measurement can be pursued.

Range of Work. Three different land conditions were thought to be the minimum that were necessary if a reasonable assessment of the test machine's versatility is to be made. Light land free from stones, light land with stones, and heavy land with clods were decided upon as providing a reasonable range from an " easy " to a " difficult " condition without the introduction of too many different factors.



POTATO HARVESTER TESTING PROCEDURE — FIELD LAYOUT. FIG 1.

Definition of Condition. Following a small-scale investigation of the possible differences in the yield of adjacent rows of potatoes[17] and consideration of the various methods which might be used to define a test condition, it was decided to analyse the contents (potatoes, soil, stones and clods) of the potato ridge by measurement, to photograph the ridge to show haulm and weed, and to rely on descriptions of other details required. In order to get over the problem of varying conditions on any one test site, it was decided to adopt the principle of using two zones on the site : the one—a small area—where detailed measurement of condition and quality of work would be concentrated ; the other—the bulk of the site—where all other features would be assessed. On the small area it would then be possible in a reasonable time to take samples of the ridge which would represent quite a large proportion of that area, and thus accuracy of definition would be more likely.

A special ridge-collecting device (Fig. 2) was developed for taking each of the 5-yard long samples of the ridge required for analysis. This apparatus consists basically of a share and a length of rubberised canvas so arranged that the sample length of ridge is lifted almost *in situ* on to the canvas as the collector moves forward. Each ridge sample is then analysed separately using a special grading apparatus (Fig. 3) which is similar in principle to some types of potato sorter, but much more mobile. By this means the proportion of potatoes to soil, clods and rubbish, and the weights of each, are determined ; and the clods, stones and potatoes are further subdivided into size groups, and the weight of each group recorded. Some typical results of ridge analyses done in this way are given in the table above. These results illustrate the small proportion of potatoes to soil in the ridge and the considerable degree of variation in ridge content which can occur from field to field. The results shown for Fields 1 and 4 also illustrate the variations in soil and clod content which can occur from year to year since these two fields are on the same soil type at Wrest Park, but the figures were obtained in successive seasons.

Some care is necessary in using such ridge analysis results since quite large variations in soil, clod or potato content can occur between samples taken in the same field. Small differences in results from field to field should therefore be ignored.

Quality of Work. Information about the efficiency of separation obtained by the test machine, the picker's efficiency while working on it, the amount of damage to potatoes and the amount of " leavings " (ungathered potatoes) are obtained during the work on the small area of each test site. Although the methods used for each of these determinations are described in some detail in the Appendix, it is perhaps necessary to give some additional information about the procedures for assessing the amounts of damage and of " leavings " and to comment briefly on the background to them.

Assessment of Damage. The problem of avoiding damage whilst harvesting potatoes has been widely discussed in recent years, more especially since the introduction of pre-packaging ; and it is a problem of which manufacturers of potato harvesting machinery are now well aware. During early tests of harvesters it quickly became apparent that considerable damage to

TYPICAL RESULTS OF RIDGE ANALYSES

Field No.	*Soil.*	*Loose soil thro' ½ in. riddle. tons/acre*	*Clods over ½ in. thro' 1¼ in. riddle. tons/acre*	*Clods over 1¼ in. thro' 2 in. riddle. tons/acre*	*Clods over 2 in. riddle. tons/acre*	*Stones over ½ in. thro' 1¼ in. riddle. tons/acre*	*Stones over 1¼ in. thro' 2 in. riddle. tons/acre*	*Stones over 2 in. riddle. tons/acre*	*Potatoes over ½ in. thro' 1¼ in. riddle. tons/acre*	*Potatoes over 1¼ in. thro' 2 in. riddle. tons/acre*	*Potatoes over 2 in. riddle. tons/acre*	*Haulm. tons/acre*
1‡	Sandy loam ; dry.	356	45	10	1½	*	*	*	1	10	2	2
2‡	Clay ; dry.	125	30	9½	2	*	*	*	½	3	6	1
3‡	Clay loam with flints ; moist.	160	20	3½	½	16½	2	½	½	4	½	1
4†	Sandy loam ; moist.	148	12½	3	Nil	*	*	*	¼	4½	3½	Not Recorded
5†	Clay loam with flints ; moist.	167	56	6½	4	27	18¾	10	Nil	3¾	3½	Not Recorded

‡ Figures derived from N.I.A.E. Test Report No. 123.[15]
† Figures derived from N.I.A.E. Test Report No. 156.[16]
* Very few stones were present and they were therefore included with soil and clods.

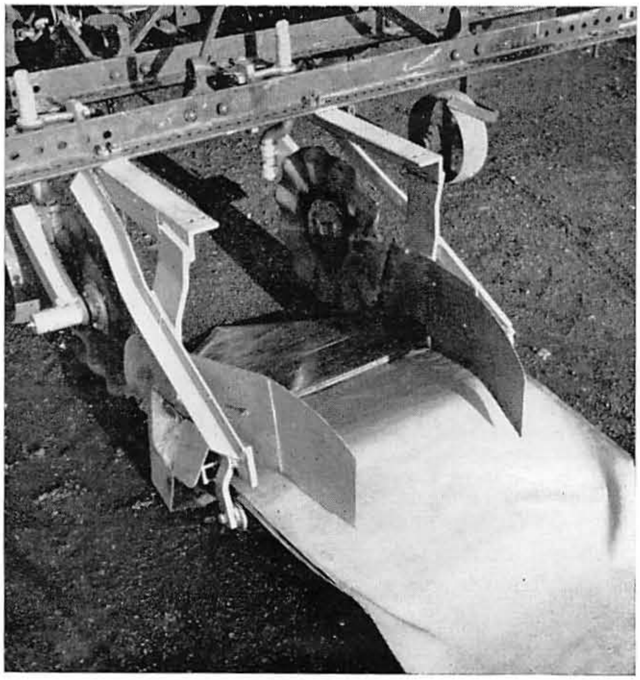


FIG. 2. Ridge-collecting Apparatus.

FIG. 3. Grading Apparatus.

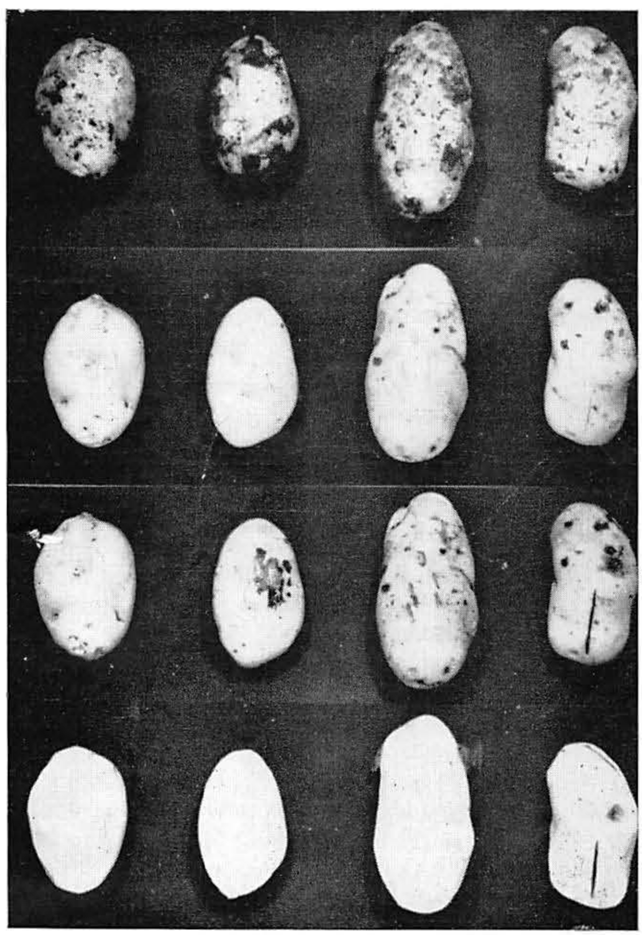
the potatoes was occurring and that a means of assessing the amount and extent of the injury inflicted by the harvesting machine was needed. Obviously a tuber may receive splits, cuts, bruises or abrasions to an infinite degree and an exact assessment of degree of damage is virtually impossible. However, a visual inspection and weighings of the tubers under the classification given below has been found reasonably satisfactory for practical purposes and is used during tests.

