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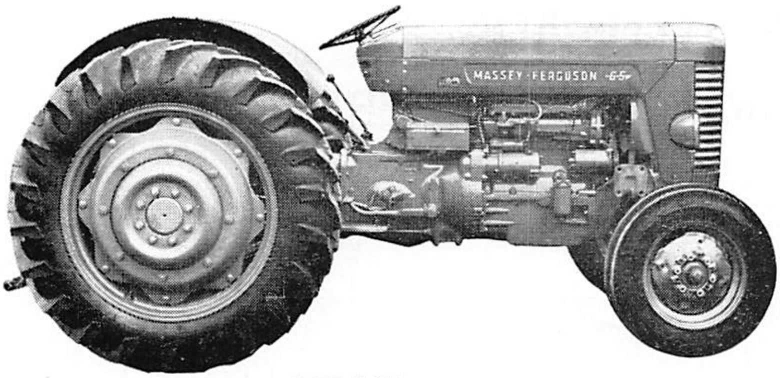

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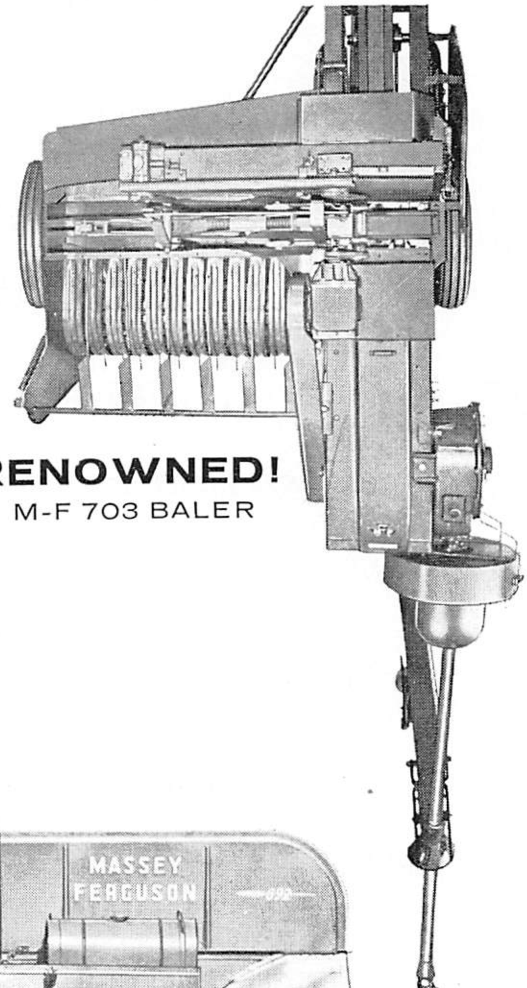

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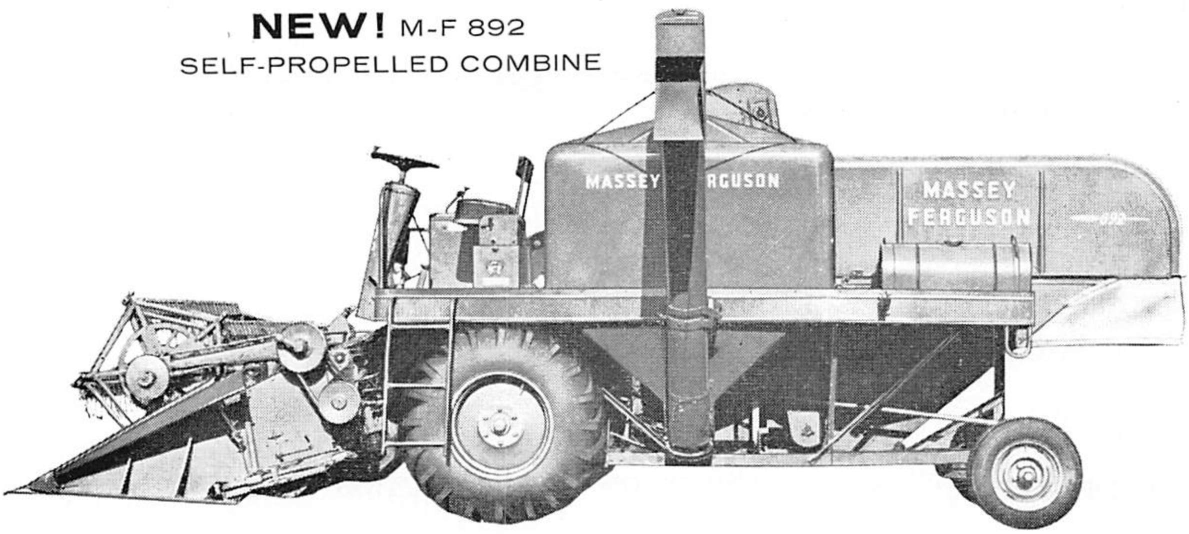

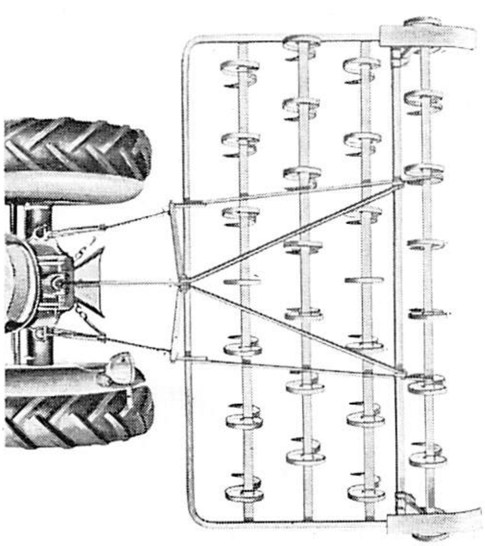

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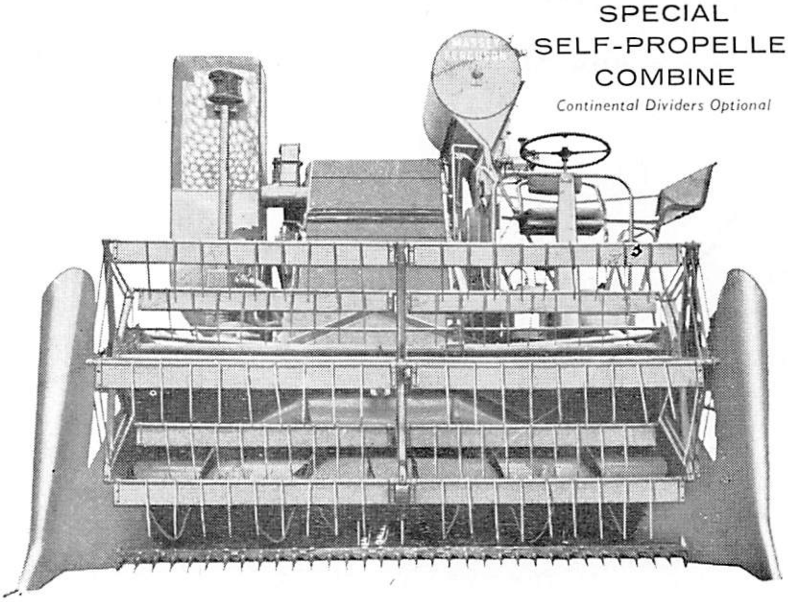

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INSTITUTION NOTES

Careers in Agricultural Engineering

IN pursuance of its policy of interesting school leavers and others in careers in agricultural engineering, the Council arranged a lecture during the Commonwealth Technical Training Week in June. The Speaker was Dr. P. C. J. Payne, and his talk was attended by a gratifyingly large number of boys, together with some careers masters.

Copies of the lecture have been widely distributed to Universities, Colleges and Schools throughout the country, together with information about the Institution's two examinations, the National Diploma in Agricultural Engineering and the Membership Examination.

During his talk, Dr. Payne referred to the speech made by the Duke of Edinburgh at a joint meeting of the Institutions of Civil, Mechanical and Electrical Engineers, when His Royal Highness mentioned the pressing need for agricultural engineers in the newly developing areas of the world. Dr. Payne emphasised that it had been the policy of the Institution since its earliest years to train men for this work, and that this had been one of the reasons why, for so many years, the Council had pressed for the establishment of a National College of Agricultural Engineering.

Membership Entrance Examination

The existing syllabus for this examination having been in use for three years, and applications for membership increasing rapidly, the Examination Board and Council have decided that the syllabus shall be revised and the required period of training increased in order that higher standards of entry may be applied.

The new syllabus will be published in the Autumn of this year.

Appointments Service

Following the reference in the last issue of the Journal, many members have applied for the regular provision of the monthly Appointments Service bulletin ; others who would like to receive the bulletin should apply to the Secretary.

Membership Certificates

A large number of Certificates have now been sent to members. Copies may be obtained, free of charge, from the Secretary. Framed copies are also available at 15/- each.

Presidential Badge of Office

At its meeting in June, the Council accepted with gratitude an offer by Shell-Mex & BP, Ltd., to provide a Presidential Badge of Office, together with small badges for the Past Presidents of the Institution.

Consideration had earlier been given by the Council to an appropriate crest for the Institution, and draft designs commissioned. It is anticipated that a final design will be approved, and the Badge of Office prepared, in time for its use on the occasion of the change of Presidency in April, 1962.

In making their offer, Shell-Mex & BP, Ltd., referred to the value of the Institution's work and their appreciation of the honour conferred on Mr. W. J. Nolan by his election to a third year of office.

Proposed Institution Tie and Car Badge

In view of the preparation of the crest referred to above, Council has reconsidered requests made from time to time for an Institution tie and possibly for a car badge.

Branches have been asked to ascertain the number of their members who would purchase ties, and those members who are not in the area of any of the Branches are asked to notify the Secretary if they are interested. Similarly, it would be of assistance if those who support the suggestion for a car badge would make this known.

Affiliated Organisations

At the recent meeting of the Council the following Companies and Organisations were elected Affiliated Organisations of the Institution :

- Bamfords, Ltd.
- British Electrical Development Association.
- Ransomes, Sims & Jefferies, Ltd.
- Ricardo & Co., Ltd.
- Joseph Sankey & Sons, Ltd.

The Council is grateful for this recognition and practical support of the Institution's work from the above, and from other Companies who have been elected in the past.

Membership Qualifications

Following representations that the Membership Committee is rejecting a high proportion of applications and that some adjustment of standards of admission should be made, the Council has reconsidered the criteria upon which the Committee work. The Council agreed unanimously that there should be no relaxation of these standards, but that a simplified form of application should be prepared for those whose experience qualified them for Associateship.

The volume of applications is such that it has now become necessary for forms to be photo-copied and circulated to members of the Committee prior to each meeting.

Papers presented at the Institution Conference 25th April, 1961

TRACTOR REQUIREMENTS FOR INTERNATIONAL AGRICULTURAL ENGINEERING STANDARDS

by C. H. HULL, A.M.I.Mech.E.

Mr. Hull, Chief Engineer of David Brown Tractors, Ltd., received his academic training at the Harris Institute, Preston. After serving a student apprenticeship with Leyland Motors, Ltd., during the 1930s, he worked on diesel engine development in the Research Department. He joined the Royal Aircraft Establishment, Farnborough, as technical assistant and worked on aircraft engines and hydraulics. He had three years' design and development experience on fuel injection systems with Simms Motor Units, Ltd., London, between 1946 and 1949. He first joined David Brown Tractors in 1940 as designer, was appointed Research Engineer in 1943, Assistant Chief Engineer in 1954, and Chief Engineer in 1956.

Mr. Hull has attended International Standards Organisation meetings in Lisbon and Paris as a United Kingdom delegate. He has also travelled extensively in Europe and North America in connection with tractor development projects and tractor testing at the various national tractor testing stations.

SUMMARY

A BRIEF outline is given of the need for and the way in which the present International Organisation for Standardisation was set up and the manner in which it operates. The Paper reviews some of the standards concerning tractor design and the problems in applying them.

The British drawbar standard does not define the required strength ; a reason for this is given and suggestions for clarifying the situation.

The power take-off speed standard is being overtaken by the rising trend in tractor power. Some confusion has arisen due to lack of a specific definition of rated engine speed. The new American P.T.O. speed standard is outlined. The question of ground speed P.T.O. is examined and commented upon. The effects of the introduction of three point linkage and of tractor design upon the standard height for the P.T.O. shaft are discussed and the probable lines of revision indicated.

The Continental trailer hitch is described and reasons given why it is not used here. The three-point linkage standards, both national and international, are explained and various proposals for development of these are discussed.

Other standards and some regulations which affect design are mentioned. In conclusion, some suggestions are made of ways in which progress in this field could be facilitated.

* * * *

Since the Industrial Revolution, mechanisation has spread with ever-increasing rapidity throughout the civilised world. Each country is inclined to follow trends according to its own traditions, conditions and circumstances. This leads in many cases to unnecessary diversity, wasted effort and confusion.

Yearly, the world becomes a smaller place ; individual countries become technically more dependent upon each other, with the result that more and more manufacturers must design their products for international usage. The requirements of traders and the convenience of users must be considered. To provide the required guidance and co-ordination, the International Organisation for Standardisation (I.S.O.) was formed.

In 1944 the United Nations Standards Co-ordination Committee, comprising 18 allied countries, was set up with the aim of re-establishing the interchange between countries of information on standardisation, which had been interrupted by the war. At a meeting of this Committee in London in 1946, the proposal was made to form a permanent organisation to deal with this problem. In 1947 I.S.O. was founded and a constitution drawn up.

Let us take a brief look at how I.S.O. operates. The membership consists of the standards bodies of each member country. There are a total of 40 of these working together in over 90 technical committees. Suggestions of subjects suitable for consideration by I.S.O. for international co-operation are made by members. These suggestions are circulated to all members inviting comments and participation in work on the subject.

Based on members' comments, an I.S.O. planning committee determines the work to be initiated and which committee will undertake it, or if a new committee is required which member shall be responsible for the secretariat.

The secretariat of a committee assembles details of existing national standards and the views of participating members, and, based on this, prepares proposals. Periodic meetings of the committee are arranged by the secretariat, at which delegates from all participating members discuss the proposals. Proposals on which agreement is reached are put forward as Draft I.S.O. Recommendations by formal resolutions of the committee. Approved drafts are published as "I.S.O. Recommendations." Up to the present, over 400 I.S.O. Recommendations have been published.

It should be noted that I.S.O. committees do not produce I.S.O. Standards, but I.S.O. Recommendations.

Members are pledged to accept these as the basis within which standards or standard revisions will be drafted.

Thus the aim of I.S.O. is not to produce new standards, but to secure national standards which do not conflict in their essential requirements.

The I.S.O. technical committee responsible for agricultural tractor standards is ISO.TC22/T, the secretariat of which is France (AFNOR). This committee has been in existence for some years, and substantial progress has been made towards reaching agreement on some of the basic standards. As yet, however, no I.S.O. recommendations have been published.

The purpose of this Paper is to review some of the national standards and proposed I.S.O. Recommendations relating to agricultural tractor design and to consider some of the problems in their application to current designs.

Drawbar P.T.O. and Belt Pulley

The oldest established standards relating to agricultural tractors are quite logically those relating to the Drawbar P.T.O. and Belt Pulley, as these are the original external means peculiar to a tractor which enable it to fulfil its designed purpose.

The original standards in this field were the A.S.A.E. American Standards, and no doubt as a result of the Americans being the largest exporters of tractors and farm machinery prior to World War II these became the basis of many other national standards. Certainly the P.T.O., pulley and drawbar standards in the current B.S. 1,495 were originally based on the American Standards. A wide measure of agreement has been achieved in the I.S.O. committee on standards for these parts.

Drawbar

The A.S.A.E.–S.A.E. Standard up to 1958 specified that " the hitch hole shall be not less than $\frac{13}{16}$ in.," and that " The Drawbar shall be strong enough to carry a 500 lb. vertical load at the hitch point." The load-carrying capacity was revised in January, 1958. The current standard classifies tractors into four power groups by drawbar pull. These are up to 2,000 lb., 3,500 lb., 6,000 lb. and above 6,000 lb., with vertical static load limitations of 500, 750, 1,000 and 1,500 lb. respectively. There is a dynamic load limitation corresponding to 2·5 g. acceleration.

The British Standard 1,495 limits its power classification to being a standard for light and medium tractors. The hitch hole size is specified as $1\frac{1}{16}$ in. The $\frac{13}{16}$ in. minimum hole was considered to be inadequate for a coupling pin of low carbon steel.

It was felt that the standard drawbar should not require a coupling pin of high tensile material, as in this case accidents could occur with casually-used substitutes.

The specification does not cover the drawbar strength or permissible vertical loads. A note in the foreword states : " It has not been found practicable up to the present to embody in the standard any requirements regarding the strength of the drawbar or a definite value for vertical loading for which provision should be made."

It should also be noticed that whereas the S.A.E. standard illustrates a simple tongue of unspecified thickness other than " The material in the tractor drawbar shall clear an implement clevis 3 ins. wide," the British Standard as revised in 1958 specifies that " the drawbar shall terminate in a clevis to design and dimensions given. The clevis may be constructed with one of the jaws detachable " (Fig. 1).

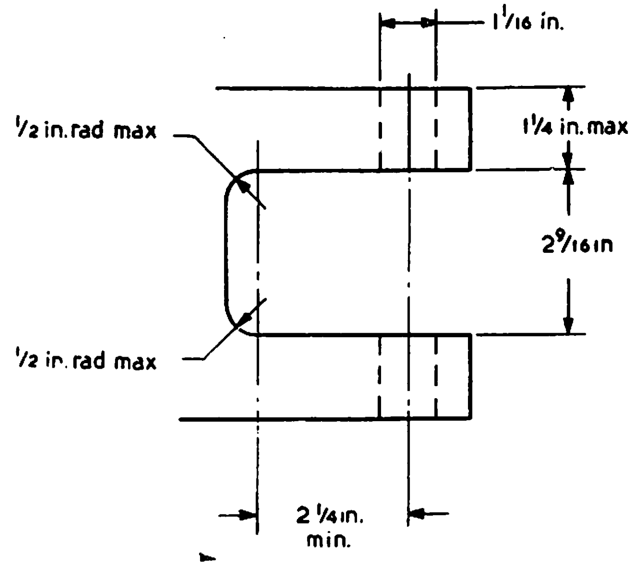


Fig. 1. Drawbar clevis dimensions

This latter point avoids conflict with the S.A.E. standard, but reflects British practice—*i.e.*, that not all farm machines are provided with a clevis connection. At the same time, the detachable jaw avoids the unfortunate circumstances which result from connecting two rigid clevises together.

The question of vertical load limitation reflects the differing practices in various countries. In the United States the four-wheeled farm wagon appears to be the usual form of load transport ; these do not impose any great vertical load on the tractor drawbar. In this country the two-wheel trailer with the axle to the rear is widely used ; this can impose vertical loads greater than 2,000 lb. on the drawbar.

Trailers of this latter type were originally introduced to operate with a pick-up hitch, which is a special-purpose drawbar located much closer to the tractor rear wheel centre to permit a high vertical loading to be carried. This arrangement is designed to ensure maximum load transfer from the trailer to give optimum tractor wheel adhesion without upsetting the fore and aft stability of the tractor. It has become common practice by users, however, to couple trailers designed for pick-up hitch connection to the standard drawbar of the tractor, with

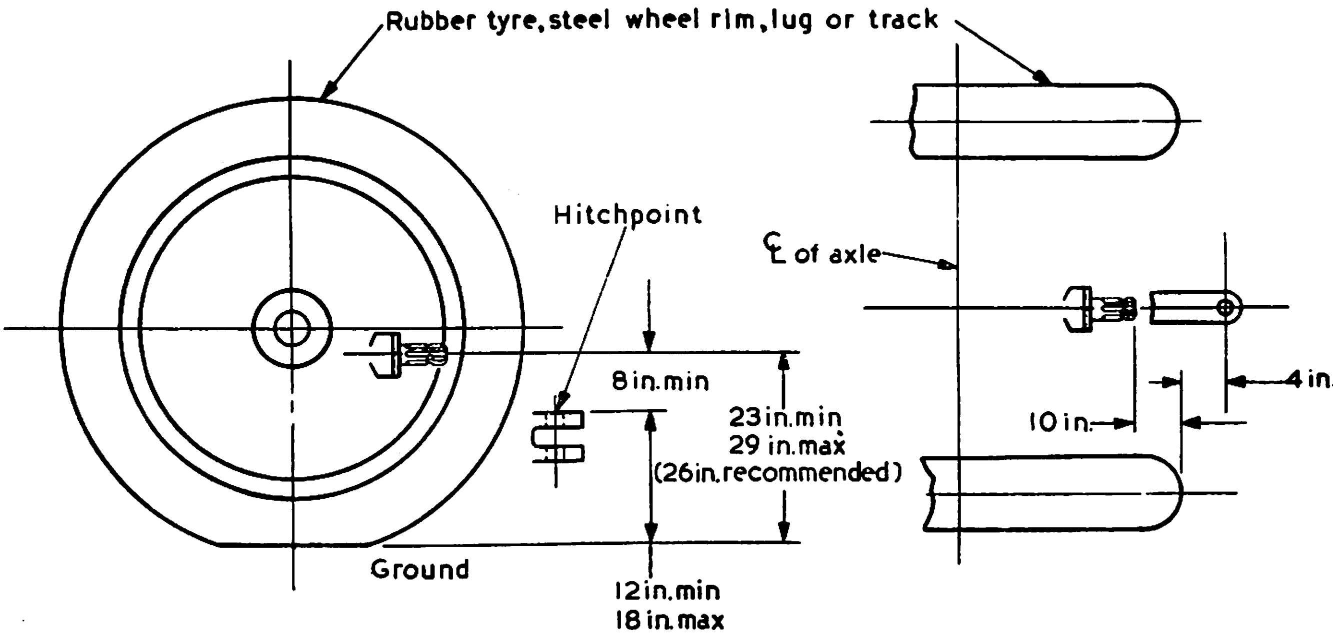


Fig. 2. Power take-off and drawbar hitch locations

(for metric equivalents see Table 1)

The dimensions given above are based on the assumption that the tractor is fitted with the manufacturer's normal wheel equipment.

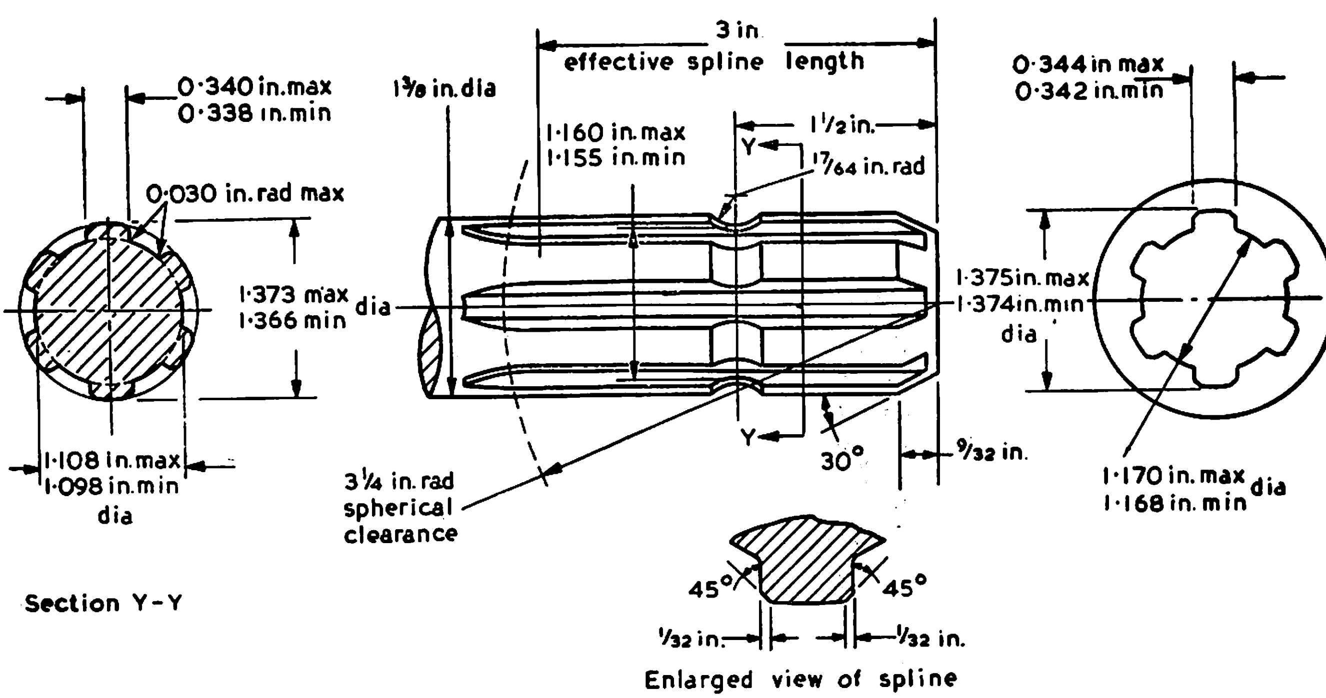


Fig. 3. Power take-off spline

(for metric equivalents see Table 2)

the result that standard tractor drawbars have had to be strengthened considerably. The fore and aft stability of some of the combinations used often leaves something to be desired. There would seem to be a need here for a standard for pick-up hitch drawbars and a recommended code of practice for the usage of drawbars.

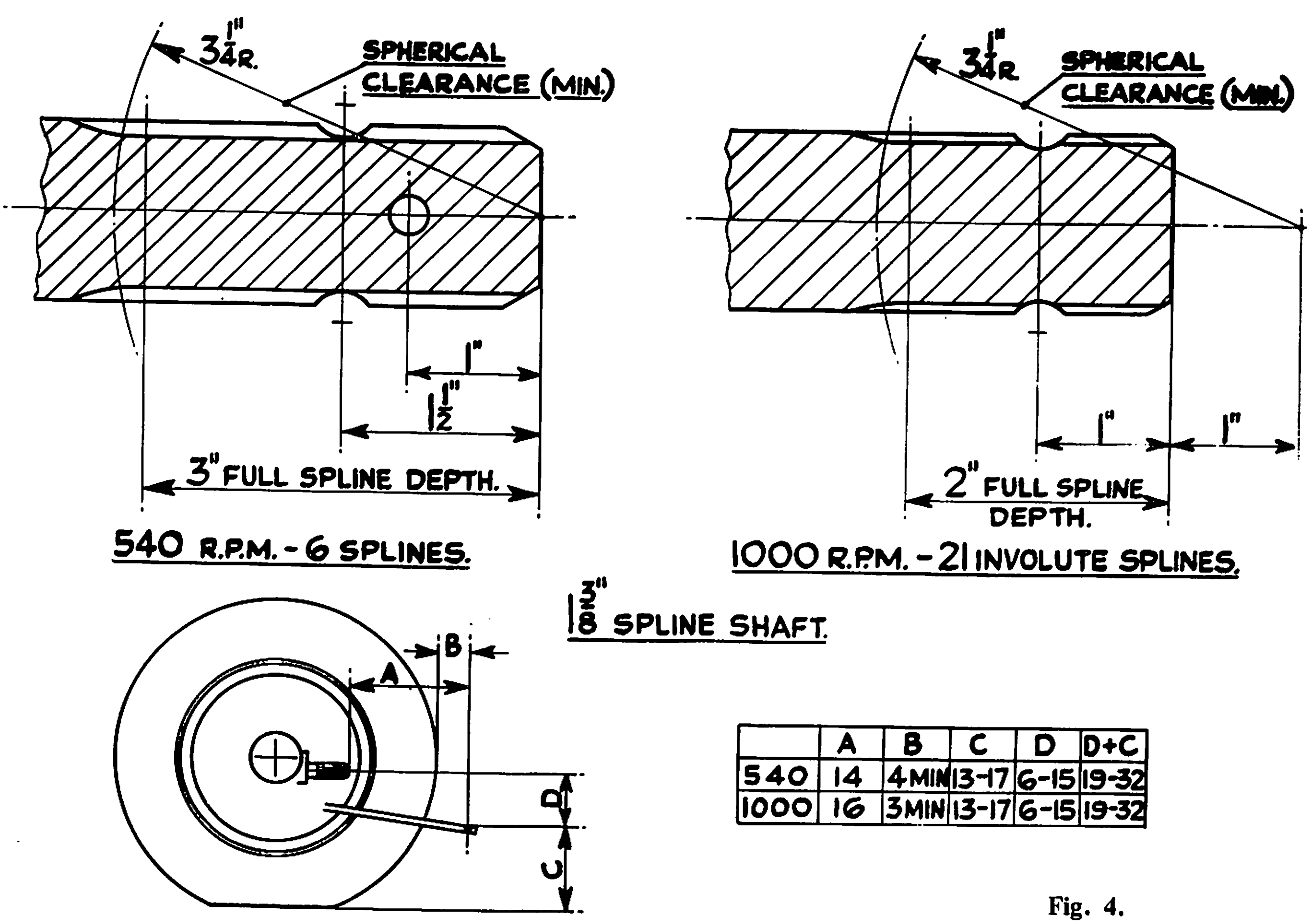
Power Take-Off

The standards relating to the tractor power take-off define the size of the shaft, spline details, coupling locating details, its direction of rotation, speed, height relative to the drawbar and the ground, and its position laterally with respect to the vertical centre-line of the tractor (Figs. 2 and 3).

From the purely technical point of view, it is rather alarming to be informed that the only justification for the well-established 540-r.p.m. standard for the speed is that this was the speed of the shaft in the transmission of an early American tractor which was first used to secure an external drive. Nevertheless, this standard has provided an adequate basis for standardised tractor power drives for nearly 40 years.

In recent years, however, American tractor engineers have found that the rising trend in tractor powers, particularly in the medium power class of general-purpose tractors, has shown a need to provide for a P.T.O. of increased capacity. They have recently issued a new standard for a 1,000-r.p.m. shaft (Fig. 4). In addition to the change of speed, the standard defines a shaft with involute splines in place of the previous six splines of shorter length and with revised dimensions in its location with respect to the drawbar. The change of speed practically doubles the power transmitting capacity of the shaft. The change of splines was selected for a number of reasons. The involute spline further increases the power capacity and it introduces a safety factor, in that a machine intended to be driven at 540-r.p.m. cannot unwittingly be coupled to a 1,000-r.p.m. drive. The shaft can be manufactured by more economical modern production methods—*e.g.*, spline rolling. This gives a still more fatigue-resistant shaft.

This new American standard raises many problems of great magnitude, of which they are very fully aware. Its adoption will render a vast quantity of tractors and farm machinery obsolescent. The ASAE must have been motivated by the strongest possible convictions of its absolute necessity. On the international scene it has many repercussions. The desirability of adopting a similar standard in this country is being considered at B.S.I. If proposed as a standard to I.S.O., it would



	A	B	C	D	D+C
540	14	4 MIN	13-17	6-15	19-32
1000	16	3 MIN	13-17	6-15	19-32

Fig. 4.

possibly delay or even prevent the adoption of the present 540-r.p.m. standard. This would be unfortunate, as the existing standard covers tractors and machinery already in use throughout the world and which will still be manufactured and designed for some years to come.

In the change-over period we may see tractors with two-speed P.T.O. gears or with two separate P.T.O.s each running at its correct speed and with the appropriate splines.

Rated Engine Speed

Recent experience has shown that the apparently comprehensive standard covering P.T.O. requirements has not been entirely adequate in securing full interchangeability of tractors and driven machines. It must be said, however, in defence of the P.T.O. standard that the difficulties have only arisen due to farm machinery designers building P.T.O.-driven machines which have to be driven at speeds higher than 540-r.p.m.

The earlier farm tractors had slow-running engines with often only one governed speed—the maximum. In recent years, tractor engine speeds have increased, and it has become normal practice to have a wide range variable-speed engine governor. The power take-off standard specifies that " the speed of the tractor power take-off shall be 540-r.p.m. at the engine speed recommended for power take-off work."

Practice has varied widely in selecting the engine speed used for P.T.O. units. American tractors have generally been designed with comparatively low maximum engine speeds and are geared to give 540-r.p.m. at the P.T.O. at maximum engine speed. British tractors have been produced with rated engine speeds varying from 60 to 100 per cent. of the maximum. With machines such as rotary cultivators and forage harvesters capable of absorbing all the power available from most tractors, it is found that with tractors having a low rated engine speed for P.T.O. work the overall performance compared unfavourably with tractors with high rated engine speeds. To overcome this disadvantage, the gearing of the machines has been selected to permit maximum engine speed to be used. This results in P.T.O. speeds in the region of 750-r.p.m. being in common use.

This departure from standard has resulted in a demand from some sections for a new standard speed of 700 or 750-r.p.m.

A logical approach to prevent recurrence of problems of this kind would be to specify in the standard that the standard P.T.O. speed is obtained at some specified percentage of the maximum engine speed.

Ground Speed P.T.O.

While discussing the question of P.T.O. speeds, it may be appropriate at this point to introduce the question of the ground speed P.T.O. This feature has been provided on some tractors of European, American and British design. It usually takes the form of alternative gearing to drive the P.T.O. shaft at a speed proportionate to the forward speed of the tractor.

The question of standardising a speed for this feature has already been raised by the Swedish delegate at an I.S.O. meeting.

On the question of ground speed drive a curious situation seems to exist. Although tractors are in use equipped with this feature, relatively few implements appear to have been produced to use such a drive. Articles in the technical Press indicate numerous applications for which such a drive would be most suitable. Is the farm machinery industry slow in taking full advantage of such new developments in tractor design, or does the real requirement for a drive of this type not exist ?

A ground drive P.T.O. speed used on several tractors is around 20 ins. of travel per revolution of the P.T.O. shaft (Fig. 5). Examination of this speed shows that,

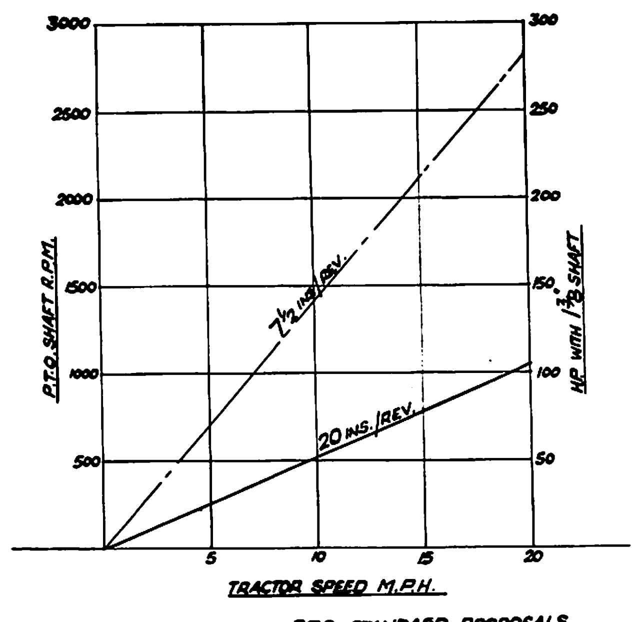


Fig. 5.

although this gives usable P.T.O. shaft speeds over the whole tractor speed range, the horse-power which could be transmitted at speeds below 5 m.p.h. would be only a fraction of the tractor's full power. It would appear that this speed ratio would only be suitable for light applications at low speeds.

An alternative proposal of 7½ ins. of tractor travel per revolution of the P.T.O. shaft would be capable of transmitting more power at low tractor speeds, but would be rotating at excessive speeds for anything but high-precision propeller shafts at the highest tractor speeds. A standard using this ratio may have to be limited to usage at tractor speeds below 8 m.p.h. The choice of which of these ratios (or of any other possible ratio) will be most suitable as the standard speed for ground speed P.T.O. will be determined by the intended field of use of ground speed drive.

P.T.O. Height

The existing standards for P.T.O. shaft height and position with respect to the drawbar were obviously drawn up to cover the requirements of trailed P.T.O.-driven equipment connected to the drawbar. The widespread introduction over the last 10 to 15 years of the three-point linkage of a rear-mounted equipment, a proportion of which is P.T.O. driven, has introduced new factors.

It is well known to tractor designers that all P.T.O. shaft positions within the height tolerance specified by the Standard will not necessarily be practicable with three-point linkage.

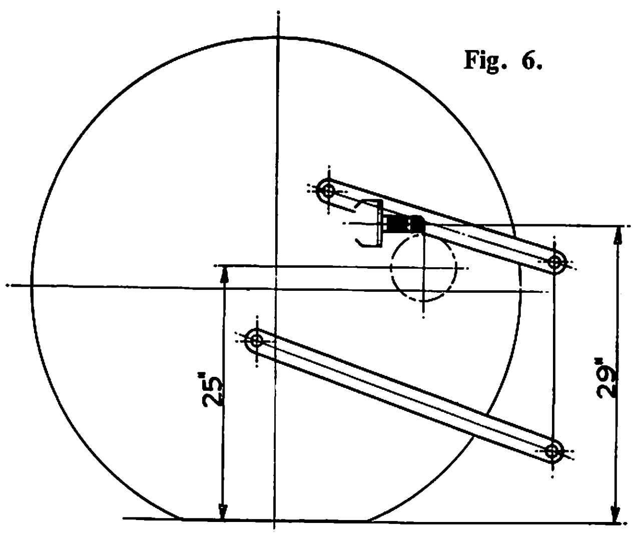


Fig. 6.

Fig. 6 shows a three-point linkage in the fully lowered position and, super-imposed, a P.T.O. shaft in the highest possible position within the Standard. The top link fouls the P.T.O. shaft. The highest possible position of the P.T.O. shaft with this particular linkage geometry, in which the top link clears the specified clearance zone for the universal joint, is shown below.

This is 4 ins. lower than the highest position within the present P.T.O. height tolerance.

No doubt, by adjustment of the linkage geometry a shaft height greater than 25 ins. could be obtained, but not much greater without either impairing the performance of the linkage or imposing some other limitation on its usage.

The simplest and one of the most economical layouts of the rear end of an agricultural tractor is with the differential in the centre of the rear wheel drive shaft, and with a P.T.O. drive shaft driven at the correct speed by gearing located in the centre of the tractor. The P.T.O. drive shaft passes to the rear either under or over the differential cage.

On Fig. 7 three sketches are shown of the rear of a tractor with tyre sizes of 10 × 28, 11 × 32 and 11 × 26. These are generally representative of small, medium and large tractor rear wheels for a general-

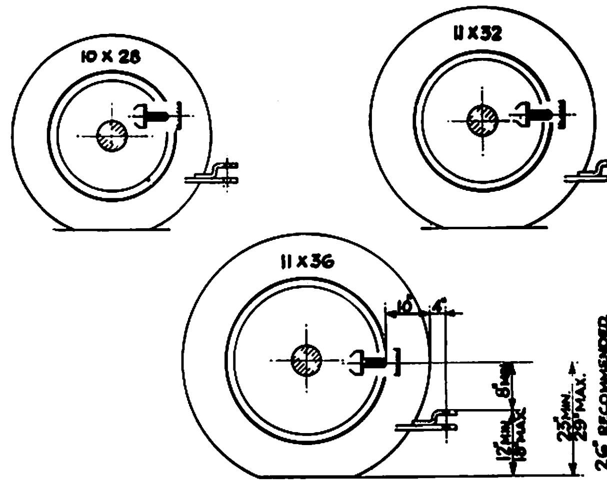


Fig. 7.

purpose tractor. The height tolerance zone for the P.T.O. shaft is shown as a shaded zone to the rear of the sketch of the shaft, shown at its recommended height position of 26 ins.

Study of these diagrams shows that the positions within the present tolerance which can be used to pass the drive shaft under or over the differential cage are very restricted.

With the medium tyre it will be seen that the P.T.O. shaft cannot be brought below the differential cage, but could be fitted in above it within the tolerance zone. However, as the recommended height of 26 ins. is possibly the highest position which can be used without fouling the top link, it appears that a design of this nature cannot be used without departing from the standard. Alternatively, gearing may be used behind the axle to adjust the P.T.O. shaft height. Examination of some existing tractor designs will confirm this point. Some tractors are manufactured with P.T.O. shaft heights outside the Standard. Tractors which are within the Standard usually have a rear-mounted P.T.O. gear driving train.

By inference, if commercially successful and satisfactory designs can be produced which are outside the Standard, there appears to be a case for revision of the Standard.