Samples are drawn from the output point of a complete harvester for immediate inspection ; while, for comparison, samples are also taken from the ground after being lifted by a spinner under the same conditions. As an added " control " comparison, tubers are carefully hand-dug and these, too, are inspected. The potatoes are then classified and weighed in accordance with the following headings :

1. Sound potatoes.
2. Skinned (or " scuffed ") potatoes.
3. Potatoes with deeper damage, but which can be removed by normal peeling.
4. Potatoes with severe damage.

It was quickly found and later confirmed by experiment[17] that all the damaged tubers were not detected if inspected as they came from the field in a dirty condition. Washing revealed additional injuries, but some of these were still not very obvious and means of emphasising the damaged areas were sought. Eventually, the use of an iodine solution[18] in which the potatoes, after washing, were dipped, provided a suitable medium for showing up the damaged areas as the typical blue-black colouration of a starch/iodine reaction. Subsequently, a para-cresol solution[19] has been used, partly because of the red colouration it induced, and partly because it was cheap. The illustration (Fig. 4) shows how much easier it is to see the damage after washing and staining (although a coloured photograph would give a truer picture) as well as the type of damage according to the classification. Additional injury can, of course, be caused later in the transport, sorting and storage of the tubers,[20] but these sources of trouble should not be laid at the door of the harvester. However, the assessment using the stain is done at the time of harvesting and the question naturally occurs as to how the damaged tubers will keep. Will disease organisms enter and spread through the damaged tissue ? Has there been damage by bruising which is undetected because of an unbroken skin ?

Sound | Skinned | Damage Removable by Peeling | Severe Damage



i, ii, iii, iv

i As Lifted
ii Washed
iii Stained
iv Peeled

FIG. 4. Degrees of Potato Damage and Stages in Assessment.

As there are a number of additional factors which may affect the issue during storage, particularly factors of temperature and humidity which affect the rate of healing of the wounds, the answers cannot be simply stated. Nevertheless, during the tests of harvesters, samples of harvested potatoes, taken in the field in the same way and at the same time, have been assessed for damage by immediate inspection and after storage in chitting trays in a dark room. The stored samples, after three weeks, were all peeled and the proportion of potatoes with damage that was not removed by peeling was recorded. A typical result is given in Fig. 5. It will be noted that the results indicate, in the case of the machine-harvested samples, the injury after storage was, as it were, deeper seated. The results also show the relative amounts of damaged tubers which may be expected by the different harvesting means.

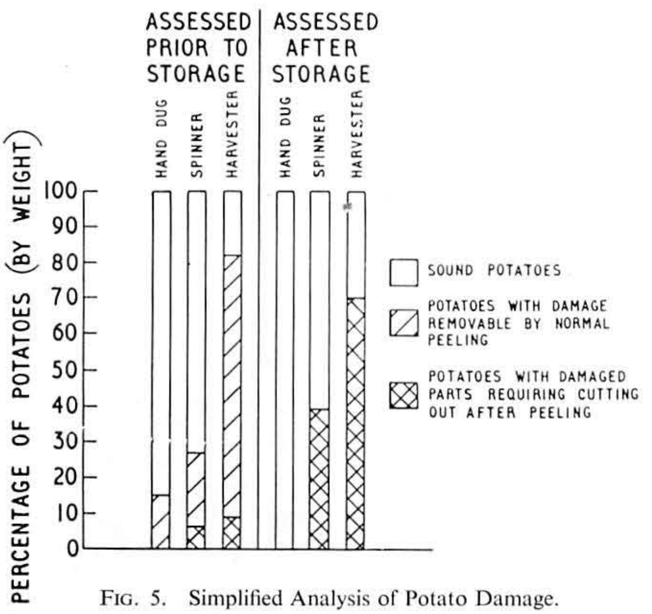


Fig. 5. Simplified Analysis of Potato Damage.

Assessment of Leavings (*Ungathered Potatoes*). As a result of a study[17] of the time required and the various degrees of accuracy which might be obtained when leavings were assessed by different methods involving harrowing, cultivating and hand-digging, it was decided to determine the amount of leavings by hand-digging rectangular sample areas (each 1/560 acre) located at random over the small area (Fig. 6). In practice, however, this method has been found to be too time-consuming for an adequate number of samples to be obtained ; and, accordingly, a special potato-leavings collector (Fig. 7) has been developed by adapting an existing elevator potato digger. Some preliminary trials have been done with this device and, as it has proved satisfactory within the limits of the conditions tried so far, it is hoped to use it in place of hand-digging in order to improve the accuracy of the leavings determinations.

The magnitude of the losses recorded during past tests of complete harvesters have often caused some surprise on the part of both test entrants and farmers since it has not been uncommon to find that the total amount of potatoes left in the ground, either spilled or not lifted, by the harvester was of the order of a ton to the acre. However, although undesirable, such a loss is not considered abnormally high since a national survey[21] has shown that the average loss during harvesting is in the region of 0·7 to 0·8 tons/acre of ware potatoes and 0·2 to 0·3 tons/acre of " chats."

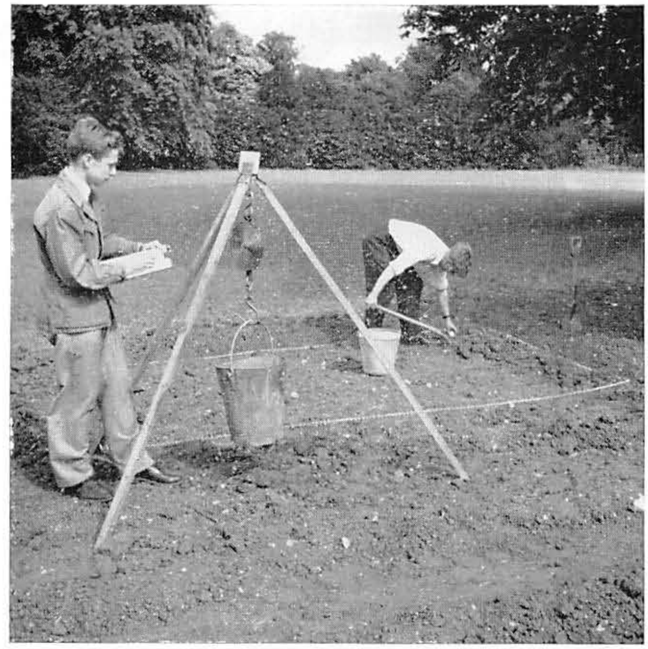


Fig. 6. Hand-digging a sample area for " Leavings."

2. N.I.A.E. Tests of Sugar Beet Harvesters

The detailed procedure of testing for sugar beet harvesters, referred to earlier, is part of a more comprehensive technique study (unpublished in its entirety) and, as with the procedures for other classes of equipment, the chief object in publishing it is to provide the manufacturer who wishes to send his machine for test with a knowledge of what information would be collected on the performance of his machine in a complete test and of how the test work will be carried out. However, neither the suggested scope of the test nor the procedure is intended as a rigid standard ; the emphasis on particular phases of the test can be shifted, or tests can be added, to meet any special requirements. Again, the procedure required for testing less complex machines than a complete harvester can be derived from the full version by omitting those parts which are not relevant.