This situation is fully appreciated by the Standards Committee responsible, and work on revision of this Standard has already commenced. Clearly, although it may be desirable to reduce the minimum permissible P.T.O. shaft height to permit the most economical mechanical design to be used, the minimum height of the P.T.O. shaft is limited by the need to maintain clearance between the drive shaft and the tractor to implement drawbar connection. Also, a low P.T.O. shaft height on the tractor may involve excessive angular movement of the universal joints of the drive shaft when mounted implements with a high driven shaft are raised to the fully lifted position. Revision of this Standard will not be an easy or a simple task.

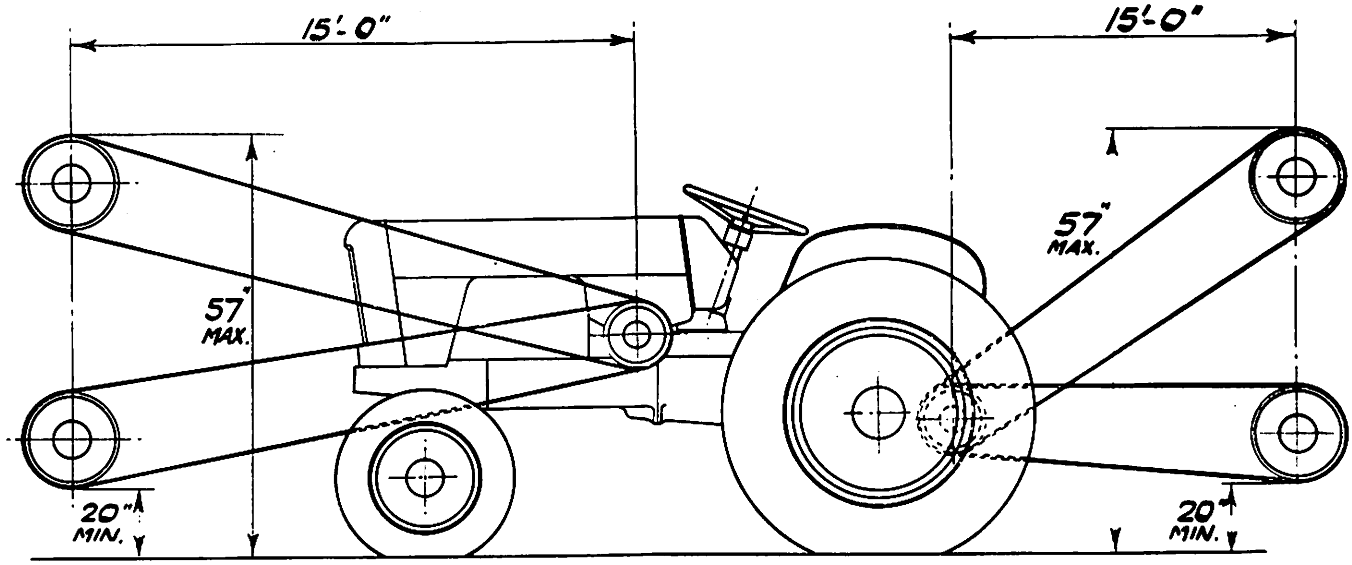


Fig. 8. TRACTOR BELT PULLEY DRIVE. ZONE OF CLEARANCE.

The Belt Pulley

This Standard again is an old-established one. It defines belt speed and belt width, without restriction on pulley size. This has served its purpose well. The British version includes details defining the zone of clearance necessary on the tractor around the pulley to clear the belt when driving all types of machinery (Fig. 8). There is widespread support for the belief that the belt drive is obsolescent and will ultimately be superseded entirely by the P.T.O. shaft drive.

Trailer Hitch

A further form of drawbar connection is the subject of the French and German standards for trailer hitch. These cover a high hitch point for four-wheel trailers or farm wagons such as are widely used on the Continent of Europe. The form of coupling used is similar to the clevis type to suit a ring trailer connection used on commercial vehicles. This high hitch arrangement is disliked by British tractor engineers because of the inherent danger of causing the tractor to rear. In Scandinavia there are reported to be regulations prohibiting its use for this reason.

The German trailer hitch standard is intended for use in conjunction with trailers with automatic brakes. The trailer drawbar is equipped in such a way that when the hitch point is lowered the trailer brakes are automatically applied. This arrangement is, no doubt, intended to cover accidental uncoupling of trailers and parking of detached trailers. Trailers of this type cannot for obvious reasons be operated from low hitch drawbars. A drawbar connection of this type is the subject of a proposal before I.S.O.

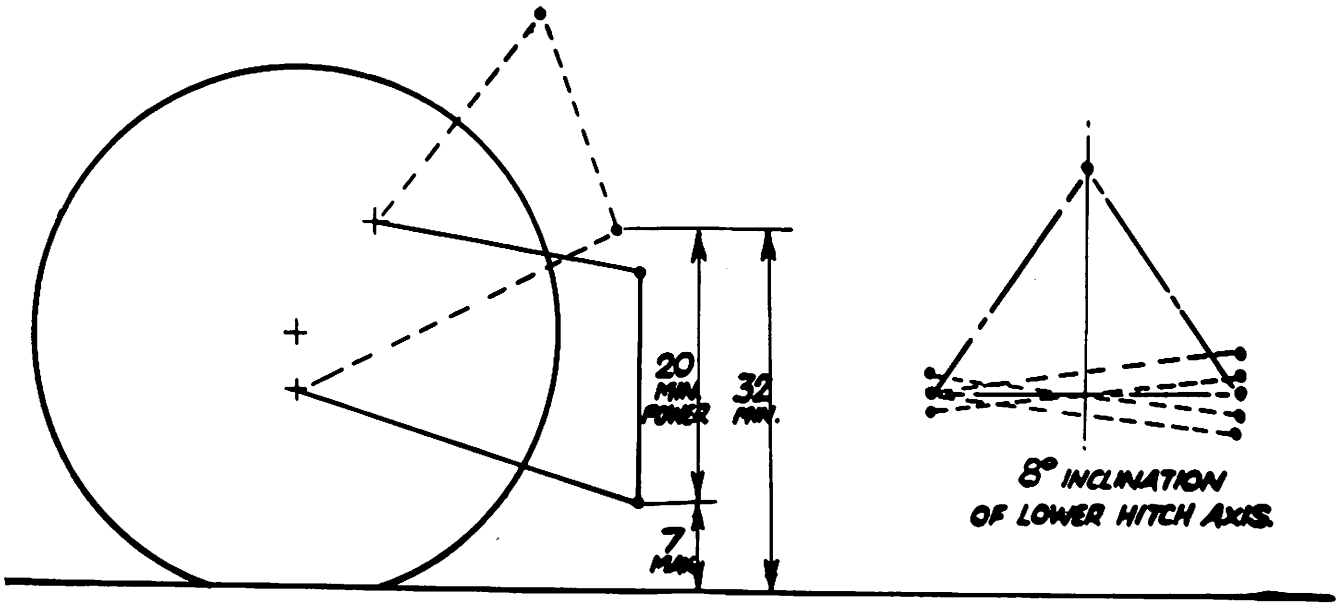
Three-Point Linkage

Appropriately, as the home of the first production series of tractors equipped with this feature, the first national Standard was B.S. 1,841 : 1951. Since its publication, German, Swiss, Swedish and American Standards have been introduced, which in general are in reasonably close agreement. Proposals have been made to the I.S.O. Committee, and a fair measure of agreement has been achieved on basing a draft I.S.O. Recommendation on the existing British and German Standards, B.S. 1,841 and DIN 9,674.

The British Standard specifies the dimensions and range of movement of the three hitch points on the tractor and the dimensions and relative location of the hitch pins on the implement (Fig. 9). This covers the basic requirement of ensuring that all tractors and implements designed within the Standard can be interchangeably connected, lifted clear of the ground, and lowered to working depth. The British Standard covers linkages of two categories suitable for light-medium and medium-heavy tractors, as there were two dimensionally different linkage connections in fairly general use at the time the Standard was drawn up (Figs. 10 and 11).

The Standard recommends that "although both categories of hitch point dimensions have been standardised with a view to avoiding the creation of other sizes, Category II (the largest size) should be regarded as the 'recommended size' in the hope that . . . a single standard size can come into use."

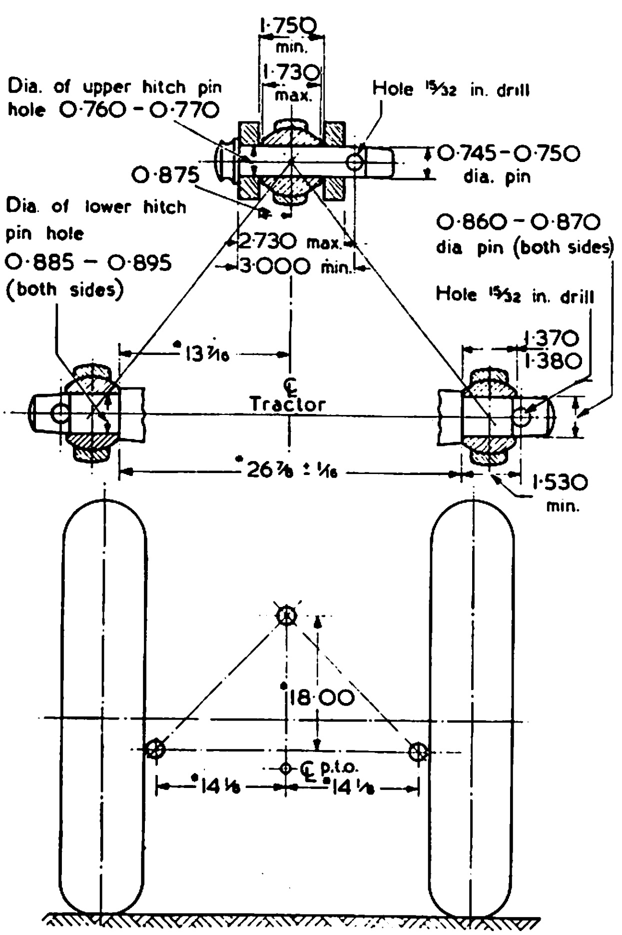
Other countries appear to think that standardisation of the connections and movement as in the British Standard is inadequate, and have written into their own standards additional requirements relating to either the



B.S. 1841 LIFT, POWER STROKE & ADJUSTMENT RANGES

Fig. 9

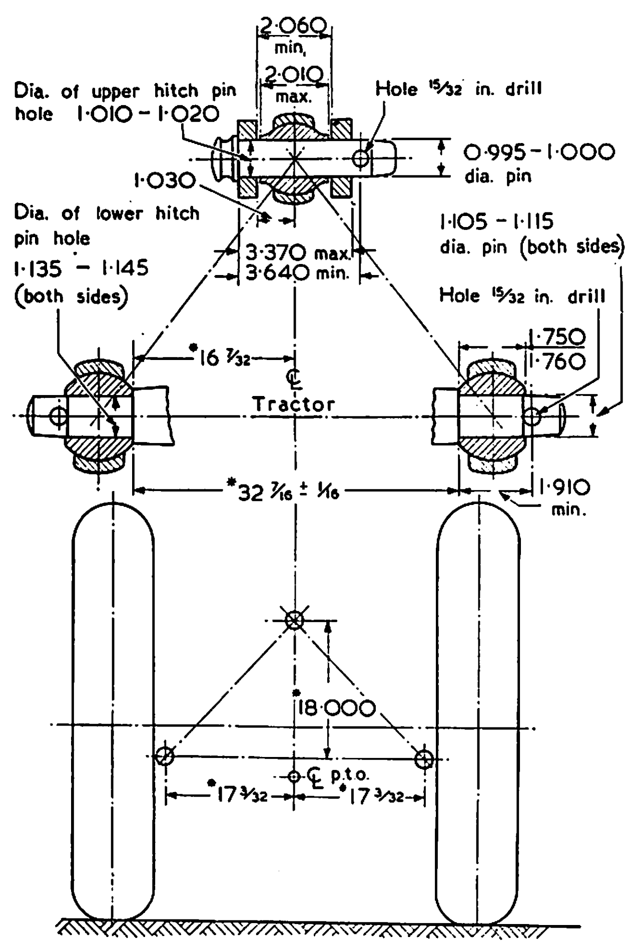
DIMENSIONS OF HITCH POINTS—CATEGORY 1



* *Recommended dimensions.* It may be necessary to vary these dimensions in the case of specialized implements.
All dimensions in inches.

Fig. 10

DIMENSIONS OF HITCH POINTS—CATEGORY 2†



* *Recommended dimensions.* It may be necessary to vary these dimensions in the case of specialized implements.
† The sizes given for Category 2 are recommended sizes and are proposed as a standard for future designs. The dimension 26⅞ ± 1/16 in. for Category 1 will remain as an alternative size to be used in narrow track designs.
All dimensions in inches.

Fig. 11

hitch point positions on the tractor or the geometry of the linkage. They have proposed that such requirements should be included in the proposed I.S.O. recommendation. I.S.O. TC22T have appointed a working group to study the various proposals for a three-point linkage standard. Britain, being the oldest established producer of tractors with three-point linkage, accepted the invitation to act as Secretariat of this working group.

The desire to extend the requirements of the three-point linkage standard stems from a worthy ambition to ensure that not only will all mounted implements be capable of being attached to any tractor, but also to ensure that they will perform satisfactorily in work.

The German Standard DIN 9,674 gives dimensions with permissible tolerances for the three points of attachment on the tractor. The dimensions used are based on experimental work in the field at their Agricultural Research Centre.

The British, American and some other delegates to I.S.O. fear that to fully standardise the dimensions of the points of attachment to the tractor in this way may cramp future linkage development without necessarily securing satisfactory work of all implements. It could restrict design of the rear end of the tractor and may limit future development of new forms of tractor transmission.

There may also be the underlying thought that in spite of commercially successful designs existing and working satisfactorily, these are based on random experiments and development work in the field of empirical methods. While the fundamentals are well understood, it is doubtful whether sufficient data, together with methods of design analysis and performance criteria, exists to permit the performance of a given linkage design to be predicted with all types of implements and in all field conditions. The necessary research work to make this possible has yet to be done, in this country at least.

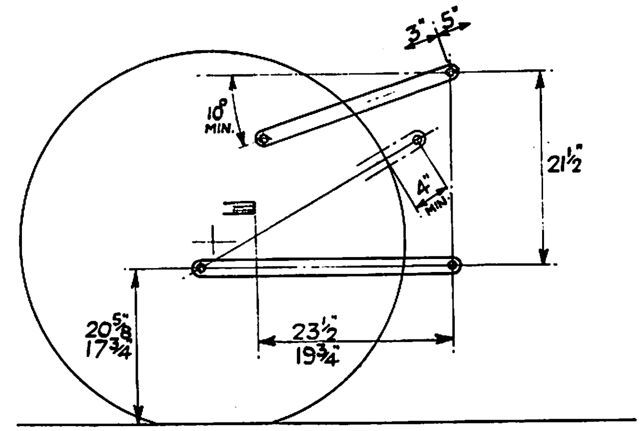
There are several proposals to meet this need without necessarily specifying the exact location of the linkage points on the tractor.

The Swedish Standard SIS 73-25-01 specifies the height dimensions of the tractor lower link hitch points only, together with a minimum angle for the top link when the lower links are horizontal (Fig. 12).

This Standard also specifies a horizontal dimension between the lower link ends and the end of the P.T.O. shaft.

A Russian proposal defines the geometry of the linkage by specifying limits for the position of the virtual hitch point of the linkage with the implement hitch points at a standardised height above the ground (Fig. 13). This proposal also covers limits for the angle of convergence of the lower links in plan view. Technically, this proposal has much to commend it, as it tackles the problem from fundamentals and avoids the design restrictions of dimensions of the linkage elements.

Several other features of tractor design—*e.g.*, hydraulic lifting devices, tyre sizes, wheel track widths, wheel fixings and control positions—are the subject of British and foreign Standards, or are being considered for I.S.O.



SWEDISH STD. SIS. 73.25.01.

Fig. 12.

Recommendations, but time prohibits these being dealt with here. In addition, other aspects of tractor design —*e.g.*, lighting, noise, maximum speed, seating and power classes—are the subject of conflicting Government regulations, which create difficulties for the tractor manufacturer in his endeavours to enter competitive overseas markets. Standardisation of regulations affecting the design and use of tractors would be beneficial to all concerned.

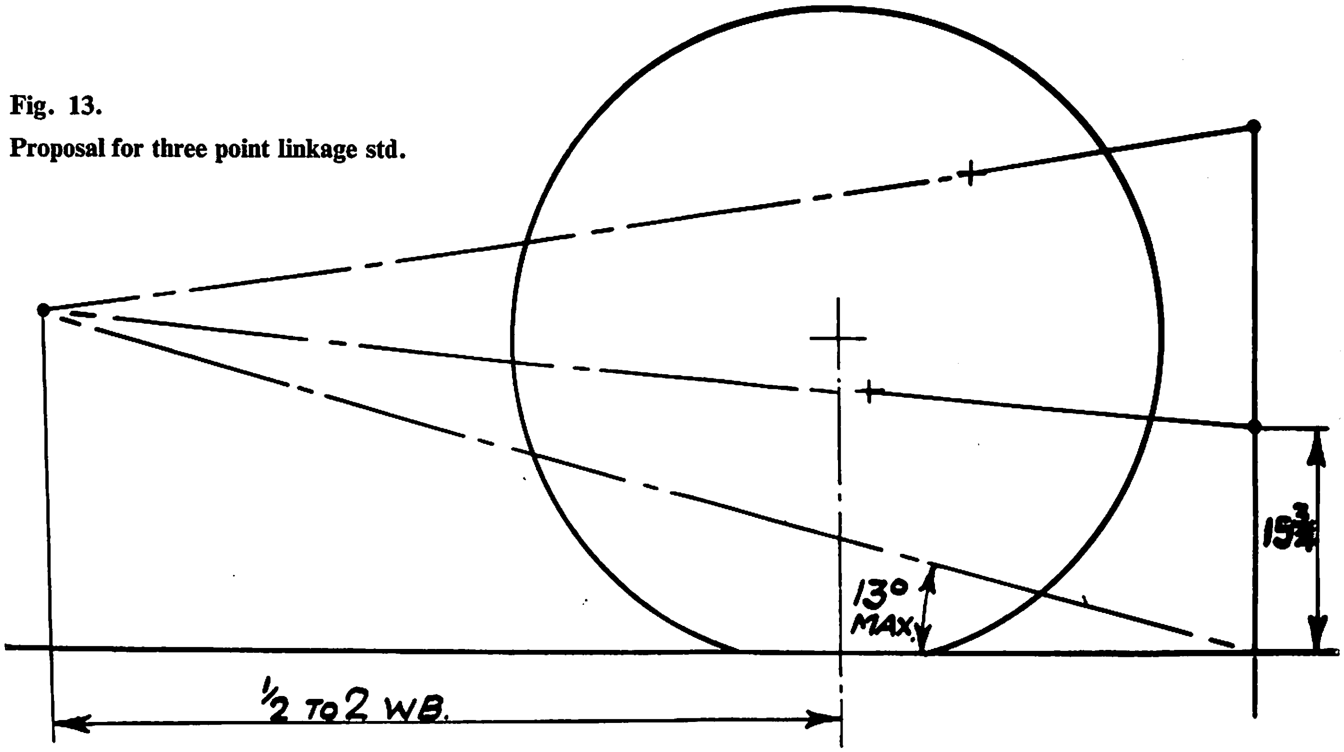
In conclusion, in the field of both national and international standardisation a great deal has been done, but much still remains to be done. It is not an easy task and will not be accomplished in a short time. Considerable development has taken place in tractor design in the last 15 years, and the pace on the whole is still quickening. In these circumstances it is important that progress in the work of standardisation should keep in step.

A better organised approach would facilitate progress If the scope and purpose of the existing organisations were more widely and better understood, they could be utilised to more advantage. The British Standards Institute primarily provides the forum for discussion between manufacturer, user, and public and Government bodies. Much time can be wasted in B.S.I. Committees while representatives of the producers reconcile technical details. If representatives met under the auspices of their trade association a great deal of this could be thrashed out separately. This would facilitate progress in B.S.I. Committees.

A further point—should the delegates to an industry standards committee, although by convention nominated by industry associations and not by individual private firms, make their contributions to the discussions of proposed standards, from the point of view of the immediate commercial interests of the particular company with whom they are associated, or as professionally qualified technicians ? There do not appear to be any directives to delegates on this fundamentlaly important issue. Perhaps clarification of this situation could

Fig. 13.

Proposal for three point linkage std.



substantially facilitate the drafting of more rational and forward-looking Standards.

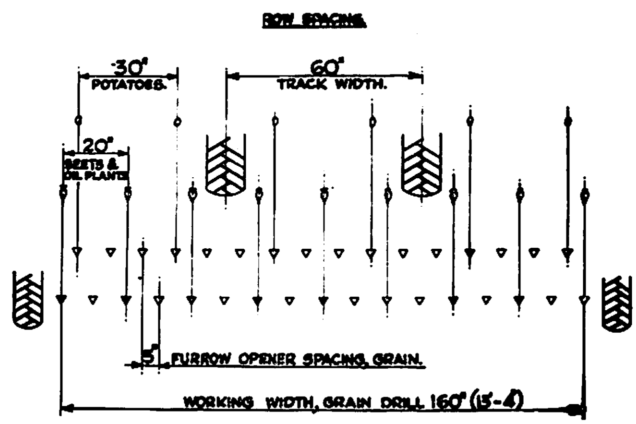


Fig. 14.

There are basically two schools of thought in approaching standardisation problems. Those who say " let us draw up a standard now before too many differences are introduced in practice," and those who say " we have not sufficient knowledge or experience with this new feature ; let us wait until more practical experience has been obtained."

For engineering standards, a rational, analytical survey of the requirements and engineering factors should indicate the specification of a reasonable standard in many cases. With regard to this point, we have much to learn from the American industry, as typified by their approach to the new 1,000-r.p.m. P.T.O. speed standard.

Some controversial issues have been raised in this paper resulting from the survey of the existing position.

If, by stimulating discussion of these issues, some contribution can be made towards the ultimate goal of better national and international standards—then my own objective in writing this paper will have been more than achieved.

DISCUSSION

MR. T. C. D. MANBY (N.I.A.E.) remarked that he was extremely pleased to be given the opportunity of being the first person to congratulate Mr. Hull for the able way he had presented his material. Mr. Manby knew of no subject more likely to increase the blood pressure of users than the lack of interchangeability of equipment. Mr. Hull had brought the subject of standards alive and had made it interesting.

International standards were really of vital importance. The domestic user had sometimes had to suffer the lack of standardisation because existing ones were not adopted. Some of the countries which had marketing arrangements which were rapidly becoming more organised were now beginning to intimate that they were not prepared to accept that state of affairs, particularly with regard to imported machines, if they did not comply with I.S.O. recommendations where they existed.

In the week previous to this occasion, at a working group meeting in Paris of T.C./22T, it had become clear that the Continental conception of the use of an international tractor test report extended far beyond its usual value of being able to make an engineering appraisal of tractor size. There was a substantial body of opinion asking that the test report should also be the medium enabling conformation or otherwise to standards to be immediately apparent, and, secondly, that the demarcation between categories should be based on test results.

Because the subject of standards was so difficult, he continued, and of vital national importance, the next steps must be taken carefully. While mentioning the International Tractor Testing Standard, he reported that, thanks to considerable help from the lead given by the O.E.E.C. test scheme that was already in existence, there now seemed to be very likelihood that this standard would be finalised. Members of the B.S.I. committee concerned could take pride in that all the main principles and almost all details of the latest B.S. tractor test specification, published last year, had been accepted by the international testing group and should be ratified in Turin in September. Mr. Manby's own understanding of the I.S.O. was, he declared, different from Mr. Hull's. The I.S.O. had not published standards because never before had it had complete unanimity and therefore it could only publish recommendations. But with tractor testing standards it seemed likely that there would be complete unanimity, and so it would probably become the first international standard.

Referring back to Mr. Hull's Paper, Mr. Manby gave it as his belief that Mr. Hull was originally the proposer of the ideas for three-point linkage for which he had given credit to the Russians. However, was there sufficient information available here to go ahead with a sensible solution ?

Rated speeds had caused chaos throughout the industry. Mr. Hull had defended the manufacturers, and a survey that Mr. Manby's organisation had made on how tractors were driven had supported that it was wrong to make the recommended speed for power take-off work coincide with the maximum speed for the tractor engine. The British user did not want to use his machine flat out the whole time, and 85 per cent. of tractor drivers did not do this. If the recommended speeds were obtainable at 85 per cent. of the full tractor speed, no trouble would have been experienced.

Mr. Manby concluded by saying that those who had been associated with international standards conferences would know that the work had gone on with extreme harmony, although national interests had always been fought for strongly.

MR. R. BERRY (British Standards Institution) stated how much he appreciated the honour given to him to speak among such a gathering, because, like Mr. Hull, he was not a member, although in his own case because he did not specialise in agricultural engineering.

His first comment was on the basic subject of standards itself. At an Institution West Midlands Branch conference twelve months before there had been a forum, he recalled, and the subject then was also standards. It reminded him, rather humourously, that in a B.S.I. committee recently he had remarked that agricultural engineers were becoming increasingly *standards* conscious. One of the more critical farmer members had suggested that the word " standards " could be deleted from that ! The same rather sad farmer, he remembered, had recently proposed in a glossary that the term " farmer " be included with the definition " the last stage of machinery development before going for the export market " !

Talking about international standards as such, Mr. Berry said he thought we ought to realise at once two different reasons for international standards : First, I.S.O. agreements provided the buyer with a basis for good-quality equipment interchangeable from maker to maker ; and second, they had a direct effect on trade between the countries, for there was an advantage to the manufacturer who could claim to produce to I.S.O. requirements. The European Common Market was a very obvious reason for the interest of some countries. At the meetings it was desirable to influence the I.S.O. standard as far as one could nationally, to adopt it in practice, and then to use it as a sales factor. The Germans especially intended to do that, particularly associated with the less-developed markets.

Behind all this lay the inch/metric problem and there was a growing disadvantage to the United Kingdom in this. Up to now in the tractor and machinery work of the I.S.O. the United Kingdom had made the major contribution, and most of the agreements reached were British-based. In the more complex subjects now developing in the I.S.O. we had the individual capability to keep pace with these, but we were not organised properly—not as well as Germany and the U.S.A. Also we were at some disadvantage with Russia, where standards were mandatory ; although this could hinder development, it gave advantages when putting forward proposals so based for consideration as international standards. He emphasised that we must organise here and have centralised investigation and research, either through the I.A.E., the A.E.A., or the N.I.A.E. Better still would be a combined effort by all these organisations, centred at Silsoe—the home of research and investigation. Results of that research could be fed to B.S.I. committees on the national level for adoption in British Standards, and thence to the I.S.O., because the national standards were the only sound basis for international action.

As he attended B.S.I. meetings, Mr. Berry saw that sometimes the technical committees had to call upon, perhaps, two or three manufacturers for research on any particular subject, and the British manufacturers always seemed to have limited facilities of finance available to provide the information wanted by the committee. Far too many recommendations put forward in B.S.I. committee were based on insufficient knowledge, and this sometimes necessitated early revision of important basic data before issue of a Standard. Co-operation amongst our manufacturers was essential to meet the challenge of Germany, the U.S.A. and Russia. They worked on different tenets, but were achieving better results than we were likely to do under our older, parochial approach.

A further need was to adopt the national standards as agreed in committee. A U.K. proposal to the I.S.O. often had little force if other countries asked if this was based on national practice. All too often the U.K. members had to say that only a percentage of British firms had adopted the design feature concerned.

He also stressed the need for primary co-operation prior to B.S.I. work, saying that each of the fields in the industry should have representatives who, through close technical contact with the various trade associations, could lay down policy on standards. Something of this nature already existed in the N.I.A.E. He knew that it was not so easy for the A.E.A. or the I.A.E. to channel their opinion through representatives, but he was sure that some organised effort could be made upon these lines. The agricultural engineering industry, in B.S.I. experience, was an exception in this respect. The work of the B.S.I. committees in other fields with which Mr. Berry dealt was very much facilitated by organisation within the groups concerned. In agricultural engineering it was more a matter of two steps forward and two back.

He referred to the great prestige and effectiveness of the B.S.I., and gave assurance of readiness to help the agricultural engineering industry both nationally and internationally.

MR. HULL, replying to Mr. Manby's points about the examination of the three-point linkage, said that he had condensed the Paper to bring it within the time. However, he had made the point in the Paper that, while the fundamentals of the three-point linkage had been laid down, the necessary research work had yet to be done. Mr. Hull gave an example to substantiate what Mr. Berry had been saying about the need for co-operation with the various bodies. When the Germans had wanted to standardise the connection points on the tractor, they could say that this was based on tractor research work, and thus their arguments were difficult to refute.

Our examination of the various standardisation proposals, he added, was often limited to analysing current designs in British and other tractors and seeing to what extent they lay within the proposals. This was making the assumption that all machines were satisfactory.

He said that Mr. Manby's remarks on rated speeds were interesting because here one got one of the most striking differences between the practice of users in different countries. In Britain, as Mr. Manby had said, the driver did not like to drive the machine flat out. But in America there had been trouble with tractors with a rated speed only 85 per cent. of the maximum, because it was found that the tractor driver always drove the engine flat out, and there had been a lot of service trouble. Answering a questioner, he said that the need for a standard for lubrication filters was under examination. There was, Mr. Hull finally commented, a valid case for co-operative research on the lines of that done in the motor industry.

MR. J. H. W. WILDER (Berks.) disagreed with the remarks on rated engine speed to the effect that farm machinery designers were making machines which had to be driven at higher than 540 revs. per min. The flail-type forage-harvester was designed for maximum power at 540-r.p.m., and he did not know of any other machine which was causing trouble. He hoped that 750-r.p.m. was not a serious demand.

A questioner pointed out that there was nothing in the Paper about hydraulic connections at the rear of the tractor. Trailers sometimes could not be transferred from one tractor to another. Why could they not have a standard for the coupling position and the coupling itself?

MR. J. M. CHAMBERS (Warwicks.) said that tractor manufacturers disagreed with Mr. Wilder and others, because in the last few years implement manufacturers had been producing implements to be power-driven which were pushing the power of the tractor engine to the limit. He cited flail forage-harvesters and the like. He said that tractor engines were becoming more flexible and that manufacturers were specifying higher and higher engine speeds. With this in mind, he suggested that it might be possible to have both the 540 and 1,000-r.p.m. p.t-o. speeds with the same gear ratio by using different engine speeds. About 1,350 revs. would provide the 540 power take-off speed and about 2,500 the 1,000 revs. This would also provide greater power for the 1,000 revs. speed, where it was really needed for many of the new implements being produced. This would leave the 540-r.p.m. speed with lower h.p., which was all that was required for many machines, such as hay machinery, etc.

MR. F. MOORE (Rotary Hoes, Ltd.) asked why it was intended to adopt an already obsolete standard.

MR. HULL remarked that he had not intended to allocate blame in his Paper for the position regarding power take-off speeds, although the wording might have conveyed that impression. Certainly there were many flail forage-harvesters for which one must run the engine at maximum revs. for the harvester to be running at the proper speeds. If the power take-off was geared to get maximum engine revs. at 540 revs. per min. one could not drive a forage-harvester of that type properly. While there were no proposals to standardise the position of the hydraulic power take-off, there had been some for standardising the coupling itself and its threads.

He said that Mr. Chambers had made a very good point on the question of the two speeds. The reason for forming an international standard for 540 revs. was merely to ratify the existing position ; if this was not done, the situation was open for all sorts of different speeds in between to be created.

FORUM

"WHY PLOUGH?"

MR. J. H. COCK, the chairman of the forum, started by declaring that it might be thought surprising to challenge the supremacy of the plough at this time, because people had ploughed from time immemorial, not only in this country, but throughout the world. However, the plough had to keep pace with the modern power unit in speed and quality of working, and there were now several challengers. The first challenge came from the engineer, who had introduced rotary cultivators, heavy cultivators and chisel ploughs.

A challenge also came from the farmer himself, who had to deal with the soil in all conditions of climate and weather, including the abnormal conditions of last winter. Most of them had seen a sea of mud at the end of the winter. Mr. Cock asked if they had been right to plough in such mud and to rely on natural forces, such as frost, etc., to condition the mud. Cost entered into the question ; clay soils could be vastly more expensive to deal with than some others. From the farming point of view, it was questionable if the plough was the best implement, because of the soil structure problem ; were farmers, in fact, creating difficulties by ploughing and relying on natural conditions ? Mr. Cock had dispensed with the plough when working on winter wheat ; at the end of the winter when the weather clamped down he had left land unploughed and got away with it. But the general tendency at the present time was to take the plough as the standard cultivation implement. Further, one of the plough's main tasks —weed control—was now being challenged by the chemist, and some, if not all, weed control could now be done with chemicals, even though at present the expense was high.

The three speakers were to talk from the engineer's point of view, the farmer's, and that of the research worker, and Mr. Cock concluded by asking Mr. Gass " Why plough ? "

MR. J. GASS (Ransomes Sims & Jefferies, Ltd.) commented that he was not a soil scientist, and his arguments were based on experience in farming and with the plough. He was only interested in good ploughing and not with poor attempts. There was now little waste of time in finishing, because it had almost been eliminated by one-way ploughs, and finishing took only a small percentage of the total time.

It was the poor standard of ploughing that had led some people to look for alternatives, he asserted. The subject had been much studied, but the plough went on from strength to strength. Obviously, no one had found a way of soil inversion which was more efficient in a temperate climate. His explanation for the continuance of ploughing was partly that the job provided a challenge to farmers, as there was the satisfaction of being able, by good operation, to control the results so that the job was not monotonous. The beautiful picture of good ploughing provided another reason, and it was the best example of good farm work—an example which provided for competition at local, national, and international levels.

A further reason was that it was only the plough which buried weeds, buried organic matter, dealt with stones, and left the surface in the driest condition for a seedbed. No other method of doing this was quicker and cheaper, and also provided for natural drainage in a way useful for soil conservation. He submitted that no other implement was able to turn in farmyard manure and green crops and leave the ploughed surface clean. Thus ploughed land would lie for months and then be ready for seeding operations. Harvesting machinery tended to become bigger and the surface was often disturbed by wheel ruts—there had been examples of deep ruts in sugar beet that winter. One ploughing across them and they had disappeared. Where else was there such an implement ? Other machines failed to compete in this, and they left the soil in a state in which it tended to absorb moisture. Ploughed furrows, on the other hand, would dry out.

Turning his attention to the costs of the operations, Mr. Gass quoted from a list of contract charges recently published. Ploughing was from 40s. 6d. per acre, and cultivating from 20s. per acre. Rotavating was from 40s. 6d. per hour. If the cultivator or chisel plough was used as an alternative to ploughing, in Mr. Gass's opinion, the operation must be carried out twice—so the costs were then equal. However, the weeds were still not buried, and that extra work must be added. Charges for rotavating were difficult to compare, being quoted by the hour. However, one manufacturers' leaflet contained the statement : " It may be necessary to make more than one pass to obtain the depth," so perhaps the job had to be done twice as well. Alternatives were thus not cheaper and ploughs possibly offered a saving.

One point was that Nature's way of providing soil fertility was to allow the surface vegetation to rot on the surface and leave it to the worms. This could still be done by the plough if it was not set too deeply. But whta happened to the worms when the land was sprayed ?

The life of a plough was, he declared, greater than that of other machines. Another point was that it was comparatively easy to estimate the spare parts requirements for ploughs ; the majority of parts could be classed as earth-wearing, so it was mainly a question of the soil in each area, although climatic conditions had an effect.

Mr. Gass used the words of Mr. Wendell Bowers, of the University of Illinois, who had said that the mouldboard plough was hard to beat as the first step in preparing a seedbed, for most other methods failed because of variations in soil moisture. Rotary tillage, for example, had not been too successful for that reason. The chances were that there would be no changes in the future.

Commenting on this, Mr. Gass said that a large number of American farmers were striving for better methods, and that their opinion of the plough, as Britain's progressive cousins, was of particular interest.

MR. P. HARDING (G. P. Harding & Son, Ltd.) : " Why plough ? " was quite a normal question to ask, and it was certainly rather difficult to think why he did not.

Early in his life he had accepted the plough for the first operation, as he thought many people do now, and he took a delight in seeing a well-ploughed field. But when he came to his present farm, with light, sharp land, he had second thoughts. With the ground hard and dry after harvest it was necessary to change plough shares every day and sometimes even more often. This cost time and money ; again when the soil was wet the breasts loaded, and that took more tractor power, with a definite deterioration in the quality of the ploughing. So looking at the seedbed he felt that there was, perhaps, another way to start preparing it, especially now that chemical weed control was almost here and would be sure to improve. So he tried the disc plough and did not find it was what was wanted. Then he bought a heavy-type Goble Disc as used in South Africa and America, and this was more what was required. It was used more and more, first after harvest to germinate the weed seeds ; then a second application later killed the weeds and went deeper and germinated more weeds, and sometimes was deep enough for a seed bed. The third discing did all Mr. Harding wanted.

This year, in spite of a very wet autumn, he had planted 270 acres of corn and beans, and only 49 acres of this was planted behind the plough. This is in a season when most farmers got less than 50 per cent. of their winter ploughing done.

He had not reached the stage when he could throw all his ploughs into the chalk pit, but he felt the time might soon come when he could do just that.

MR. J. C. HAWKINS (N.I.A.E.) felt that his position was midway between the two previous speakers and thought the truth lay there also. It was necessary, he said, to think of a wide range of conditions, including those outside Britain, and to remember that the greater part of basic cultivation was still done by the weather. One could not go into a field on a given day and produce exactly the tilth that was wanted. The ultimate aim for agricultural engineers must be to arrive at a system of cultivation that was independent of the weather, but they were a long way from that. Better results were being obtained with power-driven tools, but their performance still depended very much on the weather.

Practically all the processes required in primary cultivation could be done, Mr. Hawkins asserted, by implements other than the plough. But there was one thing that the plough did that nothing else would do—it buried the surface. It was essential to look at the plough from this angle and to weigh up how important burial was rather than how important ploughing was. It might be desirable to bury weeds, plant residues, or surfaces damaged as the result of heavy traffic, and the plough was the only tool that could do this.

It was, however, unquestionably wrong to invert most tropical soils. No experimental results that he knew of showed any benefit from turning the top soil over, but there were many examples where ploughing had led to loss of valuable top soil because of erosion. One did not, therefore, think of mouldboard ploughing, but rather of an operation that did a less complete job of burial. Although rotary cultivtaors had been modified for the tropics, many tropical soils were so hard that porbably only a tine would penetrate them. Further, as one rarely found skilled ploughmen in the tropics, the trends were against the plough in those regions. There was, perhaps, one exception. In paddy fields there was, he thought, a place for the mouldboard plough, because erosion was not a problem here and weed control was.

Thus, returning to his original three things to be buried—weeds, plant residues and damaged surfaces—Mr. Hawkins agreed with Mr. Gass that there was better weed control behind the mouldboard plough than behind any other implement. He was supported in this by work in America, which showed that there were fewest weeds with the mouldboard plough, more with the disc plough, and more still with the chisel plough and the rotary cultivator.

On the subject of burying plant residues, Mr. Hawkins asked whether it was a good or a bad thing to do this. There was no clear-cut answer, he continued, but there were signs that some of the more difficult soils were losing their structure—crops failed in patches and water stood on the surface when the drains were dry. Such structure loss seemed to be linked to deeper ploughing. Modern farming systems probably returned less organic matter to the soil than previous ones, and farmers were ploughing at 14 to 16 ins. deep instead of 6 to 8 ins. It was his opinion that while there was enough organic matter to keep the top 6 or 8 ins. in condition, there was not enough for 14 to 16 ins. Since crops seemed to be most sensitive to soil conditions in their early stages, there were strong arguments in favour of keeping what organic matter there was in or near the surface. The mouldboard plough could be criticised for burying the organic matter under these conditions, although it might well be merely a matter of the wrong use of the plough.

On burying damaged surfaces, Mr. Hawkins felt that it was far better not to have a damaged surface to bury. A good deal of the damage caused by traffic in root harvesting, for example, could be avoided even in a wet season by careful planning and the choice of the right equipment. It was amazing, too, how often the damaged surface re-appeared relatively unchanged when the land was ploughed next time.