As many of the basic testing methods described in the published procedure of testing for sugar beet harvesters[8] have been adapted with the assistance of the N.I.A.E. for use during the annual National Sugar Beet Harvesting Demonstrations, and are thus reasonably well-known, only some of the more important points of difference between the respective procedures for potato and sugar beet harvesters are briefly referred to here.

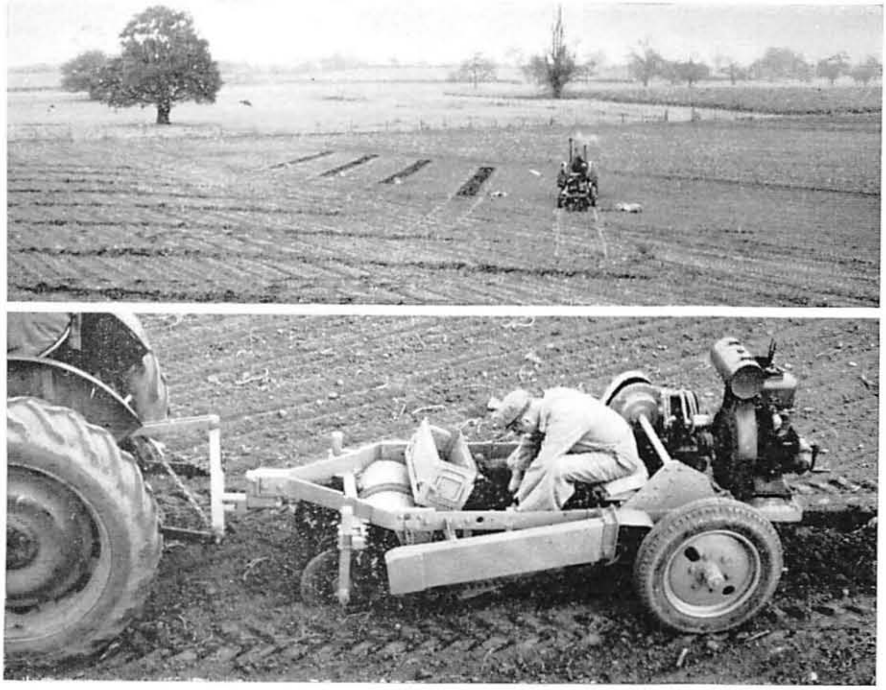


FIG. 7. Potato-leavings Collector.

Range of Work. As in a potato harvester test, a reasonable range of land conditions from " easy " to " difficult " is selected for a test of a beet harvester. In addition, such factors as the effect of " bolters " or weeds upon the operation of the harvester have to be taken into account when choosing test sites, and an attempt is made to include work both early in the season and at the end when the tops have withered (after frost). Furthermore, in view of the increasing interest in mechanical thinners, it is desirable that the test should include some work on a crop which has been mechanically-thinned (and subsequently hand-trimmed).

Definition of Condition. Although most desirable, a precise definition of each condition chosen for a test of a beet harvester is not quite so vital as it is in the case of a test of a potato harvester since, broadly speaking, the complications normally associated with a major soil separating process are not present. Nevertheless, crop and land conditions do vary considerably from field to field and from year to year, and to facilitate a detailed assessment of quality of work a comparison machine is usually included in some or all of the field work as a yardstick. The comparison machine used in such cases is always one that is well-known and which is already on the market, but it is not in any way implied that it is necessarily the best in its class. Results obtained with a comparison machine are not included in the final report.

Although each test site is not divided into two specific zones as in a potato harvester test, the samples taken for the " quality of work " assessments (see below) are drawn from as compact an area as possible and in a part of the field where there is a minimum of variation in soil and crop conditions. The crop yield in each field (in terms of both roots and tops) is estimated by weighing a number of hand-dug and hand-topped samples.

Quality of Work. In the case of a sugar beet harvester, this feature of the test machine's performance is subdivided into the following parts which require to be measured or assessed :

(i) Accuracy of topping.

(ii) Efficiency of cleaning and condition of the beet.

(iii) Root losses.

(iv) Placing of beet (*i.e.*, windrows, heaps, etc.).

(v) Condition and placing of tops.

Accuracy of topping and efficiency of cleaning are determined under each test condition by examining a set of samples of roots and tops in a small tare house at the N.I.A.E., which is equipped with a taring guillotine and a batch-type rotary washing machine of a type previously used in the tare houses at sugar beet factories. Each of the 15 samples taken for this purpose consists of 15 roots and a matching set of 15 tops (or in the case of machine-thinned crops the roots and tops from 15 ft. of row). The first plant in any one sample length of row is selected by some method (*e.g.*, casting a marking peg) which ensures randomness, and the roots and the corresponding tops that make up the samples are collected during or immediately after the harvesting process by a method appropriate to the type of machine involved. The accuracy of topping is expressed in terms of lb. of trimmings per cwt. of clean, correctly topped beet. To determine the extent of under-topping, the washed roots are trimmed in the N.I.A.E. tare house to just below the lowest leaf scar—the criterion used in the tare house at the sugar beet factory when examining samples of beet as delivered—and the trimmings are then weighed (the number of roots requiring trimming, including those diagonally-topped, are also recorded). The extent of over-topping is determined in a similar manner by trimming the crowns in the samples of tops (for convenience this determination is sometimes done in the fie.d).

Information on the efficiency of cleaning is obtained from the dirt tare figures which are recorded in the tare house when the sets of samples of roots are washed prior to the examination for accuracy of topping ; the dirt tare is quoted as lb. per cwt. of clean, correctly topped beet. As a basis for comparison, the relative standard of cleaning which can be achieved by ordinary hand-knocking is commented on in each field used for the test.

Root losses are measured by collecting and weighing all the marketable roots and pieces of root which are left on the surface and in the ground—the latter are recovered by hand-digging with a fork—in sample lengths of row which are marked out before the harvester passes in the area where the tare samples are taken.

The remaining items listed under " Quality of Work " —condition of beet, placing of beet and condition and placing of tops—are at present all assessed by subjective observations only.

APPENDIX

A DETAILED PROCEDURE OF TESTING FOR POTATO HARVESTERS

SCOPE OF TEST

The test will be carried out under different field conditions to assess the following features of the machine.

(*a*) The separating efficiency (potatoes from soil, stones, rubbish, etc.).

(*b*) The amount of damage to the potatoes.

(*c*) The amount of " leavings " (ungathered potatoes).

2. Rate of work (acres/hr. and tons/hr.).
3. Fuel consumption, draught (and power requirement when specially requested).
4. Labour requirement and handling characteristics.
5. Suitability of construction.

A total period of actual harvesting work of not less than 50 hours will be attempted.

Field Conditions. Full records of all features of the machine will be made under each of three different soil and crop conditions which can be broadly defined as follows :

(*a*) Light land (5 to 6 acres) reasonably free from stones, clods and weeds.

(*b*) Light land (5 to 6 acres) with a large amount of stones, but with an average amount of clods and weeds.

(*c*) Heavy land (3 to 4 acres) with many clods, but with an average amount of weeds.

In each of the above conditions the amount of haulm present should not be extreme and it should be in a " dead " condition, either naturally or by acid-spraying. Some potato harvesters are designed to work in crops after the haulm has been pulverised by a flail or other similar implement. The manufacturer's wishes in this respect will be met as far as possible, but any such special requirement will be placed on record in the test report.

Additional Conditions. A small amount of work on sloping land of up to approximately 1 in 8 will be attempted ; and, if feasible, some work may also be carried out under conditions where there is a considerable amount of green haulm present. Under these conditions the object will be to form an opinion, based mainly on observation, on the behaviour of the machine, and records will consist of a minute by minute time record together with a record of the area harvested. The recording of any further detail will be at the discretion of the officer in charge.

PROCEDURE

The testing work described below is presented as far as possible in the order in which it will be done in practice.

Construction

There will be a careful examination of the machine prior to any field work, preferably with the manufacturers present, to check that all parts are in a new and proper-running condition. At the completion of the field work the machine will be re-examined to note whether there is any obviously excessive wear. Breakage or distortion occurring during field work will be recorded as it occurs.

Field Preparation

Each field in which full records are to be made will be prepared for the test work in the following way :

1. Both headlands will be lifted and also, if necessary, the ends of the main rows so that the harvester can be easily manœuvred.

2. Each field will be divided into two areas as follows :

(*a*) A large area of about 4 acres will be used for preliminary setting and for assessment of the Rate of Work (and some other features of performance). This work will be done as the first operation.

(*b*) A smaller area of about 1 acre will be used for detailed measurement of the Field Conditions and of the Quality of Work. This work will be done as the second operation.

A dividing strip between the two areas, equal to the combined width of the trailer into which the potatoes are delivered and the potato harvester, will be lifted to allow free passage and to prevent any disturbance of the ridges in the Small Area.

3. The N.I.A.E. mobile weighbridge will be conveniently placed for weighing trailers and their loads before the loads are delivered into a clamp or other storage place.

4. A stack sheet will be spread near the clamp for rubbish determination work.

5. Four sighting pegs will be set in each of two or three locations of the Large Area to mark 88-ft. long stretches for speed assessment (spot readings).

6. A plot of not less than 100 yds. long and 11 or 12 rows wide will be marked out next to the dividing strip in the Small Area. The full length of the rows should be greater than 100 yds. so that there is a " run-in " of not less than 30 yds. before the plot.

WORK IN THE LARGE AREA

The work in this area is for the purpose of assessing the rate of work, the practical labour requirement, the fuel consumption, the handling characteristics under normal working conditions and the suitability of construction.

Preliminary Work

The manufacturers will be asked to be present to demonstrate the operation of the machine. It will then be worked without recording the performance for as long as is necessary to determine the number of pickers required, to determine the best speed to work at, to get the crew familiar with the machine and to ensure generally the correct setting of the machine.

Recorded Work

The remaining part of the Large Area (about 3 to 3·5 acres) will be measured and marked, and then the recording work will begin and the following items will be noted.

1. *Speed* of forward travel by spot readings over 88 ft.

2. *Number of pickers employed.*

3. *Total time* from start to finish, including all stops, etc.

4. *Stopped time* and the reasons for stops.

5. *Headland Time.* All turns on the headlands will be timed by a stop watch (alternatively, the number of turns will be determined by counting the number of rows and at least 20 per cent. of all turns will be timed).

6. *Weight of Crop Harvested and Rubbish Content.* For this determination sample trailer loads will be weighed and the amount of potatoes and rubbish in them will be recorded. At least three trailer loads, each from a *known length and width of row*, will be weighed on the N.I.A.E. weighbridge and analysed for rubbish content. It will generally be convenient to make up each load from one or two complete rows (according to length and yield). The first load will be sent for weighing and analysis at the beginning of the recorded work, the second in the middle and the third near the end. After weighing the loaded trailer the analysis will be done by emptying the load on to the stack sheet, from which all the potatoes will be picked by hand and thrown directly on to the clamp, or into another trailer, or into bags. The empty trailer will be weighed ; and all the rubbish (soil, clods, stones, weeds, haulm) remaining on the sheet will be weighed. The row length and width will be recorded.

Two alternative methods may be employed at the discretion of the officer in charge :

(*a*) After weighing the loaded trailer it can be taken to the clamp and there the potatoes can be picked out and thrown off. Subsequently the trailer can be re-weighed together with the rubbish remaining in it.

(*b*) In a condition where there is very little rubbish passing into the trailer the officer in charge may decide that it is feasible to collect all the rubbish into a bag or other container as it passes up the final elevator. In this event the potatoes and rubbish from a given row length can be weighed separately.

7. *Fuel Consumption.* The fuel consumption of any engine on the harvester (not that of the tractor) will be measured. A separate removable fuel tank (N.I.A.E. apparatus) with appropriate couplings will be used if practicable. The fuel used throughout at least one day of recorded work will be weighed. Alternatively, the harvester's own fuel tank may be used. In this event the tank will be filled before work is commenced and the amount of fuel added (to leave a full tank at the end of the day) will be weighed.

8. *General Observations.* Throughout the recorded work such items as ease of adjustment and operation, manœuvrability, condition of work for the pickers and safety precautions will be noted. Optimum headland width will also be recorded.

WORK IN THE SMALL AREA

The work in this area is designed to give precise information on :

(*a*) The condition of the crop and the soil.

(*b*) The efficiency of separation obtained by the machine.

(*c*) The pickers' efficiency while working on the machine.

(*d*) The amount of damage to the potatoes.

(*e*) The amount of " leavings " (ungathered potatoes).

(*f*) The draught (and the power requirement when specially requested by the entrant).

The conditions under which the machine is worked will be defined by sampling and analysing the ridges and from photographs of the ridges. The efficiency of separation achieved by the machine and the efficiency of the pickers will be obtained by analysing the issue from the machine when worked firstly without pickers and secondly with pickers. The amount of potatoes left in the ground, either spilled or not lifted, by the harvester will be determined by hand-digging sample areas. The damage sustained by the potatoes after passing through the harvester will be determined by examination of samples, the samples being obtained as the potatoes issue from the output point of the harvester. The draught and power requirement will be determined by the use of draw-bar and p.t.o. dynamometers, or other apparatus, as appropriate. The method of work in this zone will be as follows :

Photograph

A row towards the middle of the marked-out plot (see " Field Preparation " above) will be photographed. The photograph will be taken by positioning a camera above the centre of a ridge and directing the camera straight down the row. The picture taken should be composed of 75 per cent. of view of the ridges and 25 per cent. of the horizon and sky.

Row 1—Ridge Analysis

Two five-yard long samples of the ridge will be taken from the first row of the plot by using the N.I.A.E. ridge-collecting apparatus. The first sample will be taken at a place 20 yds. from the beginning of the plot and the second 20 yds. from the end of the plot. Before using the ridge-collecting apparatus the haulm and top cover of each sample length of ridge will be collected and weighed. The ridge samples will then be collected and analysed separately, using the N.I.A.E. grading apparatus, according to :

(*a*) Soil content—*i.e.*, all material which will go through ½-in. riddle.

(*b*) Clods and stones graded into ½ in. to 1¼ ins.
1¼ ins. to 2 ins.
2 ins. and above.

N.B.—In the stony land condition the clods and stones will be separated by hand and the weights of each group will be given separately.

(*c*) Potatoes graded into ½ in. to 1¼ ins.
1¼ ins. to 2 ins.
2 ins. and above, and the weight of each will be recorded.

The remainder of the row from which the two samples have been taken will be harvested by the harvester.

Rows 2, 3 and 4—Separating Efficiency—No Picking

The second row of the plot will be harvested at a speed of travel rather lower than the optimum (as judged during preliminary and recorded work in the Large Area) and, although the normal number of pickers will be carried on the machine, they will not do any picking. Arrangements will be made to collect the whole of the issue from the machine, both rubbish and potatoes, into a trailer or other container. If there are two streams of material, one of potatoes and the other of rubbish, each will be collected into a separate container.

The method of work will be as follows :

The harvester (with clean riddles and clean share) should start at the beginning of the " run-in " and not at the beginning of the plot. The harvester, set as described above, will therefore harvest part of a row before reaching the beginning of the plot. When the *rear end of the harvester* gets in line with the beginning of the plot the movement forward of the harvester and the revolution of all parts of the harvester should be stopped simultaneously. An empty trailer or suitable container(s) should be substituted for the partly filled one(s) ; and the harvester, the harvester drives and the picking should start simultaneously at a given sign, when the timing with a stop watch also will start.