He thought it was unquestionable that more and more farmers were becoming discontented with the ploughing that they were doing at the moment. He felt that it was because the quality was so poor that people were turning to alternative implements. There were two factors that had led to this decrease in quality. For the first the tractor manufacturers were to blame. They had provided what the farmers had asked for—tractors with more and more power, but mounted on rubber tyes. That power could not be used to pull bigger and wider implements ; the only way to use it was to go a good deal faster with the narrow ones, and this was what had been happening. But most of the plough bodies in use had been designed for horses or steel-wheeled tractors, and so were being worked at speeds much higher than those for which they had been designed. This problem could be solved by the development of suitable body shapes, and indeed work on this was going on in Germany and in this country. But until suitable designs were produced, the full benefits of ploughing at these higher speeds would not be realised.

The other reason for poor ploughing was linked to the increased ploughing capacity on farms. It was now possible to do the season's ploughing in such a short time that it was often all done in the early autumn when conditions were good. This gave no time for weed seeds to germinate. Some stubble cultivation followed by a waiting period might well let farmers plough in a growing plant rather than a seed and so get better weed control. Mr. Hawkins suggested that the chemist might soon have the last word on cultivations. He asserted that they were reaching the time when it would be possible to say that if a given material were applied to this field then only the crop could grow there for the next six or eight months. This was already a possibility with some crops and might apply to all one day if the cost was low enough.

Summing up, Mr. Hawkins declared that, for Britain, good mouldboard ploughing probably gave a cleaner surface for less money than other primary cultivations, but he could not say that it would be so in the future—so much depended on the design of the plough and on the chemist. Overseas there seemed to be no case for ploughing as it is known in Britain, except possibly in paddy fields. There were times in Britain when one could economise by missing out ploughing now and then, but primary cultivation would be based on ploughing for some time yet.

MR. L. R. BOMFORD (Hants.) wanted to challenge the statement that the plough had been used from time immemorial, because the early ploughs were basically single-line cultivators, like one he had seen in the Canary Isles. The reason why the steam cultivator had gone out was because ploughs were easier to pull. He had hoped Mr. Hawkins would have given some figures on the amount of power required to break up the soil with ploughs and cultivators. He expressed surprise at the emphasis on burying ; it was all very well to bury weeds, but that meant burying seeds as well—and they came up again. On his farm there was some couch, and he had yet to see the weedkiller that made a good job of getting rid of that.

Referring to Mr. Hawkins' remark about ploughing—in the growing plant, he said that years ago he had done stubble cultivations by ploughing in the winter. He remarked that it was often possible when ploughing up a ley to find straw still unrotted that had been ploughed in before the lay was sown. He had done very little ploughing for a number of years and had found no difference in the effect, and many farmers nowadays thought that more could be done with the cultivator and less with the plough.

MR. HAWKINS' comments on this were that when people changed from ploughing to something else, or to less ploughing, they might have in their land a " hang-over " from generations of ploughing. One would not expect to see a violent change in weed population in the first year or two. He was very pleased to hear the questioner say that his stubble cultivation was followed by a long wait. The point about finding buried organic matter unchanged supported him on the dangers of deep ploughing. The organic matter might be put down to a level where there was no chance for bacteria to get to work on it. Couch could be controlled if it were ploughed under deeply enough, although the ordinary size of plough was not quite adequate for this. There was very good experimental evidence that frequent rotary cultivation could control couch. This was, perhaps, not an effect peculiar to the rotary cultivator, as no plant could stand continual disturbance. The chemical control of couch was only a matter of time. Mr. Hawkins said that he could not work out the power figures for cultivation and ploughing in his head.

MR. H. O. S. PILKINGTON (Worcs.) asked to hear more about bacteria and earthworms.

COL. P. JOHNSON (Middlesex) declared that he could not speak in any way whatsoever about bacteria. However, there had been a publication by Sarwin about earthworms, in which their enormous advantages had been pointed out. Darwin could not have been familiar with a certain type of soil which appeared all round the world, which had many names and was very fertile—but it had not a single earthworm of any description.

MR. A. H. BOARDMAN (Essex) said that he wanted to support Mr. Bomford in that on lighter soils farmers were going more for cultivation—*i.e.*, cultivation some 16 ins. deep. He also asked if Mr. Hawkins could report any experience with a Dutch spading machine.

MR. HAWKINS first replied to the question about cultivating 16 ins. deep. He asserted that very often farmers claimed increases in yields after deep cultivation in place of ploughing. He suspected that the following was what had happened. For a number of years, farmers had been ploughing at their normal depth and the rubber tyres of the tractor had been at work on the furrow bottom. A surface smearing and puddling had resulted and these effects were not destroyed by winter frost. Year by year they built up into a plough pan, and it was only when this was broken with a deep cultivation to 16 to 18 ins. that the benefits mentioned could result. He could give no answer on the Dutch machine.

MR. J. M. CHAMBERS (Warwicks.) asked why Mr. Hawkins blamed the tractor tyre and not the plough share for puddling.

MR. HAWKINS answered that the experimental work had shown more puddling behind the tractor tyre than behind the plough share.

A questioner referred to the difficulty with mounted ploughs of using the full power of the tractor. One alternative, he said, might be to increase the furrow width of the plough and he would be interested to hear Mr. Gass's views on this.

MR. GASS reminded him that in this country there had to be a limit to furrow width. When the ploughing season was like that of 1959, the narrower the furrow width the easier ploughing had been. If it was very wide the plough would be thrown sideways to land, because the mouldboard pressure would be too great.

MR. MOORE (Essex) pointed out that the land dried out more quickly when ploughed. He thought that this was surely a bad thing in the spring and at other times when it was desirable for the soil to hold moisture.

MR. GASS agreed with Mr. Moore, but said that the answer was to plough at the right time—that was one of the problems in leaving ploughing too late.

MR. HARDING wanted to support Mr. Moore in that it was desirable to keep the moisture in—he had never had any trouble from too much moisture.

MR. GASS replied that he had met farmers who had taken the precaution of using their ploughs immediately after the combine and they had got their winter wheat in.

MR. BOARDMAN mentioned the matter of furrow width. He said there had been a tendency for farmers to use a greater width, but he had gone back to a smaller furrow of perhaps 10 ins. because it broke up the soil better.

MR. GASS had found that on medium land the tendency was to plough 12 ins. wide or so, but 10 ins. wide on heavy land.

MR. HARDING recalled that he had started with 14 ins. and had gone down to 10 ins. He would prefer a wider furrow section.

MR. E. N. GRIFFITHS (Essex) felt he could not let Mr. Hawkins say that rotary cultivation was not suitable for tropical agriculture. He remembered in Uganda that an African grower had said that his machine was doing as good a job as his wife—and that was the highest compliment he could pay !

MR. HAWKINS repeated that the rotary cultivation, as known in Britain, was not suitable for tropical conditions. His basis for saying this was experimental evidence produced in Kenya, where an analysis of the particle sizes resulting from various forms of tillage, including rotary cultivation, had shown that a higher percentage of fine particles came from rotary cultivation. It was these smaller particles which were carried by rain and weather.

MR. G. T. MERRYWEATHER (Staffs.) asked about competition ploughing, which Mr. Gass had mentioned. The Conference had heard about bad ploughing ; were competitions important in bettering the standard ? The F.A.O. were using them in lesser-developed countries.

MR. GASS's answer to this question was " yes." Competitions did raise the standard of ploughing and also gave the local ploughmen an added interest in their work—for a change, they saw someone else do the job. There was a lot of comment on the time taken to plough a plot in a competition. But the ploughmen in a competition had to do the same job as in a field, with opening, etc. From what he had seen, they usually had great difficulty in finishing in the required time.

MR. HARDING declared that ploughing matches had done more to finish the plough as a tillage implement than anything else. The last thing he wanted to see was his land ploughed as in a competitoin, because of the time it took to get a seedbed subsequently.

OPEN MEETINGS

LONDON, 1961–62

The programme of Meetings for the 1961–62 session will be circulated in September. Meanwhile, members are reminded that the Meetings will commence at 7 p.m. instead of 2.15 p.m. as previously, tea being available from 6.15 p.m. It is hoped by the Council that this alteration will be the means of increasing attendances.

Advance copies of all Papers may be obtained on application to the Secretary.

METALLURGY IN AGRICULTURAL ENGINEERING

by IAN G. SLATER, M.Sc., Ph.D., F.I.M., C.I.Mech.E.

Dr. Slater, who is at present Head of the Department of Metallurgy in the College of Advanced Technology, Birmingham, has had a varied experience both in the academic world and in industry. He graduated in Metallurgy in the mid-twenties and subsequently joined the staff of the British Non-Ferrous Metals Research Association. In 1936 he joined the Royal Naval Dockyard, Portsmouth, as Chief Metallurgist, completing his career with the Royal Naval Scientific Service in 1949 as Director of Operations Research. His subsequent appointment was Director of Research and Development to the Aluminium Division of Tube Investments, Ltd., and five years ago he returned to the academic world in his present post.

Dr. Slater spent two years after the war as Scientific Adviser to the British Admiralty Delegation in Washington, D.C. His subsequent travels have taken him to a number of countries in Europe and in the Americas on various projects of metallurgical interest.

SYNOPSIS

METALLURGY is an applied science which has a vital part to play in agricultural engineering in order to ensure economy in the usage of metals, greater durability of equipment and advances in designs and applications. Following a brief review of economic factors which influence metal costs, the useful properties of metals are discussed at length. It is convenient to review these properties under the headings of physical, mechanical and corrosion characteristics respectively. Many individual factors are involved in each of these ; we can define well some of them, but there are many about which our knowledge is limited. In a final section, materials, design and usage are discussed and certain views are expressed as to where progress may be expected.

* * * *

Introduction

The object of this Paper is to outline and to discuss matters of metallurgical concern which are involved in agricultural engineering practice and in the successful operation of agricultural equipment. Metallurgy is an applied science dealing with the extraction of metals from their ores, their fabrication into the shapes and forms of use in industry, together with their ultimate application in a completed piece of equipment or structure. Like other applied sciences, metallurgy depends for its fundamentals on the pure sciences of chemistry and physics, together with mathematics. It also demands a knowledge of the arts and crafts and motives of the engineer and of the man of action so that practical and economically worth while solutions of problems can be secured. These solutions often involve " combined operations " on the part of the metallurgist and his fellow engineers, and ultimate success may well be a fair indication of the measure of this co-operation.

The environments in which farm machinery may be used or lie disused are legion. An obvious difficulty which faces every maker of agricultural machinery is to establish a level of design and durability which will be acceptable to the average farmer in these diverse environments of heat or cold, rain or sunshine, mud or dust, clay or sand, care or neglect. Like the craft of farming itself, probabilities, chances, the unexpected, luck and fate can all play subtle parts in the economics and performance of agricultural machinery. The very diversity of such machinery must surely make its lone designer sigh for the happy lot of his colleagues elsewhere who are concerned with structures such as railway engines, aeroplanes and motor cars where each and every detail is treated with loving care by thousands of professional staff.

Economic Factors Influencing Metal Costs

Metal costs may vary immensely according to the particular material involved—thus from pennies per pound for mild steel, to shillings per pound for aluminium alloys, to pounds sterling per pound for titanium and to many pounds per ounce for the precious metals. It is wise to appreciate why this should be, and a brief survey of the underlying economic factors will not be amiss.

Virgin metals are obtained from ores which are widely scattered in the earth's crust and which firstly require discovery by the exhausting and expensive process of prospecting to prove both the amount of ore available and its metal content. Whilst the farmer traditionally may claim that Nature is all " agin " him, the seeker of metal ores surely has a very much greater grouse, for it usually happens that many of our most valuable resources are tucked away in some remote jungle, desert, mountain range or arctic waste with certainly no reasonable access road to a neighbouring railway.

Metallic ores, apart from those of iron, normally require concentration by a suitable mineral dressing process before they can be smelted to produce the virgin metal. Costs depend on a number of factors, not the least of which is the actual metallic content of the ore as mined, which sadly diminishes as the richer ores of the world are used up. This metallic content varies enormously ; thus iron ores containing upwards of 60 per cent. iron are commonplace, copper ores containing $1\frac{1}{2}$ per cent. copper are typical, whilst gold ores containing a $\frac{1}{4}$ ounce of gold per ton are commonly exploited. Smelting and refining costs also vary greatly according to the nature and details of the processes involved. Iron is relatively cheap, since simple reduction agents (carbon) can be used and very large tonnages can be produced from a single unit. Aluminium is dearer because preparation of the ore requires a substantial chemical treatment and a large amount of electrical energy is required to smelt it—in fact, 9 k.w. per pound of metal produced. Titanium is a tougher infant still because of the ramifications of the processes involved in concentrating and purifying the ore and in the actual smelting operations.

A point worth mentioning at this juncture is the part which scrap metal plays in helping the supply of metal at any one time. It is useful to note that this source of supply may be equivalent to nearly half our total requirements at any one time and therein resides much wealth to those who handle it. Farmers have the reputation as being notorious hoarders of scrap metals, much to their financial loss.

Before the engineer can usefully employ metals, it is necessary to melt and cast them. Subsequently, if wrought forms are required, the ingots have to be processed by rolling to produce bars, sections, plate and sheet or by forging to produce special shapes and forms or by drawing to produce tube, wire and smaller sections or by extrusion to produce special sections in certain alloys. Additional factors which are involved may include shaping and cutting to required dimensions with specialised machine tools, heat treatment, welding and joining. All these are highly specialised metallurgical processes which require technological knowledge, skill and experience, and moreover involve, in total, an enormous capital outlay in the necessary plant and equipment.

It will be appreciated that the objectives in all these matters are aimed at securing an ever-improved range of alloys which will provide the engineer with materials of greater economic value and usefulness. Cost is but one factor in this, but more particularly the development of physical, mechanical or chemical properties more suited for the purpose in prospect may be a predominant aim. The number of alloys available to the agricultural engineer is legion, but, fortunately for him, the vast majority of these are of limited commercial significance or have highly specialised applications.

The Useful Properties of Metals

This is a rather complex subject, but a study of it is essential if full advantage is to be made of available metals and alloys in the construction of agricultural machinery and equipment. Additionally, it is wise to reflect on the fact that the knowledge of the engineer is limited in many cases as to the precise usage of the equipment both by man and by nature, and this will result in a series of shrewd guesses or approximations on his part in the details of design and materials chosen. The user of the equipment has an important role to play in this by making sure that the manufacturer is made thoroughly aware of deficiencies in performance or durability so that designs and materials can be modified appropriately. Mass-produced articles of similar design are readily evaluated by the user and meet a suitable commercial fate, be it success or failure. As has been mentioned earlier, agricultural machinery and equipment is of very great diversity and consumer evaluation can only be applied to a very limited range of products.

Useful properties of metals can be divided conveniently into three general categories—physical, mechanical and chemical—and discussion of these will bring out fundamental features which are essential to the discussion. It will be necessary to deal with some of these at length, and they are set out under their appropriate headings in the following :

(1) *Physical Properties.*

The physical properties of metals are those which are fundamental to the material and can be measured in some precise way and are not dependent on a particular method of test or form of test piece. Everyone, these days, knows that atoms consist of a small but dense nucleus surrounded by electrons in orbit, and that the physical and chemical properties of the various elements are directly related to the number and distribution of these electrons. In metals, the outermost electrons of the electronic shell are rather loosely held, and in the solid state are freely shared with neighbouring atoms. This rather over-simplified model accounts for such things as the good electrical and thermal conductivity of metals, the simple atomic packing arrangements of metal and crystals and also their remarkable toughness and ductility. It can readily be appreciated that the individual atoms are held in a sort of tenuous elastic medium which is not easily ruptured. If the strength of metals depended on the force required to shear one atom relative to another, one would expect a metal to have an enormous strength, but, unfortunately, defects are found to exist in the regular crystal lattice which move about very freely and make shear possible at much smaller applied stresses than would be expected on theoretical grounds. However, all is not lost, for with progressive cold working these dislocations entangle and interlock, thereby increasing the strength. Alternately, by suitable alloying—*e.g.*, carbon in steel—these dislocations may be anchored, as it were, or staked in position.

Additional to these sub-microscopic defects, there are many others possibly present which may mar the properties of cast and wrought metals. These are familiar to all of us, such as cracks, blow-holes and shrinkage porosity in castings, inclusion of slag and impurities in wrought metals and, indeed, a whole host of others.

With these limitations in mind, it is possible to list certain physical properties which may be accepted in a conventional way as fundamental. These properties include the melting point, density, thermal conductivity, electrical conductivity, specific heat, magnetic susceptibility, modulus of elasticity, colour and reflectivity. Most of these physical properties are involved and are of major significance in some way or another in the machinery and equipment under discussion, and relevant features will be brought out later on in actual examples.

(2) *Mechanical Properties.*

The dividing line between physical and mechanical properties is, perhaps, rather hard to define, but, for the purpose in view, mechanical properties are those which are not absolute but depend on a particular method of test which has been devised. In this manner, the property may be of a descriptive nature, such as the comparison between tough and brittle or between hard and soft, or between wear resistant and otherwise. However, the engineer and the metallurgist have between them developed test methods and standards for most of these mechanical properties which are commonly accepted and can be used with success in applying certain metals to certain designs for specified conditions of usage. This is, indeed, a full study in itself, on which the engineering sciences have made great practical advances in recent years *vide* the successes achieved in aircraft frames and engines, atomic reactors and the like in the past couple of decades.

Mechanical properties of concern to the agricultural engineer include hardness, elastic limit, ultimate strength, ductility, machinability, toughness, fatigue resistance, wear resistance, damping capacity and creep strength. In so many cases, an integration of several of these properties may be required, either for the purpose of manufacturing the article or to ensure a useful working life of the final equipment.

Some of these properties are often referred to as "strength" properties, and can be used directly for design purposes. The elastic limit of the material—the load (normally expressed in tons per square inch) above which the metal will show permanent deformation—is of particular significance. This property is less dependent on the shape and form of the test piece used to evaluate it than are many of the other mechanical properties. However, under biaxial or triaxial stresses, such as are so often encountered in machinery, possible values are far less predictable. Fatigue resistance relates to the strength of the material when exposed to live or fluctuating loads and is of prime concern in all components where the stresses are other than static. These fluctuating stresses may be alternating bending or alternating torsion or other combinations thereof, which add complications in applying simple endurance limit data to specific designs. Fatigue strength also depends on the condition of the surface of the shaft or other component under consideration. It may be lowered, as for example in mild steel, by 20 per cent. or more if the surface is roughly machined ; keyways and particularly sharp corners may be even more harmful.

Relative toughness or brittleness are even more difficult to assess in a precise manner, although the metallurgists have evolved many useful but comparative tests for these properties. So much depends on the shape and form of the test piece, and in particular whether or not it carries a sharp notch. This latter feature must have been discovered by the earliest of our ancestors, in that they freely took advantage of a nick or a scratch in a stone or a piece of wood to fracture it with greater ease. Rough usage is commonplace in agricultural machinery and shock stresses of unpredictable magnitude must necessarily be taken into account in the designs involved. Treatment of this design feature can never be exact, and a golden rule is to make sure that if relatively brittle materials are to be used they are robust in contour and certainly free from notches, nicks and slender sections. It is also useful to know that ordinary tough mild steel can become relatively brittle at lower temperatures—a fact which disturbed us greatly in ships during the late war and which many farmers have encountered on frosty days in other ways.

Hardness is a well-appreciated characteristic of metals which is simple to measure by recognised test methods, but which is far less easy to interpret for design purposes. In many steels hardness is related to strength, but there are notable exceptions to this in many other metals. A popular conception is that hardness may be associated with wear resistance, ability to cut and similar practical phenomena, but again there are instances which completely refute this general description. Thus manganese steel (1·2% C, 13% Mn) is considerably less hard than a fully hardened carbon steel, but its wear resistance under certain conditions is vastly superior. There are well-recognised reasons for this ; in fact, with manganese steel the act of abraiding or deforming the metal surface results in a conversion of the softer austenitic structure into harder martensite.

The subject of wear resistance must be one near to the heart of any agricultural engineer, since the movement of cutting or moulding tools through the earth and through vegetation generally is so commonplace an experience. The mechanism of wear is complex ; much remains to be discovered and a qualitative theory of wear is lacking. Thus, the actual wearing agent can be of a most diverse character, whether it be soil, fibre or any other agricultural media. The wear of the metal may arise by seizing or penetration of the metal surface wherein small pieces are torn loose. Moreover, the surfaces of most metals are covered by a corrosion product of oxide or sulphide which may be mechanically weak and easily rubbed off. Additionally, the friction arising from the rubbing action can result in the heating of the metal surface, thereby causing it to lose some of its mechanical strength or perhaps even melting it locally or, alternatively, speeding up oxidation of the surface. In a general way, wear resistance is enhanced if the metal is hard, corrosion resistant, and has a high melting point, but it is conditioned in no uncertain way by the extraneous factors of lubrication, lack of lubrication, dry friction, particle impact, presence of water and many others.