When *the rear end of the harvester* comes in line with the end of the plot the harvester will be stopped and the drive to the harvester and the picking will also stop at the same time. The time taken on this row over the plot length and the length of the plot will be recorded. All stops which occur during the work over the plot length will be timed and recorded. The contents of the trailer or container(s) will be tipped on to a stack sheet and analysed for the rubbish content (if there have been two streams of material, each will be analysed separately), the amounts of potatoes and rubbish being weighed.

The third and fourth rows (and additional rows if the officer in charge considers further runs are needed) will be harvested according to exactly the same procedure, except that the forward speed will be altered for each successive row. The speed will usually be increased, but the officer in charge may decide to try a slower speed.

Row 5—Picking Efficiency—Picking Rubbish

For harvesters on which arrangements are provided for picking off rubbish, the fifth row of the plot will be harvested at the optimum forward speed and with clean share and riddles in exactly the same way as the second row, with the exception that pickers will be employed picking off rubbish. The number of pickers will be such as to ensure that each is fully occupied. The rubbish picked off will be collected and weighed ; and the potato stream will also be collected, analysed into potatoes and rubbish and the amounts of potatoes and rubbish weighed.

Row 6—Picking Efficiency—Picking Potatoes

For harvesters having an arrangement for picking off potatoes, the next row (sixth) of the plot will be harvested as the previous row, but the pickers will be employed in picking off the potatoes. In this case the number of pickers must be such that, as far as possible, no potatoes are returned to the ground ; but, at the same time, no more pickers than is absolutely essential should be employed. The potatoes picked off will be collected and weighed ; and the rubbish stream will also be collected, analysed into rubbish and potatoes (if any) and the amounts of rubbish and potatoes weighed.

Row 7—Ridge Analysis

The seventh row of the plot will be sampled, three samples of the ridge each 5 yds. long will be taken, one in the centre of the row, one at the quarter length of the row and one at the three-quarter length of the row. The samples will be analysed in the same way as the ones taken from the first row of the plot. The remainder of the row will then be harvested.

Row 8—Damage

The eighth row in the plot will be harvested at the same speed of travel and setting as Rows 5 and 6, and, during the work, eight samples, each containing approximately 25 lb. of potatoes, will be collected into sack-lined chitting trays, the trays being held close under the elevator or the delivery point of the harvester. The samples thus collected will be taken to the damage-recording centre. Four of the samples may be stored for approximately three weeks and an assessment of damage made at the end of this period by peeling and examining the potatoes. The remaining four samples will be transferred to buckets, soaked in water to remove the soil, drained and dipped in a para-cresol (or an iodine) solution for purposes of staining, and then, if an iodine solution is used, rinsed again in water. The skin abrasions and cuts will be emphasised by colouration.

The potatoes will be inspected one by one and divided into two main groups.

1. Undamaged.
2. Damaged.

The type and degree of damage will be classified into grades as follows :

Grade I.—Skinning ; tissues below skin unbroken.

Grade II.—Injuries in any amount (other than Grade I) which will be removed by normal peeling (using a potato peeler).

Grade III.—All other injury.

The sound potatoes and each grade of damaged potatoes will be further classified into size groups by riddling over square mesh riddles as follows :

(*a*) Below 1¼ ins.

(*b*) 1¼ ins. to 2 ins.

(*c*) Above 2 ins.

After classification the weight of each group will be recorded.

Row 9—Draught and Power Requirement

The ninth row of the plot will be used to measure the draught and, when required, the power requirement at the power take-off or of the harvester's own engine. For a determination of draught, 20 readings should be obtained at 5-yd. intervals along the row, and preferably a run should also be done in the reverse direction near the plot. The N.I.A.E. power-take-off dynamometer will be used for p.t.o. power determinations, and special equipment will be needed for power determinations of the harvester's own engine.

Row 10—Damage

In the tenth row 8 samples of potatoes to be used as control samples, each of approximately 25 lb., will be dug by hand and will be taken to the damage-recording centre for treatment (4 samples for immediate staining and, possibly, 4 samples for storage) in exactly the same way as described for Row 8.

Row 10 will then be lifted by a potato spinner (N.I.A.E. stock machine used as a standard).

Row 11—Damage

The eleventh row will be lifted by the potato spinner, after the passage of which 8 more samples of potatoes will be collected. The samples will be gathered from the ground ; and each sample, randomly located, will be marked by enclosing a strip of ground containing about 25.lb. of potatoes. *All* the potatoes in the enclosure will be gathered for the sample, and the procedure for damage determination will then be the same as described above (4 samples for immediate staining and, possibly, 4 samples for storage).

Leavings.—The leavings (ungathered potatoes) will be determined by hand-digging 5 rectangular sample areas, each of 11·1 ft. × 7 ft. (8·643 sq. yds. or 1/560 acre). The sample areas, delineated by marking chains, will be located at random over the plot (the small areas from which samples for ridge analysis have previously been taken and the areas lifted by the spinner will be avoided). Each sample of leavings will be weighed and then all the samples will be dumped together and will be weighed as a check and then graded into groups of under 1¼ ins. ; 1¼ ins. to 2 ins. ; and over 2 ins. ; and each group will be weighed. The discrepancy which there will be between the sum weights of the individual samples and the weight of samples when dumped together will be due to weighing errors and loss of soil, etc. The weights of individual samples will be obtained in order to check the sampling technique statistically.

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DISCUSSION

IR. J. CRUCQ* : After hearing Mr. McLaren's Paper, I am more than ever convinced of the great value of the N.I.A.E. Test Reports. Implements here are subjected to a more thorough and intensive test than at any other Institute in Europe.

To get a clear idea about the testing procedure applied by our Institute, the differences between England and the Netherlands should be kept in mind. In your country agricultural engineering is an important industry ; in comparison, the Netherlands' industry is insignificant. Nearly all tractors and implements are imported. Therefore, the testing of implements in the Netherlands is not meant to assist the industry in the development of implements and to test prototypes, but to help farmers in making their choice.

We try, by means of our test reports, to draw attention to good implements and to limit the selling of unsuitable ones. A vital factor in this connection is that the Netherlands' farmers, in contrast with many other countries, are very keen on getting advice from the advisory services and from other institutions. This does not only concern problems in the field of crop growing, plant diseases, and so on, but also the purchase of tractors and implements.

The difficulties met with in testing, already mentioned by Mr. McLaren, are also experienced by our staff, but to a lesser degree.

Our work is simplified as we select the machines ourselves, not waiting till a machine is presented for test. We contact importing firms or manufacturers regarding the testing of implements, which are, or might become, of importance. This has the advantage that the work can be distributed over the whole year and that care can be taken that there are at least two machines of the same type being tested simultaneously.

In the testing programme space is left for implements which are presented for test by manufacturers or importing firms. Machines which offer few possibilities are refused.

We have at our disposal a farm of 500 acres, the types of soil varying greatly. Nearly all the types of crops grown in the Netherlands are grown on the farm. The enterprise is completely mechanised, so that the whole staff is experienced in operating tractors and implements.

Test Conditions

We try to classify these conditions, as far as possible, in a simple way. We are, however, well aware of the fact that we are not yet as advanced as the N.I.A.E. in this field. The difficulties are reduced by testing machines under a wide variety of conditions and by comparing these machines with each other and with a standard machine.

Quality of Work

With our small staff it is not possible to carry out the research work required for establishing standards at short notice. I am convinced that extended international co-operation would be of great advantage in this respect. For the time being, our assessments are more or less subjective, based on our experience and on practical results.

From what I told you about the Netherlands tests, it will be obvious that we proceed more in a practical than a scientific way. Our method is similar to the German, and is an intermediate form of the Swedish and Danish tests, by which some very important results were achieved, and the more intensive and particularly more scientific British method.

Our procedure for testing sugar beet harvesters is nearly the same as yours. This method is also applied at the annual Sugar Beet Harvester Demonstrations in the Netherlands. When assessing the performance of machines under test, however, the results of these demonstrations and the results obtained on farms in different parts of the Netherlands are also taken into consideration. Is it not a pity not to use this experience, often gained over several years and under very different conditions ?