The rate of wear of many metals can be diminished by hard surfacing treatments which provide a wear-resisting exterior with a softer and tougher core and which is more resistant to the possibilities of brittle fracture. In this manner, steels can be case-hardened by a variety of processes known under such names as carburising, nitriding, cyaniding, carbonitriding, induction hardening, flame hardening. Alternatively, hard layers can be added to the surface by welding on special alloys or by electroplating with chromium. All these processes require a proper choice of steel for the core and appropriate care in the processing.

Bearing metals have properties and problems closely allied to the foregoing, and the solution of bearing problems lies largely in mechanical design, together with appropriate choice of alloy for the bearing. Again, there is no simple rule to follow, since conditions of service are so varied. Ball or roller bearings made from highly hardened steels represent one solution, whilst plain bearings in which the alloy used is relatively soft may present other solutions. A vast fund of practical experience has been built up in these matters where strength properties, anti-seizure characteristics, corrosion resistance can be matched with service conditions such as load, speed, temperature, dirt and corrosion, lubrication and shaft hardness.

It is appropriate at this stage to look at, in further detail, mechanical properties which are of particular concern to the builder of agricultural equipment, for these, integrated with the cost of his raw materials, will determine the price of the products which he sells. Machinability is certainly commercially important to him, and again it is a much-sided property. This is, indeed, a realistic and royal metallurgical battle for so much depends on cutting tool characteristics and metallurgists have moved fast and far in the past half-century from plain carbon steels to high-speed alloy steels to stellites, to sintered carbides and now to fused alumina with a hardness near to that of a natural sapphire. The latest arrivals are harder and wear better, but lack the toughness of the earlier ones. Fortunately, the skill and enterprise of the machine tool manufacturer has overcome some of the problems in the use of harder but more brittle cutting tool materials. As regards materials to be machined, a fair guide to their relative machinability in the case of steels is their hardness, but with certain notable exceptions, including the austenitic stainless steels. In the case of non-ferrous metals, the picture is rather more complex, but it is useful to note that aluminium alloys and free cutting brass are at the easy end of the list, with the special nickel alloys at the harder end. Very soft metals such as lead or pure copper, and even wrought-iron, can be troublesome indeed, in spite of their relatively low hardnesses.

Formability of metals, as by hot forging or cold bending or by any other method of plastic deformation, is also of much practical significance to the manufacturer. In a general way, formability is associated with the behaviour of the metal at stress levels between its elastic limit and its ultimate strength. Usually, metals show greater plasticity at higher temperatures, and the effort required to deform them is less, since their elastic limit is lower the higher the temperature. An interesting feature in the case of rolled sheet and extruded sections is the fact that properties are not necessarily similar in all directions. Thus "ears" may appear on components deep drawn from such material, or if the direction chosen for bending is unfavourable, the material may snap short.

Welding is now the common method for joining metallic parts and is indeed a vast technology in itself. As a process, it may vary from the use of simple equipment readily handled in the village blacksmith's shop to that of mammoth machines for mass-production and costing thousands. In all these processes, material problems abound, since different alloys require different welding processes. Mild steel is, fortunately, one of the most amenable of metals from a welding point of view. Other metals require more care ; thus in the case of aluminium protective atmospheres of argon or other inert gas are required for electric arc welding in order to avoid reaction between the molten pool of metal and the air. Alloys which owe their strength to heat treatment require special care, for it is to be remembered that the heat of the welding operation penetrates into the neighbouring parent metal, where all sorts of changes can occur. It may be said in general terms that most metals can be welded in efficient and economical ways, but the wise agricultural engineer will seek proper guidance when he starts on something new.

Corrosion

This is, indeed, a sad topic for all those having agricultural interests. The phenomena of rust and decay are so evident in field and farm that there must be some factor so ingrained in our farming community as to suggest a fatalistic attitude to anything which will not provide for itself in growing a new coat annually, be it of wool, hair or feathers. Thus, if only farming ironwork would grow a new coat of paint at reasonable intervals, or acquire fresh galvanising or some other form of exterior protection, the savings to the farmer would make agricultural subsidies look like chicken feed. Several people have made estimates of the cost attributable to the rusting of iron and steel in the world, and the latest guessses suggest that it may well be over £2,000 million per year.

There are several sides to this matter, however ; we have many alloys which will not corrode in agricultural atmospheres, but perhaps the vast majority are far too expensive to merit a second thought. Again, the rate of rusting (be it steel we are thinking of) depends on the type of environment or atmosphere in which the metal is exposed. With a clean steel surface, nothing will happen by way of corrosion if it is exposed in bright, dry sunlight, but as soon as the dews of eventide fall, the insidious attack will commence, or if a sea mist envelops it the attack will be even more rapid. Even the salty sweat from the hand of the perspiring plowman will leave its mark on the bright steel. The environmental factor is indeed important and good housekeeping is most vital if long life is to be secured, more so for mild steel than for the man of the household.

Other factors may influence rates of rusting of steel ; for instance, by joining together dissimilar metals, it is possible either to accelerate the rate of decay or to diminish it. In connection with the latter, the protection of steel with a coating of zinc is very familiar. The zinc coating corrodes away very much more slowly, and even when it has gone in local spots, the residue will still afford galvanic protection to the underlying steel. On the other hand, copper, brass or bronze are protected galvanically by iron and contacts of this nature result in rapid wastage of the neighbouring iron.

Protective coatings—the artificial ones, of course, and not the hides or horns of the animals—are the common line of defence by the farmer against corrosion and he would be wise to study them. Metallic coatings such as those of zinc applied to steel by hot dipping or by metal spraying or by electro-deposition or by zinc rich paints are in the front rank and will give many years' protection. Another line of defence is the application of paint of the right quality applied thickly enough on the clean, dry surface of the steel. " Clean and dry " is probably a more important feature than finding the right brand of paint and certainly more difficult of achievement. Yet another line of defence lies in the use of so-called temporary protectives which are liquids or pastes which can be brushed or sprayed on and will give protection for a limited time. Alternative to leaving the combine mid-field nearby where the last rabbit used to fall to the final fuselade, if the machines were hauled to the barn, cleaned down and sprayed at vital parts with a pint or two of suitable temporary protective, all would be well until the following harvest. Incidentally, a number of these temporary protectives contain lanolin derived from sheep's wool.

This subject of corrosion is far too vast for further mention other than the rough illustrations given in the foregoing. Perhaps one more outstanding illustration of its ravages might be mentioned—that of corrosion fatigue. Ordinary fatigue consequent on fluctuating stresses was mentioned on page 14 ; if the component concerned is also undergoing corrosive attack, it will fail far more quickly—indeed, almost catastropcally.

Materials, Design and Usage

It is appropriate at this stage to attempt an integration of several of the factors which may have emerged from the foregoing survey and to place them on a practical basis. An objective is to suggest possible new approaches in the arts and crafts of agricultural machinery which will yield ultimate economic dividends under operational conditions.

A useful start can be made considering strength/weight ratios of possible materials and designs. To be strong and light is a clear objective in all structures we have to move around ; aeroplanes and hay-rakes are no exceptions. Granted in some examples of agricultural machinery, there is need for weight in order to secure tractive effort, but often this can be modified by subtilities in design. Simple improvement can often be secured by using materials of higher strength ; for example, alloy steels in place of mild steel, which can result both in weight saving and in overall reliability. Design must be integrated with this so that robustness of construction is maintained and components do not fail by buckling and torsional instability. The aircraft designers can teach us a lot here.

A change to an alternative material which is much lighter merits most serious thought in certain applications. It is useful to approach this by looking at the strength/weight ratios of a number of possible alloys as indicated in the table below.

In practical consideration of the foregoing, it is fair to rule out titanium alloys at present because of their cost, but it is wise to look at the aluminium alloys in more detail. Where strength alone is of less significance, as in constructions involving sheeting, weight saving can be very substantial indeed for aluminium is a little more than one-third an equal volume of steel. The corrosion resistance of aluminium is very greatly superior to that of mild steel, and in many applications no protective painting is required. In this respect, aluminium can fill a gap between mild steel and the more expensive stainless steels, especially in applications involving quite severe corrosive environments. Castings in aluminium alloys are also available which will show advantages of light weight, corrosion resistance and ease of machining and construction. Quite a lot of headway has been made in using aluminium alloys in agricultural equipment, but the real economics of its use merit much further exploration, especially from the ultimate operational gains on the farm.

STRENGTH/WEIGHT RATIOS FOR VARIOUS STEELS ALUMINIUM ALLOYS AND TITANIUM ALLOYS

Material	*Density*	*Yield Strength, tons/sq. in.*	*Ratio, Yield–Density*
Mild Steel	7·86	15	1·9
Carbon Steel EN8 heat treated		30	3·8
Alloy Steel EN23 heat treated		50	6·4
High Tensile Steel Wire ..		120	15·2
Pure Aluminium, hard rolled..	2·7	6·0	2·2
Aluminium Alloy H.10 ..		15	5·5
Aluminium Alloy D.T.D.363A.		33	12·2
Titanium Alloy	4·3	70	16·3

These general observations lead to wider thoughts as to improvements which may be possible in selecting better materials for specific applications ; the problem of matching in many cases a somewhat higher initial cost of matching in many cases is a somewhat higher initial cost against a higher ultimate yield in usage. The metallurgist has an almost unlimited range of metals and alloys to offer, but the economics of their actual value to the agricultural industry is an integration of literally all that has been said in this Paper with the serviceability and usage of the machinery or equipment. In some cases, we are driven to use quite expensive materials, since the less expensive ones will have a relatively short life because of deficiencies in their physical and mechanical properties or their lack of corrosion resistance. In many other cases, the balance is less obvious and it may take months or years for the farmer to discover the cost of uneconomic service and deterioration. In particular, the feature of " weight " and all it implies in effort of moving or in compacting the earth can become a very vital issue.

It is difficult in a small unit industry as in farming to cost operations over the years and thereby establish the real price paid for services afforded in machinery and equipment. By comparison, the large ship operator or the heavy transport industry have an easy task. There are obviously lots of opportunities for the operational research worker to get busy on the farming task whereby some of the broader issues can be enunciated and elucidated in scientific and measurable terms. Meanwhile, there is much left to the designers and builders of agricultural machinery and equipment to ensure that they make the best use of the available metallurgical resources in order that they advance with the times.

DISCUSSION

DR. SLATER, in reading his Paper, drew attention to his figure of over £2,000 million as the cost of the rusting of iron and steel in the world ; at a recent conference the global cost of corrosion had been quoted as £5,000 million.

MR. F. LEE (Rubery Owen Organisation) said that Dr. Slater had given an excellent and interesting Paper. Many questions were presented. He noted Dr. Slater's comment that farmers tended to hoard scrap metal and agreed that this scrap was of great value. One steel company using only scrap metal produced the same tonnage from six modern furnaces as it did previously from 24 open-hearth furnaces. Agricultural engineering firms should never hesitate to call in the metallurgist. Unfortunately, however, sometimes one had to provide him with so much information that it was quicker to put the machine out on test !

He quoted his own experience of using steels in the 36-ton tensile range. One might find three steels with different specifications, but with similar properties, yet the prices might vary considerably. The metallurgist could help in such matters.

Dr. Slater's remarks on the use of mild steel in agricultural engineering, Mr. Lee continued, were probably no longer quite relevant, in that the tendency now was to use higher tensile steels. Wear presented the industry with one of its biggest problems. For example, on ploughs there was wear on mouldboards, shares, and coulters. Here also the metallurgist could advise. Steel must not cost very much, because the farmer would never pay for the quality the engineer would prefer to put on.

He said that he had not had much experience of aluminium, but did not think it had found much use in agricultural engineering. However, Dr. Slater's strength ratios table was very interesting and they might have to examine aluminium more seriously, especially for tools carried on the three-point linkage.

Mr. Lee said that he would like Dr. Slater's opinion on the quality of British steels. Was it not time the standard E.N. range was brought up to date, because it was sometimes possible to get better steels and better prices than were listed in the E.N. book ?

Mr. Lee understood that a new series of heat-treated steels in the heavy range was being introduced by metallurgists which would prove useful in the field of earth-moving, although he doubted if they would have very many applications in agriculture. He welcomed Dr. Slater's remarks on corrosion, adding that in his opinion many farmers still used the hedgerows to store equipment.

Dr. Slater was asked if British steel was inferior to Continental steel ; for example, was it comparable with German steel as regards inclusions ? It was a pity that machinery which corroded did not make a bad smell, because then the farmers would take action !

DR. E. G. WEST (Aluminium Development Association) said that he appreciated the opportunity of speaking about aluminium, as he had taken much interest for many years in its applications to the agricultural industry. He believed that the savings in maintenance and running costs experienced in many other industries by the use of aluminium could be also achieved in farming. Referring to Dr. Slater's table showing the strength/weight ratios for various alloys, he said that the alloys used for agricultural equipment would have a ratio of about 6. The price of unwrought aluminium was admittedly very different to that of steel for a given job, although it was possible to reduce or even eliminate this difference. If an article was properly designed and engineered, using, for example, efficiently-designed extruded aluminium sections and die castings, plus the latest methods of welding, the cost of the finished assembly could be very little different as between aluminium and conventional materials. Sometimes, savings in running costs, frequently of the order of 15 to 25 per cent., could off-set increased first costs. The highest savings were to be found in reduced wear. The main cause of wear that took place on tipping trucks, manure spreaders, etc., was by corrosion rather than abrasion of the metal. Wear occurred because of the removal of layers of rust. There were many examples where aluminium substituted for steel or cast-iron had outlasted the original material by considerable margins.

Dr. West remarked that a great deal of work was being carried out on the simplification of welding some of the slightly higher tensile steels, particularly not those in the 35 to 40 ton class, which were not generally regarded as being weldable—certainly not by the local man using normal methods. Difficulty in welding had militated against the adoption of some of these steels, as it had also against the use of aluminium.

MR. T. P. GREGORY (Hants.) announced himself as one of those farmers who put his tackle under hedges, for it was in that way always accessible and did not seem to come to much harm, if rightly positioned. He declared that if one wanted to save money then it was best not to spend it on buildings. Farmers liked things to look strong, and it was dangerous to produce things which were too light for them. There must be some advantage from the weight, particularly if it was cheap. DR. SLATER replied that the ideal was a design that did not break.

MR. LEE returned to the question of machinery left in hedgerows. Coming to the meeting by train that morning he had seen a lovely combine drill—with the crop growing all round it. He thought it strange that the big makers in this country painted their machines as carefully as a motor car, yet people did not treat them like that.

MR. GREGORY was not sure Mr. Lee was right there, for he saw many motor cars in London left outside doors all night. MR. W. H. CASHMORE remarked that bright colours helped the farmers to find machinery.

MR. A. SENKOWSKI (Massey-Ferguson (Research), Ltd.) said he wished to remind the conference that there was a drawback to the use of low-tensile steels. It was well known that the majority of implements, including whole structures, were exposed from time to time to very heavy shock loads. If this structure were built up of heavy sections of low-tensile material, the average shock absorption property of that structure would be inferior to the average absorption of a structure made in high-tensile material, which was more flexible per one pound of load per foot-pound. So under the same conditions of impact the heavy structure could acquire a permanent bend, whereas a light one would deflect under the load much more, afterwards being in perfectly good order.

MR. J. M. CHAMBERS (Warwicks.) addressed his question to Mr. Lee, because he had been rather taken aback by a designer who said that we must use poor-quality steels, as farmers would not pay for better. Were they not deceiving themselves ? He thought that farmers wanted machines that would stand up to use or abuse. For years they had been telling themselves that farmers wanted something cheap, and he did not think it was so.

MR. LEE replied that Dr. Slater had given him the impression that all agricultural structures were made in mild steel, whereas it was his view that the tendency was for higher carbon steels to be used nowadays. It was Mr. Lee's view that we had got to have a light structure, but had got to design intelligently at an economic price.

MR. CASHMORE asked if any smaller firms were finding difficulty in obtaining steels to the specification they desired.

MR. J. H. W. WILDER (Berks.) said that it was difficult for smaller manufacturers when they were not in a position to go to the steel manufacturer. He wondered if Dr. Slater was satisfied with the British standard range of steels. The limits of the steel ranges seemed to be too great and it was possible to get a batch of steel which was unsuitable for the purpose for which it had been ordered.

DR. SLATER agreed that British steel specifications left much to be desired.

MR. SENKOWSKI indicated the need to decide whether bending of a component was permissible or not. For instance, in a gearbox bending of the shaft would not be permissible. But for some other implements there was no object in trying to keep down bending, for the object was to keep down the yield point. All steels, unfortunately, had the same modulus of elasticity.

DR. WEST thought there was very little hope in increasing the modulus of elasticity of aluminium—or of any other metal—and it was necessary to allow for this. Sometimes an engineer would not accept aluminium because of the lower modulus of elasticity, but now they found that the knowledgable engineer could use the low modulus aluminium to reduce shock loading. Thus a shock load deformed the metal elastically without damage, and he was pleased that Mr. Senkowski had appreciated the importance of the modulus of elasticity.

MR. E. W. ORCHARD (Warwicks.) referred to Mr. Lee's remarks about specifications, and suggested that if a resolution could go from the meeting deploring the E.N. series.

MR. LEE, answering Mr. Orchard, said that he understood this was causing some concern in the steel industry, and that some developments were expected.

A questioner asked about the training of metallurgists. Were metallurgists being trained in a comparable ratio to Russian and Continental programmes ?

DR. SLATER declared that they were not. He turned out 70 a year, and all of those young men had jobs long before they finished their training. He had seen one Russian example where there were 2,400 metallurgists in just one college.

MR. CASHMORE thanked Dr. Slater for his most interesting talk.

THE PRESIDENT then closed the conference, saying that it was the first one the Institution had held in London, and that he was sure that all would agree that it had been a good one. He thanked all who had particpiated.

BOOK REVIEW

Agricultural Engineers' Handbook, C. B. RICHEY, PAUL JACOBSON and CARL W. HALL. McGraw-Hill Book Co. 1961. £7 11s.

This excellent book comprises three sections : (1) Crop Production Equipment, (2) Soil and Water Conservation, (3) Farmstead Structures and Equipment. Each chapter is the work of a specialist on the subject, and the 41 contributors are acknowledged experts in their field. The chapter on the Design of Field Machinery will afford particular interest to agricultural engineers in this country.

The volume as a whole forms a concise work of reference concerning the fundamentals of agricultural engineering and farm mechanisation, and the Handbook will not only be a valuable aid to students, but also a most useful publication for all agricultural engineers.

SPEECHES AT THE ANNUAL DINNER OF THE INSTITUTION

25th April, 1961

MR. W. D. AKESTER (Director, Ransomes, Sims and Jefferies, Ltd., Past President, Agricultural Engineers' Association) proposed the toast of " The Institution of Agricultural Engineers." He congratulated the President on being re-elected for the third time, and said that he was grateful to have been invited as his guest to this Annual Dinner. He felt greatly honoured at being asked to give an address.

He remarked that he felt very much out of his depth amongst such a distinguished gathering of the " boffins " of the agricultural engineering profession, for what little knowledge he had of the art had been obtained the hard way—"on the job." He had to confess that, in the years he had spent in the industry, more information on agricultural engineering had come to him from the user end than the creative end. That being so, he had learnt more what not to do than the reverse, because farmers were a very discerning section of the public, and their criticism could be very much to the point and embarrassingly frank, particularly at harvest time.

As he had just completed a very busy but interesting year as President of the Agricultural Engineers' Association, he was full of statistics, he said. The total production of their industry in tractors and farm machinery in 1960 was £190 million. As a result of this achievement, the agricultural engineering industry was now the fourth largest in the engineering field. With the present need for more exports, it was nice to know that the exports of the industry had risen from £73 million in 1956 to £128 million in 1960—a record to which the President of the Board of Trade had been kind enough to pay a congratulatory tribute recently.