When testing sugar beet harvesters you use a standard machine. I suppose that this is usually a machine corresponding with the test machine as compared to the degree of automatisation. When testing potato harvesters, however, a spinner is used as the standard machine. This only gives a standard for the assessment of damage ; why not use a complete harvester to this end, so that the assessment of rubbish content and leavings will also be possible ? I assume that it is not easy to give, at present, the correlation between the composition of the potato ridge and the performance of the machine.

A difficulty experienced when testing potato harvesters is the correct setting of the machine. One can start from various standpoints. You can try to obtain as high a capacity as possible ; on the other hand, you can operate the machine in such a way that the damage caused or the dirt tare is as low as possible. The correct setting is between these two extremities, but where ? It is almost impossible to judge during the operation whether the damage caused is too great.

Quite rightly, it is outlined in the detailed procedure for testing potato harvesters that some rows should be harvested at different forward speeds. This, however, is not the only possible variation ; the forward speed, number of revolutions, and the setting of the shaking action play an important rôle. The number of settings is infinite and it is not possible to try them all. The same difficulties arise in testing different implements. We choose the setting which we think to be the best. In the end we want a machine that can be set by the average farmer.

The greatest difficulty in testing potato harvesters is the assessment of damage. What percentage of damage is still allowable and what not ? Besides the variety of

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the potatoes, the conditions experienced during the harvest and even during the growing period have an influence on damage. Therefore, a standard machine is indispensable in testing potato harvesters.

Much attention is paid in the Netherlands to this aspect. Extensive investigation on the influence of damage on the quality and keeping qualities of the potatoes is carried out. We store the samples for four to six weeks. They are then externally inspected and peeled with a peeling machine. We tried the N.I.A.E. method, but got different results. Our potatoes are quite different from the English potatoes. They are smaller and contain more starch. Consequently, they get different injuries—for the most part, internal bruises and less cracks and abrasions.

To end with, I should like to point out that in spite of all differences in agricultural methods and ideas we should try to standardise our test procedures as much as possible. To this purpose, exchange of each others' views is necessary. It is for this reason that I am so grateful to the council of the I.B.A.E. for extending to me an invitation to attend and speak at this meeting.

MR. G. W. JONES : I should like to congratulate the author on his Paper from the farmer's angle. I do not think he left out one thing that any farmer could suggest which should be tested in order to give a true picture of what paces the machine should be put through. Unlike our friends in Holland, I do not think that 10% of the farmers in this country know that the N.I.A.E. exists. I believe that most manufacturers know of its existence, but, speaking for myself, ten or eleven years ago I did not know it existed. Since then my education has been improved, and I must say that my contacts with the N.I.A.E. have been very beneficial indeed, and I do not think that either manufacturers or farmers make anything like the use of the Institute that they should.

I do not propose to touch on beet harvesting. That might sound like advertising, but I can say that the battle of the beet really started in about 1946, and I think we can claim that by 1957 the battle had been completely won. I do not mean to claim that the machines are perfect, but they are equal to any hand labour, and having said that I think I can forget them.

The potato harvester is quite a different matter. I believe it is the most important to be tackled in agricultural engineering. I notice that at no demonstrations do the big firms come along with a potato harvester. They leave it to the small firms to carry on with the battle in that connection ! It is my ambition to produce an efficient potato harvester, and I think we are going a long way towards it, but I feel that whatever is published on these tests and trials, industry has to be careful not to scare farmers off potato harvesters. So far as the question of damage is concerned, Mr. Crucq raised a very pertinent point regarding the degree of damage. If we are to have potato harvesters in England there is going to be damage. There is no doubt about that ; but what has to be decided is what degree of damage can a potato harvester cause to the crop and yet be called efficient ?

Coming to the manufacturing side of the question and the N.I.A.E.'s testing problems, I am not so sure that a machine should be sent for test until the manufacturer is satisfied that the N.I.A.E. Report can be published. At the moment, I believe we are wasting the Institute's time when we send machines, although I know we partially pay for the job. I think that we are under some obligation to the industry and to the farmers in this respect, and that if we send a machine for testing we should be reasonably satisfied about a report being issued on it. The time factor would not be so urgent and you would not get so many machines. The farmer would also be able to see what you thought independently of our machines.

MR. J. R. WARBURTON : I am very pleased to be replying to Mr. McLaren's Paper, because as the farmer with probably the longest experience of the N.I.A.E. it gives me the opportunity to say how greatly I and other farmers appreciate the important research that goes on at Silsoe.

It was as long ago as 1929 that I first worked in conjunction with the N.I.A.E., or the Oxford Institute as it was then. The occasion was the first tests of combined harvesters to be held in England. The enthusiasm shown by the staff at those trials was so infectious that I believe it inspired me to start farming on my own.

This long and happy association will, perhaps, entitle me to make some criticisms of their work, which I hope will prove to be constructive.

Mr. McLaren's Paper describes well the intricate and scientific work that is used for the testing of farm machinery, but, because it is so factual, it follows that it is a difficult Paper to criticise, so I propose to refer principally to the general work of the Institute.

I would say that if the N.I.A.E. have any sins these are sins of omission only. Firstly, they have omitted to blow their own trumpet, with the consequence that much of their important work is not generally known. Could not the Agricultural Research Council be appointed as their Publicity Agent ?

Secondly, a great deal of their fundamental and significant research seems to me to remain locked up in their files, and is therefore unknown to farmers.

Let me now examine the tests of the potato harvester as described in the Paper. After amazing and often ingenious work, and the use of several unique appliances, they have come to the conclusion that the complete potato harvester, given suitable circumstances, does in fact harvest successfully, but with appalling damage to the tubers—nearly double that of the spinner.

After two years' work, an immediate neighbour and myself have come to the same conclusion. The damage and the bad condition of the stored potatoes is so bad that we have stopped using the machines.

Now, although the tests reveal this damage and the very clever means of assessing it, for some reason unknown to me the Institute does not even hazard a guess as to the reason for this damage.

To me it seems that as the spinner and the elevator digger only appear to do about half the amount of damage caused by the complete harvester, it must be because in both these machines the tubers are shielded from direct contact with moving metal by a cushion of soil. If this is so, the damage done in the complete harvester must take place in that part of the machine where all the soil has been riddled away. Alternatively, the damage may happen at the place where the tubers drop from the elevator into the accompanying trailer.

Yet a third reason was suggested by one of my own men which, although it may seem a little far fetched, is deserving of some study. This old farm hand pointed out to me that after the spinner or digger had been used the potato was left on the surface of the ground and subjected to about 20 minutes of light and air. This, he suggested, had the effect of toughening the skin of the potato and so improving keeping qualities. In the complete harvester, of course, the potato is in the soil one minute and in the clamp the next.

I would suggest that the Institute is mature enough, and its reputation high enough, for them to make some such sweeping statement that, in their opinion, further capital expense on the production of harvesters is not warranted until this problem of damage has been settled.

Might not the final answer to the problem be to develope an elevator digger that will dig and place two or three rows into one windrow, and then use some form of elevator to pick up this row? Some years ago, I remember a John Deere beet harvester based on this conception and wonder if the idea has been abandoned?

The need for a complete potato harvester is obvious to all, and hundreds of thousands of pounds have been spent in trying to perfect one. Might not the best solution be for the N.I.A.E. to be given a Government grant to enable them to develop one in their own good time? I remember that they made quite an encouraging start some years ago when they fitted a disc plough underneath a tractor and ploughed the entire ridge on to a side delivery elevator. This would seem to me to be an encouraging start, and I wonder what happened to the idea?

In their long and painstaking tests of harvesters I wonder if the N.I.A.E. have had any experience of foreign makes?