Without doubt, Britain was now a shining example in the world of efficient farm mechanisation, but this had only been achieved through the teamwork and progressive outlook of engineers such as those present producers of farm machinery, technical and economic services, and last, but by no means least, the user, in the shape of the British farmer. Really, he thought, he should have reversed the order, because he was one who believed that most of the bright ideas in farm machinery development sprung from the farm, and of the few things that annoyed him in everyday life, one was the ill-informed statements, to which they were often subject, that the British farmers had thrust upon them products which had never been properly tested, with the inference that the users' working conditions and requirements were disregarded in the interests of the fancy ideas of the engineer, easy production, slick salesmanship, and high profits.

The true position was that the equipment was a major factor in fully increasing farm output with an ever-decreasing labour force. The percentage of the working population engaged in farm work was far lower in Britain than in many countries on the Continent, and he believed himself to be right in saying that a similarly fine achievement was the proud boast of their American friends. Some other countries were not yet compelled to mechanise to the extent necessary in this country, but the scene was rapidly altering and a drift of labour from the land was becoming a problem in most parts of the world. He was sure that Britain would be looked to not only as consultants on farm mechanisation, but that to an increasing extent the products used here would be eagerly sought.

But there was no room for complacency. Britain's ability to continue her progress quite obviously depended on her technical efficiency. He paid a tribute to what the Institution had done towards bringing recognition nationally to British agricultural engineering. It had recognised the need for, and had created, a syllabus of training culminating in a qualification such that membership of the professional body was indeed an honour for those who had earned the right to belong to it. The value of the National Diploma was increasingly being recognised by industry.

Mr. Akester had heard it said that the standards laid down by the Institution were rather on the high side—some had thought they were too high. But to his mind there was no doubt to-day as to the wisdom of the Institution's decisions, and he was sure those who had shed sweat and tears in the obtaining of the Diploma could testify as well.

Talking about the importance of the various industries, he stated that whether or not agriculture was more important than engineering was an argument that got nowhere, but both were among the important ones. These two industries must keep ahead technically and economically. The Institution had made a wonderful contribution in this respect by its attention to agricultural engineering, thus linking two of this country's essential industries, so that they could each play their part in improving and advancing their knowledge and efficiency.

It must be a great source of pride to the Institution —and rightly so—that their work had been rewarded by the decision to set up a National College of Agricultural Engineering. This was a wonderful achievement and would be of immeasurable value to all branches of the industry. He was sure we would be better placed to play our part with a technically qualified future generation. It had been encouraging to see from *The Times* the previous day that it was intended to set up a department of technical co-operation.

He would like to pay two tributes regarding the National College, to which he was sure that all would subscribe. First, to all those from various walks of life who were serving on the Governing Body, and the officials and delegates of sub-committees who were wrestling with the problems of the curriculum. They were giving up much time and people were indebted to them. Second, to the generosity of the Ford Motor Co., Ltd., who, by placing at the disposal of the authorities their training centre at Boreham, would enable the College to commence operation at a much earlier date.

He was not afraid, however, that the danger existed that the direct efforts of the Institution and those of the College would be abortive unless the output of trained men were fully taken up by all branches of the industry's interests. If his fears in this respect were based on sound foundations, he did not think it would be the fault of those public-spirited people who were freely giving of their time to ensure that the training curriculum was on a practical and realistic basis. The real danger was that the principal potential employers of these trained men —namely, industry—would not be sufficiently aware of their value.

This brought him to the all-important question of support to the Institution from the industry. It was a source of great regret that so few of the firms manufacturing agricultural machinery had taken advantage of membership as Affiliated Organisations. He had looked through the list in the 1960–61 year book and had found that of the people engaged in the manufacture of tractors and farm machinery only eight were in membership. But from enquiries he had made in recent weeks he had reason to believe that this matter would show a favourable improvement before very long, and it would give him very great pleasure to continue propaganda in the Institution's interests.

Given more support from manufacturers, this would put right another serious failing. He was amazed to find that in a large number of firms men engaged on development work were not members of the Institution. Perhaps this was not surprising if the companies for whom they were working were not in membership either.

He would like to question what were the underlying causes for this lack of support, and to suggest possibly that there should be better publicity on the part of the Institution—or should it be more properly called liaison, rather than using a vulgar commercial term ?

Having confessed at the beginning of his remarks the fact that he had an elementary knowledge of their profession, he craved their indulgence in dealing with his next points, because he realised he was getting on rather dangerous ground.

First he touched on the question of text-books. He knew Mr. Claude Culpin was in the audience, and he hoped he would not misunderstand Mr. Akester. However, as they knew, there were many aspects of agricultural engineering which were a closed book to the mechanical engineer, however well qualified. He had in mind the theory and practice relative to such things as soil—its structure and behaviour, grain and similar crops from the point of view of cleaning, separation, handling, etc., and possibly the study from a physical standpoint of such things as chemical fertilisers. It occurred to Mr. Akester that the student of agricultural engineering needed more information on these matters and that a text-book on the subject would be of great value.

After speaking at this length on the future generation, he then dealt with present-day problems. He would like, he said, to pinpoint what he described as economic forces working against the interests of the gentlemen present.

He was sure they had heard as often as himself about the criticism that development was rather inclined to follow conventional lines rather than original ones. Perhaps one was rather inclined to be misled by history into thinking that there was more originality in olden times than to-day, as exampled by the original seed drill and the first self-binder, and to view with regret that so much development time is spent on making bigger and better ploughs and combines, tractors, and the like. This was too often the economic reaction, because firms were obliged to think in terms of the maximum volume of production to be obtained from every pound spent on development. Yet if they were going to keep ahead, he felt sure that there must be development time devoted to original design, and although he knew that a terrific effort was being made in this direction at Silsoe, he felt that commercial firms must make their contribution as well.

Another economic factor which he mentioned was the development of equipment for farming conditions outside this temperature zone. Future overseas business would come to a large extent from sub-tropical and tropical areas. But the expense of design research and the development of machines was, of course, a heaty cost in terms of travelling and time. The alternative would be to limit our development of farm equipment to temperate zone crops, but he could not think this a good thing for the industry.

Finally, he wanted just to touch on the essentiality of teamwork for the future success as between the designer, the producer and the salesman. He could deal with the design side very quickly, because quite obviously they were all on top of their jobs and there was no weakness there ! As regards the production engineer, he thought he did his job fairly well. After all, it was only straightforward mechanical engineering, for which text-books were fully provided, and he was spoon-fed by all concerned. But when it came to the selling side he thought we fell down rather badly.

Were we paying enough attention to selling ? he asked. He did not think we were, and he considered the basic cause to be symptomatic of an attitude of mind which was, perhaps, valid in the days when we were one of the new exporters of manufactured goods from this country. At that time no one would have challenged the fact that British ingenuity (*i.e.*, design) and British quality (*i.e.*, the skill of the manufacturer) were acknowledged by the world as superior to an extent that we automatically obtained our export business.

Our best export was still our ingenuity and skill, but he felt that we were still of the opinion that this should be enough to earn us a living overseas. He was quite sure this was wrong and that we must pay more attention to selling and that it must be teamwork all the way through, with as much attention given by industry to proper training for salesmen as for designers and producers.

He expected his audience had all experienced arguments on the relative importance of these three sides of industry, with each one being perfectly sure that he played the most important part, whereas he had expressed the view that all three were of equal importance. But there was someone who was more important than any of them—and that was the user. He thought it was useful to remind themselves of this from time to time.

In conclusion, he renewed his thanks to the President for allowing him to stand on his " soap-box," and offered him and the Institution his very best wishes for its continued growth and success, with ever-more support for the valuable work it was carrying out.

THE PRESIDENT responded to this toast. He said that they had all listened with considerable interest to Mr. Akester's excellent speech. He could assure Mr. Akester that its content would infuse all present with the determination to achieve greater things in the year ahead. On behalf of the Council and of all members present that night, he had immense pleasure in thanking Mr. Akester for the way in which he had proposed the health, efficiency and prosperity of the Institution.

In return, the President asked if he could, on behalf of all, convey to Mr. Akester their congratulations on his completion of a highly successful year of office as President of the A.E.A. The President was certain that during that year the leadership and guidance of Mr. Akester had been of outstanding benefit to the Association. The latter's presence there that night was of significance to the Institution. Mr. Akester was, as everyone knew, a very well-known and high-respected personality in the industry. Happily, those attributes were allied to his directorship of a company with a most remarkable historical background—a background that symbolised to all the history of what was meant by speaking of the agricultural engineering industry. From its inception Mr. Akester's company's achievements had been outstanding. To-day, its products—like those of other manufacturers—were playing a valuable part in satisfying the needs of agriculture both at home and overseas.

That night they were honoured in having with them a number of guests representing many famous manufacturers whose products were now to be found in many parts of the world. Their production, in common with that of most of the agricultural industry, was scoring remarkable successes in the export drive. It was because of their fine achievements that the industry, with a record export figure of £128,000,000, was regarded with somewhat envious eyes by other industries. This achievement deserved the widest recognition possible. All of them in any way associated with the industry were proud of it. All British industry should be proud of it, too, while trying to emulate it.

He was quite confident that the many telling points made in Mr. Akester's speech would be well taken by everyone engaged in or allied to agricultural engineering or agriculture. The President was quite optimistic that it was from these two sources that the Institution would in the future receive increasing support, especially from members of the A.E.A.

None of the functions of the Institution and of the A.E.A. were basically contradictory. Each was imbued with the desire to give service to one of our country's most important industries. The giving of this service might be approached by different routes, but it was the end result that mattered. Both were doing and would continue to do their utmost in this worthy cause.

The President turned to the future of agriculture. All were aware, he said, that the labour force in agriculture continued to decline—it was now less than 5 per cent. of the country's working population. If followed from this that solving the problem of maintaining the country's food production at its present level, let alone increasing it, was vital to the national economy.

Doubtless, this problem would be solved by new engineering developments and farming techniques. The day could not be far away when they would see new types of power and machinery, consistent with the requirements of the Space Age, and giving a performance and efficiency, perhaps, undreamed of as little as a decade ago. New developments, no doubt, would be used to speed up all farming operations ; others would increase the output per man-hour, at the same time reducing physical effort and minimising fatigue. It was imperative that the future of the agricultural engineering industry should not be jeopardised by lack of man-power.

But he asked if there would be enough qualified agricultural engineers to meet the requirements of industry in an expanding market. Also he enquired if enough men would be coming forward to be trained as the lecturers, instructors, maintenance engineers and specialists that were so sorely needed overseas in countries where mechanisation was still very much in the early stages of development. The answer to these questions lay in the extent to which *now* they encouraged our youth to take up agricultural engineering as a career. Now was the time to give careers in agricultural engineering a much-needed boost.

It was against this background, he continued, that the Institution was very proud to have been so closely associated with the formation of the National College of Agricultural Engineering. The Council was fully aware of the difficulties in the tasks that lay ahead. He would, however, like to assure Sir Gilbert Flemming, Chairman of the Board of Governors, whom they were delighted to have with them that evening, that the Institution would at all times do all it possibly could to be of service to him and his colleagues.

Turning to Institution affairs, he was very pleased to report that the attendance at Branch meetings had been extremely good. Two branches had enjoyed record attendances at their conferences. The Council's policy of providing platforms for discussion through its eight branches would continue and the very widest range of subjects would be chosen. But this desirable policy must be tempered, naturally, by their financial position. At the moment, this was delicately poised just above the "Plimsoll line." Overseas interest in their work was increasing. The Institution now had representatives in eleven countries, including the U.S.A., and copies of the Journal were being sold in over 60 countries.

The Examination Board, under the chairmanship of Mr. Alexander Hay, was doing a fine job. The Board was handling more and more candidates who were taking the National Diploma in Agricultural Engineering, and they were deeply indebted to the Essex County Council and the Principal of the Essex Institute of Agriculture for the excellent facilities they provided for the students. It was most encouraging to know that industry was now providing more places for holders of the diploma. Out of the valuable financial support received from those companies affiliated to the Institution, the Examination Board would continue to increase its efforts in the educational field. He wanted to thank all the affiliated companies and other organisations for their generous support.

As most of them know, the President remarked, they had with them that evening a most valued friend—someone who was known to so many that he felt certain he must be agriculture's most well remembered personality in Show business. He hastened to add that this did not mean that he had been on the stage or, indeed, in the glamorous world of entertainment. He was, of course, Mr. Alec Hobson, the Secretary of the R.A.S.E., who had announced recently that he was to retire that year. The President knew that all would join him in wishing Mr. Hobson and his wife good health and happiness in the years to come.

Finally, he knew that members of the Council would like the President to pay a tribute to the Institution's Secretary, Mr. Slade. He had been untiring in his efforts and had given them valuable service. So to him and his staff the President said "thank you" for the part they had all played in making that day's conference and that evening so successful and enjoyable.

MR. W. J. PRIEST (Editor of *Farm Implement and Machinery Review* and a Vice-President of the Institution) proposed the toast to "The Guests." He had once been told, he began, that real hospitality was the art of making one's guests feel at home when one wished they were. If that were so, then this Institution had not mastered the art of hospitality, for they certainly did not wish their guests anywhere else than right there. They were delighted that the guests had joined them.

Usually there was something of a set pattern about proposing a toast of this kind. It was considered proper to present a potted biography of the guests. If he attempted anything of the sort they would be there all night, because the guests—all of them—were so distinguished in the various fields of endeavour which they adorned. But, of course, he would say something about them.

First he wanted to say how delighted they were to welcome the lady guests, who gave grace and charm to what could have been a somewhat austere assembly. Then, as he put it, with his Institution hat firmly planted over his flapping ears, Mr. Priest welcomed the distinguished representatives of the Press who had accepted their invitation. He knew that they would not write a wrong word about the Institution. Assembled there that night were leading personalities in agriculture, agricultural engineering and its important trade associations, and in education. But he felt he must resist the temptation to mention names. They included one gentleman who had come over from the U.S.A. that morning, and Mr. Priest hoped his visit would be "OK."

He liked to think that the guests had come to that party because they approved of the things the Institution was trying to do. The Institution hoped that they would continue to deserve that approval, for they were confident that agricultural engineering was engineering at its highest and best.

After telling a story concerning a car driver who had decidedly not kept both hands and eyes on his proper job of driving the car, Mr. Priest said that he hastened to add that the driver of the car was not Mr. David Haney. There was no doubt at all that both his eyes and both his hands were firmly fixed on the important position he held in the British agricultural engineering industry. Since he had been living and working on this side of the ocean, Mr. Haney had undoubtedly formed a great affection for the British way of life. They were proud to think that he worked beside them.

Mr. Priest invited the President and his fellow members of the Institution to join in a bumper toast to their guests, coupling with it the name of Mr. David Haney.

MR. D. C. HANEY (Managing Director, International Harvester Co. of Great Britain, Ltd.) responded, saying to the President that it was a real compliment to have been invited to attend the Dinner.

He wanted very seriously to pay a tribute to Mr. Nolan. He had known him for seven years, although he had not known him as well as he might have or as well as he would like to have done. People looked upon Mr. Nolan as a tower of strength and nothing could be happier than the news of his Presidency for another year. Mr. Haney then referred to Mr. Akester's excellent qualities as a speaker.

With him that evening he had brought the Year Book, and he thought that this was one of the finest publications in the field.

The industry's main effort was to produce something that no one else was making and to produce it better and at a lower price. They had done that pretty successfully, and farming equipment from this country was known the world over and set the standard. They were selling their tractors in the teeth of the worst competition in the world, and they could do that because they were giving the customer something better than he could get anywhere else. If they stopped doing this they were going to go out of business. He hoped that they in the agricultural engineering industry would continue to fight for the buyer markets. Let the breeze of competition blow right through the industry—they could take it.

There was not a man in the room afraid of competition. That Great Britain was meeting competition in America was an indication that in this country we could meet any kind of competition. In fact, America had been one of the best markets.

True success depended on education and the Institution had done a magnificent job in this. The Ford Motor Co., Ltd., had been most generous in offering the National College a temporary home. It was the farm workers and, more important, the farm managers who needed education.

Mr. Haney was critical of the claim that British farming is the most mechanised in the world. It might have the most tractors, but until British farming did something about mechanising more successfully the harvesting of roots, then too much man-power was still going to be used in Britain. Furthermore, until all those lovely hedgerows ceased to exist there could not be fully efficient mechanised farming.

They had got to sell mechanisation and could do much more in the selling of British tools. It was even needed in the Sudan, where labour was so cheap that it was almost impossible to tell what to pay a man for a day's work. If the right selling job was done, mechanisation could be sold.

He congratulated the Institution for the fine job it had done well. Thanking them for inviting all the guests there that evening, he said what great pleasure it had given him to meet old friends and make new friends.

This photograph shows approximately half of the Council Room at 6, Queen Square. It seats up to eighteen.

The furnishings were provided largely from donations by members, and the portrait of the Founder President Lt.-Colonel Philip Johnson, by past and present members of the Council.

FARM MACHINERY SAFETY

A joint Paper presented at an Open Meeting of the Northern Branch on 16th January, 1961

I "THE NEED FOR SAFETY ON FARMS"

by J. R. WHITAKER, N.D.Agr.E., A.M.I.Agr.E.

FARM safety is a comparatively new subject and ideas about it have not yet completely settled down. There has been some general concern expressed about the need for safety and welfare provision for agricultural workers since the 1930's, but nothing positive was done until recent years. In the '30s protection was concerned more with washing facilities, protection against fertiliser and acid sprays and the very few machines which existed in agriculture at that time. Had action been taken at this time it would have been a much simpler matter than it is turning out to be now, and because the regulations would have been in force we would not have been faced with having to deal now with all the machinery which has been delivered to farms in the last twenty years.

Everything would have been guarded as it was supplied.

Serious action really started in 1952 when the Agricultural Poisonous Substances Act was passed following the recommendations of the Zuckermann Committee in 1951. These required the provision of suitable protective clothing, including respirators where necessary and appropriate washing facilities where workers are operating with poisonous spraying compounds. They also lay responsibility upon the workers to use the clothing and facilities provided.

In 1956 the Agriculture (Safety, Health and Welfare) Provisions Act was passed which provided the framework for safety regulations. Apart from the provisions relating to washing and toilet facilities, this was an enabling Act to provide for the passing of regulations to deal with dangerous circumstances as they were found on farms. Section 1 of the Act, which covers this, allows the Minister of Agriculture, with the support of Parliament, to make regulations about virtually anything which is dangerous in agriculture.

Regulations are not the complete answer to accident prevention, and I will only touch on them briefly. I am going to deal with the need for safety from the point of view of how many accidents there are, how much do they cost, how are most of them caused and how can some of them be prevented ? I will touch briefly on the regulations themselves, illustrating some of the points by means of slides. I hope to persuade all of you that the total number of accidents must be reduced and that the concerted action of everyone can achieve this. Everyone connected with agriculture has a responsibility in this matter.

Before it is possible to say how many there are and assess the cost and cause, statistics have to be collected, examined and analysed. Individual acciednts must be investigated and reports on them studied and analysed in order to decide the causes. Once this information is available it is possible to say how accidents can be prevented and what precautions should be taken. Between 1947 and 1951, J. A. Mollett, of the Economics Department of Reading University, studied and reported on a sample of accidents in Buckinghamshire. The Institute of Agricultural Engineers did a similar survey in the eastern counties in 1956. Since then the Ministry, whose Safety Inspectorate was set up in 1956, have continued to collect information and investigate accidents.

There has been no significant change in the number of accidents, either fatal or non-fatal, since about 1949, but the recent trend is, if anything, a slight increase. How many accidents are there ? Mollett estimated that one worker in twenty was off work for seven days or more with an accident every year. If we take into account accidents which involve shorter absences from work, the figure rises to one in twelve. There has been an appreciable reduction in the labour force employed in agriculture since this investigation took place in 1947, but the frequency remains about the same to-day.

Taken on its won, such a figure means very little, and we need to put it on a more practical basis to appreciate exactly what it means. One person is killed every two or three days and 400 people hurt every week on British farms.

About one person in 150 has an accident on the roads if we take the total population ; if we halve that figure to take account of old people, babies and others who rarely use the roads, it is still only one in 75—about a quarter the risk an agricultural worker takes. I do not want to get too involved in this comparison, as factors such as severity of injury would need to be considered, but it does emphasise that for the labour force employed in agriculture there are without question far too many accidents.