In Canada, America and the Antipodes farm labour is in shorter supply than it is in England. This would seem to indicate that the need for a potato harvester is even greater in those countries than it is here. Could Mr. McLaren say whether we are ahead of those countries in this matter or have they already come to the conclusion that the problem is insuperable? I do remember seeing one American machine working in Scotland. Quite a simple idea of an ordinary digger that delivered the potatoes on to a sorting conveyor with three sorters sitting on each side. When the crop was good and little trash present, the sorters merely removed the rubbish from the crop, which was then bagged up. If, however, there was a lot of trash and clods, the sorters picked the potatoes out and placed them on two small conveyors running alongside the main one, from which they were again bagged up. This meant a simple and comparatively cheap machine, which I suggest might be the final answer.

Beet harvesters are, in comparison, far easier to design, and I think that one could say that, except for the singling of the beet plants, the full mechanisation of the beet crop has already been achieved, and I feel that with the arrival of spacing drills and down-the-row gappers hand labour in the beet crop will soon be reduced to an absolute minimum.

It is for this reason that I have switched from potatoes to sugar beet.

MR. WATTS (Department of Agriculture, Nigeria): I should like the author to clarify something that is puzzling me. When dealing with the typical results of ridge analysis, he mentioned that Field 1 and Field 4 were the same fields, but that they had been harvested under different conditions. In the first one it was sandy loam dry, and in the second sandy loam moist. A point was raised earlier about the question of the settings of these machines, and I wonder whether the author would clarify the point with regard to the setting. I notice that 356 tons of loose soil were passed through a $\frac{1}{2}$ in. riddle in Field 1, and in Field 4 only 148 tons went through the riddle. If one looks at the results of potatoes harvested it is found that there is not such a great difference. In the case of Field 1, 13 tons were harvested and $8\frac{1}{4}$ tons in the case of Field 4, when only 148 tons of soil went through the riddle. It would seem that there must be a vastly different setting on the machine or, perhaps, it is set at a predetermined depth?

MR. C. B. CHARTRES: As a Northumbrian, it is a pleasure to come and listen to a lecture given by a fellow county-man. I have known the author for a long time. We had him with us in the very early days of the war on the County Agricultural Committee in Northumberland, and we were unwise enough to send him to the N.I.A.E., then at Askham Brian, for instruction in special work. Unfortunately for us, they thought as much of him as we did, and we lost him! However, he has been serving in a much bigger field, and I should like to congratulate him on the way in which he has put the Paper together and on the excellent way in which he has presented it.

The question of testing potato lifters is a very difficult one. The author has not said much about rainy days and the gluey conditions in which the machines sometimes have to work and which makes such a great difference to their operation. I should like to ask Mr. McLaren whether he confines his testing to moderately good conditions or whether he sometimes carries them out in the sticky conditions with which farmers are often faced at the end of the season.

MR. C. CULPIN: I need hardly say how much I enjoyed the Paper. Both Mr. Crucq and the author referred to the value of what the author calls "series tests," and I would say that from the point of view of the N.A.A.S. and our advisory work, series tests—where more than one machine is tested at the same time under comparable conditions—seem to us as likely to be more valuable than the tests which are made for individual manufacturets.

We all know the reasons why testing is carried out as it is, but I thought it was interesting to know that in the Netherlands and in the other countries of Europe this business of series testing is quite the normal method, and I wonder whether we could hope to see more of it in this country.

MR. G. T. MERRYWEATHER : During the war I saw a farm which was mechanised for bulbs switch over to potatoes. The method of harvesting the bulbs and subsequently the potatoes was to commence from the end of a drill, using an elevator-digger. Potatoes, clods and stones were all collected into sacks, which were then transported to a barn. There the sacks were unloaded on to a wide, slow-moving conveyor belt, and girls picked out the potatoes from the remainder. With this method the soil provided additionally a cushioning effect.

MR. W. H. CASHMORE : The suggestion that all test reports should be published links up, in a way, with the view expressed that a great deal of experience and knowledge at the N.I.A.E. is not published. As a general rule, all our work is published in scientific and technical journals, with a follow-up of more popular versions. It is a great pity that many test reports are unpublished because they represent many months of work and contain information which would be helpful to research workers, manufacturers, design staff and farmers. However, publication can only be on a voluntary basis if a report is to be entirely frank. Obviously, no useful purpose would be served by publishing a test report on a machine which was afterwards improved as a result of the test. Few machines having a bad report go into production until improvements have been made ; on the other hand, a farmer reading an unfavourable report might be prejudiced against a machine which had afterwards been improved.

I am delighted to say that the percentage of published reports is rising and manufacturers are beginning to allow reports to be published which do contain some criticisms. I cannot see any way out of the difficulty of the unpublished reports. I know some farmers are thinking very much along the lines suggested by Mr. Jones, but under the present arrangement the decision must be in the hands of the manufacturer.

MR. D. R. BOMFORD : I am speaking as one who has an interest in two small manufacturing firms, both of which have received an immense amount of help from the Testing Department of the N.I.A.E.

I should like to refer to section 3 and to the sixth heading under which machines are tested ; that is to say, " Construction in terms of avoidance of breakage or distortion, and length of life." Length of life would, presumably, include abrasion. The author has told us that the practicable length of working time in the field is generally about 50 hours, and, of course, we understand that there is an obvious limit. If it were carried on for longer duration, tests would become impossible and the number of tests put through would be too small. But we find that, although by what I believe the author would call " shock load testing " structural weaknesses are revealed in the machines, there are weaknesses which emerge when the machines go on to the market in quantity. I thought at one time that this was probably due to the fact that even under conditions of shock load testing the staff of the N.I.A.E. could not be quite as ham-fisted as some of the people on the farms are when they are not supposed to be indulging in shock load testing ! However, that may not be the case, and I suppose the real truth of the matter is that at a later stage we come into fatigue failures which cannot be revealed in the time available in the ordinary test. I wonder whether the N.I.A.E. has anything in view which may give us short-term information on fatigue testing.

While I am speaking I should like to say that we have also had very considerable help on a prototype from the Test Station at Wageningen, and I should like Mr. Crucq to know that we are considerably indebted to him for the work which they have done for us.

MR. A. PHILLIPSON (N.I.A.E.) : Mr. Watts raised a question in regard to the amounts of soils shown in the first table in respect of Fields 1 and 4, and I think the answer is that those two results are for different years and, of course, the conditions are different. Probably the chief variation is that of different setting depths, for, of course, potatoes are not always planted at the same depth. If you plant ½ in. lower the difference in the amount of soil taken in by the harvester may be 50 tons to the acre for the extra ½ in. in depth. We try to set the machine as shallowly as possible without leaving or cutting any of the potatoes.

MR. R. M. CHAMBERS : I should like to ask the author whether plant breeders are taken into the confidence of the N.I.A.E. in connection with the damage to potatoes.

My recollection of potatoes goes back many years when I used to lift them, and I remember in Ireland that we used to throw them four or five yards into a basket. They probably bounced in the basket, but they came out of the store in perfect condition in the following March and April. I find it hard to imagine that throwing potatoes or dropping them into a trailer can be all that serious, but perhaps in those early days we were growing a different type of potato which was able to withstand the damage.

MR. CLAPP : Is there any possibility of potato lifters being used in the same way as some of the sugar beet harvesters, and lifting potatoes by the tops?

MR. MCLAREN (in reply) : To take the last point first, in a recent Paper by a member of the N.I.A.E. staff[14] it is pointed out that if a suitable variety of potato could be developed in which the tubers would remain firmly attached to the haulm, it would seem from experience gained with certain sugar beet harvesting equipment and, more recently, a type of ground-nut harvester that the potato harvesting problem would be much simplified. However, a breeding problem is involved here, and with anything associated with breeding it is usually necessary to work on a very long-term basis.

In connection with Mr. Chambers' question, the staining assessment is, of course, done immediately on harvesting, and already there is evidence from both testing work and from research work that a number of factors can affect the degree of damage at that stage. There is the question of maturity as well as the variety of potato involved. Again, soil and weather conditions at harvesting influence the result. Under wet conditions, for example, it is possible to get a compound effect, because although there may be a soil cushion to protect the tuber, more violence may be required to break up the ridge ; thus while total damage may be less under wet conditions, there may be an increased number of seriously damaged tubers. However, all these aspects of damage are the subject of current research designed to determine what is the precise cause of each form of damage and in what circumstances it is most severe. Until this research has been done, test results cannot be interpreted fully and we cannot be as helpful as we should like to be on such questions as to which particular parts of the machine are causing the trouble. Naturally, we go as far as current knowledge will allow in pin-pointing troubles for the manufacturer and suggesting ways in which he can overcome them.

Returning to the starting point of the discussion, I was most interested to hear Mr. Crucq's comments, because I and some of my colleagues at the N.I.A.E. had the pleasure of visiting Wageningen some years ago and of exchanging views on methods of testing, and particularly on damage assessments ; and I may say that we learned a great deal from our Dutch friends and were able to adapt some of their methods to our procedures.

Mr. Crucq mentioned a point about the choice of comparison machine and asked why do not the N.I.A.E. use a complete harvester as the comparison for damage assessments. In broadly the same context, Mr. Jones stressed the need for laying down the degree of damage which can be tolerated before a harvester is classed as inefficient. The difficulties associated with the latter point are, of course, referred to in general terms in the Paper, while in answer to the former I would say that any test procedure should be related to the stage of development in the particular class of machine concerned. At the present stage in the development of potato harvesting equipment, one cannot fairly do more than compare the complete harvester with a widely-used harvesting device such as the spinner. However, as with the testing of sugar beet harvesters, the testing methods for potato harvesters will advance as the class develops and known requirements are established.

Mr. Warburton asked about the possible benefits of two-stage harvesting in relation to the avoidance of damage and also referred to the question of overseas machines. In this connection, we know that in certain countries two-stage harvesting is being practised, and recently the Director of the N.I.A.E. Scottish Station visited several of the potato growing areas in the United States to study their potato harvesting methods. I understand from reports that one of the features of two-stage harvesting is that it allows a period of hardening-off and of drying out of the dirt on the tubers, and I might mention that this form of harvesting is to be investigated in this country.

With regard to progress with potato harvester development overseas, the point which always strikes me is the differences in conditions prevailing in the various countries. For instance, I think I am right in saying that the clod problem as we know it in this country does not exist in many of the potato growing areas in the United States, so that while in those areas they may be more fully mechanised in respect of potato lifting than we are, in my view, taking in account the difficulties associated with our conditions, we are ahead in this country with regard to the development of the complete harvester.

On the question of the operation of machines under test, the basic questions are " Who are you testing for ? " and " What is the purpose of the test ? " In order to get the best performance out of the test machine without the complication of operator's lack of knowledge, the N.I.A.E. does operate test machines with its own staff, and although the staff is obviously not infallible, this procedure helps to remove one variable factor.

The question about the typical ridge analysis results has been dealt with by Mr. Phillipson, who made the point about differences in setting. Nevertheless, the important feature is that the results enable one to pin-point that which was not obvious beforehand ; namely, that the harvesting problem, while apparently easier in, say, a dry season, may in fact be more difficult as far as clods are concerned.

With regard to the point made by Mr. Chartres about confining attention to good conditions only, needless to say, the N.I.A.E., like anyone else who has to operate machines under practical conditions, runs into the same sort of trouble during the test as the farmer runs into at, say, the end of the potato harvesting season. We like to start off each test early in the season so that we can get an assessment of what the machine will do under the best possible conditions, but in practically every case we run into difficult conditions in the latter part of the test. The aim is to get an assessment over a reasonable range of both soil and crop conditions.

Mr. Culpin referred to the value of series tests from the point of view of advisory work. From the N.I.A.E. angle, series tests are a valuable method of testing. As mentioned in the Paper, the big difficulty is the organisation required to carry out a series test of even moderate size and, consequently, at the moment, N.I.A.E. policy is to choose subjects which are of topical interest, and to carry out one such series test each year.

This brings me back to one of Mr. Jones' comments ; namely, that a manufacturer should not submit a machine for test until he is prepared to have the results published. Of course, a good proportion of the present N.I.A.E. testing programme is concerned with prototype testing where the aim is to help a manufacturer to improve a machine before it ever goes into production. Naturally, the results of a test on a prototype machine are not usually suitable for publication, although this aspect of the N.I.A.E. testing service is one which, I think, is appreciated by many manufacturers.

Mr. Merryweather referred to the adaptation of a bulb harvesting method to potato harvesting. As I see it, the major difficulty is the vast quantity of unwanted material which has to be transported to and handled in the store. It is an attractive approach, but one which has not been pursued because of the large quantities of material which have to be handled.

Mr. Cashmore mentioned the fact that the percentage of test reports which are agreed for publication is increasing. That is so, and it is a feature which, from the N.I.A.E. point of view, is appreciated and thought to be a wholly desirable trend.

In connection with Mr. Bomford's comments on the obtaining of short-term information on fatigue failures, we have in the past tried various methods to this end. For instance, when testing a trailer plough the manufacturer has sometimes been asked to state the upper limit of drawbar pull which he has designed his plough to stand, so that during the test we can introduce a piece of apparatus between the tractor and the plough which will release the plough at levels above that stated figure. The plough is then tested under conditions which ensure that the pull is at the figure for the bulk of the time. Again with trailer tests, test tracks have been used and in certain cases we have artificially flexed the trailer body ; however, until we can correlate much more closely what happens in the field and the conditions which we produce artificially, we are hastening slowly with the development of such techniques in case we mislead both ourselves and the entrant.

ANNUAL LUNCHEON, MAY 1958 *(continued from page 97)*

I hope in the future we shall all work even more closely together to attain greater standardisation not only in the range of products of each firm, but as a group with the future of the industry at heart.

I have had an opportunity of reading the list of the Companions of the I.B.A.E. and I find among them the names of such great contributors to agricultural engineering as the Bomfords, Rex Patterson, Newcombe-Baker, Willie Elder, E. N. Griffith, Roger North, C. B. Chartres, Col. Johnson and many others who have made valuable and enduring contributions to our industry over the past 20 years. They, and others, have been the pioneers and we thank them for their dedication to our industry and for the memorable work they have done.

Three years ago Mr. David Ransome put forward the original idea for a National College of Agricultural Engineering. Much progress has been made with this scheme, which will be of outstanding value to our industry, and we are daily expecting advice from the Minister of Education that agreement has been given for the fulfilment of this vital project. This proposal, naturally, has the full support of the A.E.A., which is co-operating to the fullest extent with the I.B.A.E. The importance of a regular source of trained men is obvious. Until such time as the College is established, there is, of course, an output each July of young men who have obtained the National Diploma in Agricultural Engineering. We should like to take this opportunity of reminding those of you here, and others in the industry who are employers, of the value of this qualification when, in the future, you are selecting men for posts in your organisations. I have seen the syllabus and must agree with some of the eminent examiners when they say that they themselves would not relish the idea of sitting the examination.

You may be certain that the men who have obtained this National Diploma are well worthy of a place in one branch or another of our widespread industry.

Our agriculture is the most highly mechanised in the world. Since 1939—yes, and before that—we have all worked wholeheartedly together to achieve greatness in our industry, in increase our prestige, to improve our exports to the stage where we are " number one " in the world, and to make it attractive and really worthwhile for the future generation to follow in our footsteps and to make agricultural engineering their life work. I feel that working closely and energetically together, as we have in the past, the achievements of our industry will be even greater in the 20 years that are to come.

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