What does all this cost ? There is without question a big enough financial loss to make accident prevention well worth while from this point of view alone. This cost is made up of three items—the actual loss in wages, the indirect loss of the cost of medical treatment, etc., and the extra expense to the employer either directly in casual labour wages or indirectly through loss of production. It has been estimated that the present annual wage loss—the first item—is over £1,000,000. Mollett, in his investigation, estimated that the indirect cost was not less than four times the wage loss—namely, a further £4,000,000. It is quite possible that the indirect cost could be even more than this figure. In agriculture, smooth progression of work depends upon a team in many cases. The loss of a good man from the team can cause serious dislocation and possible loss of crop ; for example, combining may be delayed by the absence of the regular driver or cattle may suffer a drop in milk yield if the regular cowman is away.

That, of course, is only the money side of the situation. No account has been taken of the pain and suffering of the injured party, and the fact that because of mutilation he may have to give up agricultural employment. He may also have to have special training, at further expense to the country, to enable him to continue to earn a living.

What are the main causes ? We must consider non-fatal and fatal accidents separately here, as the causes vary in these two classes. The breakdown of non-fatals into causes gives the following figures :

Tractors, machinery	16%
Falls (including from ladders, vehicles and floor edges)	24%
Hand tools	16%
Animals	8%
Blows and wounds	20%
Strains and other causes	16%

For non-fatals many people, including Mollett, say that negligence causes at least 50 per cent. of the accidents. To a certain extent, this is true, but it is the sort of negligence very often which would not be tolerated on a well-run farm or factory where the employees had been properly trained and supervised. Proper and adequate supervision is an important factor and I will refer to it again.

A lathe operator in a factory is trained during his apprenticeship to keep his lathe clean, clear all swarf chips and spare parts. Tools are kept in a toolbox or tray, the floor is kept reasonably clean and he normally wears overalls or a boiler-suit. How does this compare with the average farm ? A set of three harrows will be found with two closing a gap in the hedge and the third with its points up, invisible under the grass, just inside the gate, ready to trip up the unwary and cause unpleasant injuries. The tools are anywhere and are generally inadequate for the job ; spanners do not fit, jacks are too small and short, and there are no proper supporting tripods to enable workers to work under machines with safety. I hesitate to say more about clothing than " It leaves a lot to be desired." The accidents which are caused through this sort of negligence can be prevented if both workers and employers resolve that equipment and tools will be properly stored away and that farm-yards will not resemble even superficially a junk yard.

Many instances which can, perhaps, be put down to negligence arise through workers carrying out lubrication and adjustment while machinery is in motion. They fail to chock moving parts of combines and balers before attempting to clear blockages, and the machinery often revolves while they or their hands are within a trap area, resulting in an accident. This type of accident will only be prevented by education and appreciation of the dangers concerned.

Tractors and machinery are responsible for 16 per cent. and falls, including falls from ladders, floor edges and vehicles, for 24 per cent. Apart from the negligence factor which may be involved in a small proportion of these, the remainder are caused by dangerous working conditions, lack of guards and inadequate equipment. There are probably, therefore, at least 20 per cent. of all non-fatal accidents which could be prevented immediately if proper guards and equipment were available on all farms.

I expect that we can train workers to take more care when handling animals easier than we can train animals not to injure workers, and this is true of most of the remaining groups of accidents. It is the worker himself who has to take the precautions. One of the problems of accident prevention is a lack of awareness of the circumstances which cause an accident. Farms vary from one to another, and there is a strong tendency for workers to say, even when they hear of an accident : " Well, that would never happen to me ; I would never do a silly thing like that." The fact that virtually all the machinery supplied to farmers since before the war has been supplied without guards has tended to make both employer and worker think that it is reasonable to accept it as it is, and dangerous working conditions have become accepted as normal. The very presence of a guard tends to awaken an awareness to the fact that danger exists nad by making the worker think goes a long way towards increasing safety.

Fatal accidents present a very different problem, in that tractors and machinery are responsible for 70 per cent. and tractors overturning are the biggest individual cause. There is no doubt that it is often a matter of sheer luck that many accidents are near-misses and not fatals. If a power take-off shaft gets hold of you it is to be hoped that your clothing is rotten—you may be stripped naked, but in consequence you may live.

I know of one case where a man was pinned for less than 20 minutes under a tractor, uninjured—not even bruised ; but his face was held in about 1½ ins. of water and he drowned.

Such is luck, and all I can say is that it is not worth risking. Many people take the view that negligence and carelessness are a big factor in most of these accidents. This is a point of view with which I cannot entirely agree. If the working conditions are dangerous, then we have a responsibility either to so train the workers that they can cope with the dangerous circumstances, or look very carefully at the equipment they are using to see whether or not it can be re-designed to eliminate the danger.

Much of the lead in accident prevention should come from the management side of agriculture. It is widely accepted in industry, and until it is taken up in agriculture the reduction of accidents will only proceed slowly. Positive action on the employers' side is a very big factor indeed. The individuals concerned—those who are injured—still have to take more care ; to encourage them to do this, we need more education, publicity and better supervision. Far too often the instruction books for machinery are kept in the back of the farmer's desk and not in the hands of the operator, and too few of these instruction books contain anything on the safe use of the machine concerned. In the past, very little attempt has been made to give adequate training with new machinery, although this has improved recently. Last, but by no means least, I would put compliance with safety regulations. The regulations are designed to prevent accidents. This is the only reason for their existence. I will illustrate some of the points of these regulations by means of slides.

II "THE PART PLAYED BY THE AGRICULTURAL INDUSTRY"

by R. M. CHAMBERS, B.Sc., B.Agr., M.I., Agr.E.

KNOWLEDGE of the appalling loss to agriculture by death and by non-fatal accidents lead the Institution of Agricultural Engineers to prepare a survey about 1953. This was carried out mainly in Norfolk. It can, I believe, be considered as the first real attempt to bring to the notice of all concerned that accidents don't "just happen"—they are, in fact, "caused."

That they are caused by a number of circumstances which in total add up to a fatality, a serious injury, or just a sprained ligament or minor scratch lead to an analysis of these circumstances. The outcome of these observations and reports by official committees was an Act of Parliament which *enabled* various Safety Regulations to be made. Everyone hopes that by virtue of these the tremendous losses of operation time of skilled workers, managers and owners will be reduced. Unless the Regulations do reduce the fatalities, the maiming and the trivial injury, the Regulations should be amended—we all recognise that it is virtually impossible to legislate for fools, let alone crazy fools !

I am expected to record what the Agricultural Machinery Industry is doing to assist in Farm Safety. I hope to be able to show that we are all conscious of the need to reduce to a minimum all time and life loss on the farm. We are very conscious that some 20,000 regular farm workers leave the land each year ; we are equally conscious that some 20,000 acres of good agricultural land are lost by the U.K. farmers each year—it goes to roads, schools, playing fields, housing estates, industrial development, etc. ; and we feel strongly that U.K. agriculture must be helped to produce more food. Can it be done ? More food from fewer acres by fewer workers ! What a wonderful challenge to all who live on the land and all who help them by way of new varieties of crops, more efficient livestock, new chemicals for weed, pest and fungus control, and new fertilisers to boost the yields. A challenge also to the agricultural engineer to produce machines to help in this task. But the machines must be simple, trouble-free and *not* accident prone. Any agricultural engineer worth his salt is conscious of the need for safety. This is probably the first requirement in equipment if the cry of greater production is to be heard and fully acted upon.

Now, I am not a "legal type," so I cannot asy if the Agriculture (Safety, Health and Welfare) Act of 1956 is unique ; whether or not it is is not very important, but the main points I want to highlight are that while the Act is an enabling Act permitting certain Ministries of the Crown to make Regulations for farm safety, the Minister can only do so after

(*a*) Consulting those organisations which are interested in the proposals that would be written into the Regulations, and

(*b*) the proposed Regulations have been not only tabled in both Houses of Parliament, but *have also* been verbally presented and an opportunity given for debate and finally approved by vote.

If we take these two points, we shall, I hope, see how the Agricultural Engineering Industry fits into the various schemes to improve safety on the farm.

The Agricultural Engineers' Association formed a safety panel and were, in due course, consulted by the Ministry of Agriculture. The Ministry's proposals were not accepted in full ; for example, the original proposals suggested that the manufacturer and the dealer should be responsible to see that the machines were properly guarded. This raised all sorts of problems which need not be dealt with here. The Ministry eventually agreed that the responsibility for compliance with the first batch of Regulations should fall fairly and squarely on the farmer and his employee.

You may well say this would be a bit hard on some owners if the manufacturer could not, or did not, try to make provision for guarding the machinery he was selling. The obvious answer is that if the manufacturer didn't provide guards he wouldn't sell machinery, so manufacturers accepted it as a moral obligation to provide adequate guarding.

The Ministry have always been very willing to discuss the proposed regulations with the trade—manufacturers, dealers, contractors and users—and when doubts were expressed by any of the various interested bodies the Ministry readily agreed to "have another look" at the proposals. That is good news. Obviously, any regulation must be enforceable, and to be enforceable it must be reasonable.

Every opportunity was taken to point out the folly of the proposals, with the knowledge that at least two other, and probably more, interested organisations were also badgering the Ministry for change in the proposals. Some would want an early effective date, others would want responsibility to be put on to different shoulders, and so on. With design problems to be overcome, then tools for manufacture to be made and material to be ordered and delivered, there was no point, for example, in putting an operation date too near the final Parliamentary approval of the draft Regulations. Very little work can be done before this approval, though agricultural engineers do make intelligent guesses after reading the draft proposals.

With scarcity of skilled engineers, there were grave doubts whether the operation of new regulations on more than one type of machine at a time could be achieved. Would the proposals be really effective ? If not, there is no point in making them. Would something simpler than the proposals implied be suitable ? If so, there would be all-round savings in design and production expense and in the time factor.

All these, and many other points, were considered, and in addition Ministry of Agriculture staff were invited to the manufacturers' premises to discuss current and projected machines from the safety angle ; there has been, I am glad to say, always a good measure of friendly argument—plenty to give and take on both sides.

Of course, all this guarding of machines will cost a fair bit in hard-won cash, and the cost will have to be carried through to the customer. No one regrets this more than the manufacturer, who, with his agents, really makes only a nominal profit on the guarding to be fitted.

I have only time to detail briefly some of the other things manufacturers are doing in connection with the Farm Safety Regulations. Bearing in mind that much of the U.K. produced agricultural machinery is exported, we hafe continually pressed the Ministry of Agriculture to bear the Regulations of other countries in mind when drafting new Regulations for U.K. We have not succeeded very well, for the overseas Regulations are so varied that it would be impossible, at this stage, to meet them all and still remain competitive against other countries. I believe we have highlighted the urgent need for some rationalisation and that a conference at high level should be arranged to come to an understanding on what the future has in store for us and the overseas manufacturers. It must be just as wrong to kill someone in Africa by bad guarding as it is in Northumberland—yet unless some International agreement is reached the unscrupulous manufacturer in U.K., U.S.A., Europe or Asia would be sure to send equipment to the importing countries stripped of all the guards which we in the U.K. deem to be necessary.

That was a rather longer explanation than I intended, but it was an important point.

Each manufacturer in the Agricultural Engineering Industry receives reports from the Ministry of Agriculture on any non-fatal, and some fatal, accidents to workers using their machines or equipment where design or construction could be considered as contributing causes. Considerable attention is paid to these reports, and even if the accident appears to have been caused by operator trouble, every effort will be made to prevent such trouble again.

Apart from all the points I have so far made, I must in fairness to all agricultural engineers pinpoint some of the ways machinery has been made safer over the past 20 years.

One firm produced a tractor on which the self-starter can only be used when the gears are in neutral—a considerable contribution to safety.

Brakes are continually being improved, though the need for better brakes is not so obvious while the maximum speed is kept to about 14 m.p.h.

Unification of controls between tractors of the same make has helped to give drivers the necessary confidence when changing from one size to another.

The three-point linkage of equipment has contributed tremendously to machine safety.

Automatic hitch for trailers means that one man can do the job from his safe place on the tractor seat.

Standardisation of nut and bolt sizes, and unification of threads, go a long way towards greater safety. Eventually, when all machinery is fitted similarly and when the stock of old nuts and bolts on the farms have found a warm resting place in the furnaces of the steel industry, the contribution to safety will be more noticeable. At present the contribution is only a tickle—but it is a beginning.

The use of one spanner or, at most, two would prevent a lot of superficial human injury.

Better tyres and better traction methods add to machine safety.

Use of universal oils must contribute to better machine use, and therefore safety.

Engineers are rapidly approaching the point where most of their designs have bearings which are sealed for a season, if not sealed for life—and long life at that.

Development of the Diesel engine for agricultural use has undoubtedly reduced the fire hazard—the fuel is less liable to burst into flame and the exhaust runs cooler than petrol and V.O.

One firm has developed an electronic device to stop Diesel-engined tractors working on side land ground before they reach the roll angle. The same device stops the engine in time to keep a tractor from turning over backwards—a not infrequent happening when fools attach ropes to the top link connection and hope to pull even a moderate load.

Use of the combine harvester, since each is normally operated by one or two people only, must have reduced materially the accidents which were occurring with stationary threshing machines. Use of the spare screens, to cover up otherwise danger points, has a lot to commend it.

Pick-up balers provide a much safer machine than stationary balers ; again, the fact that they are one-man operated and that their efficiency has been improved so much must be given the credit points for safety. There are, however, still far too many accidents with balers, and more built-in safety will be required in the future.

The seats on tractors, and other machines, have been improved and contribute to the spirit of the 1956 Safety, Health and Welfare Act. Some further improvement should be looked for.

Now I should be the last to say the goal has been reached. It has not—by a long way. The future engineer must eliminate quite a few hazzards ; among them I would mention removal of sharp corners and rough edges on machine framework. For example, some companies carry out an extra operation on all struts and frames to put a " radius trim " on all edges. The machine will cost more, but the safety is improved.

Further, all " nip points "—even those remote from the operator—must be guarded. Intermittent motion of any component makes it a real hazard, and the need for a guard on this type of point is, I believe, even more important than anything with continuous motion.

Engineers must be able to visualise all danger points and reduce the risk as much as practicable ; then, I suggest, a mark by some distinguishing emblem should indicate that there is danger. We note that some countries already use a danger cross in a circle.

All switches should be clearly marked to show—not by letters like " S," which may mean " start " or " stop " —how the machine should be stopped, a far more important thing in case of an accident than how it can be started ! All valves, especially hydraulic, should show clearly—there must be no mistaking it—how to turn for " off " or " on."

Any left-hand thread should be very clearly marked. Instruction books must not withhold danger warnings, and farmers must see that their operators have a chance to read and re-read the instruction books.

Long belts and short ones are a source of danger ; belt guarding should be adequate, and guards should not have sharp edges.

Standardisation of quality—research into new techniques, large expenditure on field testing of all new equipment, field-to-factory reporting of all defects, whether within warranty or not, are all functions encouraged by the bigger and better manufacturers and all assist in producing machines which are safer than they were in the past.

The list is inexhaustible, but no matter what the Agricultural Industry does in the end, safety is a matter of the state of mind of the operator. A man who concentrates on the job in hand and not on his football pools, the forthcoming dance, or the row with his boss or wife, is more likely to come through his career as farmer or farm worker without serious injury. But on average, unless care is taken, every farmer and farm worker is due to have one " notifiable " accident in 40 years of farm work. Put another way, there are on average 80 accidents per day in farm work. Farm worker, farmer and agricultural engineer have a joint hazzard-reducing responsibility.

Safety is really a case of avoiding the operation of Murphy's Law—" If a thing can be done wrongly, sooner or later it will."

I hope this Paper has gone far enough to show you all that the Agricultural Engineering Industry is fully aware of the importance of building safe machines, yet alive to the need for economical but effective guarding. Further, that the incidence of accident and death through violence on the farm must be reduced. Agricultural engineers will play their part—an important part—in creating this greater measure of " Safety on the Farm."

RELIEF OF INCOME TAX ON SUBSCRIPTIONS

THE attention of new members is drawn to the following copy of a letter from the Senior Principal Inspector of Taxes. It will be seen that those to whom it applies should ask for Form P358 from their Inspector Taxes and complete and return it to him as soon as possible.

Copy of a Letter received from the Chief Inspector of Taxes—Branch, Inland Revenue

Ref. : CI/SUB/182.

October 8th, 1958.

DEAR SIR,

I have to inform you that the Commissioners of Inland Revenue have approved THE INSTITUTION OF AGRICULTURAL ENGINEERS for the purposes of Section 16, Finance Act, 1958, and that the whole of the annual subscription paid by a member who qualifies for relief under that Section will be allowable as a deduction from his emoluments assessable to income tax under Schedule E. If any material relevant change in the circumstances of the Society should occur in the future, you are requested to notify this office.

I should be glad if you would inform your members as soon as possible of the approval of the Society. The circumstances and manner in which they may make claims to income tax relief are described in the following paragraphs, the substance of which you may care to pass on to your members.

Commencing with the year to 5th April, 1959, a member who is an office holder or employee is entitled to a deduction from the amount of his emoluments assessable to income tax under Schedule E of the whole of his annual subscription to the Society, *provided that*—

(*a*) the subscription is defrayed out of the emoluments of the office or employment, and

(*b*) the activities of the Society so far as they are directed to all or any of the following objects :

(i) the advancement or spreading of knowledge (whether generally or among persons belonging to the same or similar professions or occupying the same or similar positions) ;

(ii) the maintenance or improvement of standards of conduct and competence among members of any profession ;

(iii) the indemnification or protection of members of any profession against claims in respect of liabilities incurred by them in the exercise of their profession ;

are relevant to the office or employment—that is to say, the performance of the duties of the office or employment is directly affected by the knowledge concerned or involves the exercise of the profession concerned.

A member of the Society who is entitled to the relief should apply to his tax office as soon as possible after 31st October, 1958, for Form P358 on which to make a claim for adjustment of his pay as you earn coding.

Yours faithfully,

(Signed) T. DUNSMORE,
Senior Principal Inspector of Taxes.

The Secretary,
Institution of Agricultural Engineers.

THE CHOICE OF A SPRAYER

by R. J. COURSHEE*

A Paper presented at a Meeting of the East-Midlands Branch on 22nd March, 1961.

Introduction

A SMALL team at the N.I.A.E. is concerned with finding out how best to apply different chemicals to crops. I should like to illustrate the way in which we work with plant protection machines by discussing the example of potato blight. We have worked for some time on this, so we can call on our own evidence. There is also the evidence obtained by the several biological teams concerned with this disease. It is a relatively complex example which illustrates many of the factors which play a part.

The definition of a best method is the one providing the greatest economic advantage through the attempt to control the pest or disease. Clearly, the fungicide which is used plays an important part. But we are concerned only with the machines to apply the chemical, and so for simplicity we have used only one, copper oxychloride, and measured how this performs when applied by different machines.

Yield Rise due to Blight Control

Large[1] (1958) has estimated the loss of crop which results when blight kills a potato crop at different stages of its development. He also shows that good, commercial spraying prolongs tuber development for some two weeks, and the yield rises correspondingly.

Poor spraying or particularly severe conditions reduce this two weeks to say a week (or less sometimes, as some farmers know to their cost). Very effective spraying or dusting might increase the extra period of growth to, say, four weeks. Then we can prepare a table of yield improvement which would be expected on average for (*a*) poor spraying, (*b*) good commercial spraying and (*c*) the best that we might attain (and has been attained).

Table I shows the credit side of the operation.

Table I
Percentage Rise in Yield through Delaying Blight (measured as percentage of the full crop obtained where there was no blight).

Date when blight has destroyed the plants on unsprayed plots	*Crop loss with no treatment*	*Loss regained by blight control for delay in blight attack of*		
		(*a*) 1 *week*	(*b*) 2 *weeks*	(*c*) 4 *weeks*
July 31	50%	12%	22%	37%
Aug. 15	28%	8%	15%	24%
Aug. 31	13%	6%	9%	13%
Sept. 15	4%	3%	4%	4%
Sept. 30	0%	0%	0%	0%

On the debit side there are the several costs of the work—chemicals, labour, machinery and wheel damage. In total, these are equivalent to about 5 per cent. of a full crop.

With Large's data it is possible to see how very important it is to test the biological performance of a spraying machine (and a given fungicide) in order to say whether or not it is a valuable one. Four weeks' delay in blight from an effective sprayer is so important in a blighty area compared with two weeks' delay as to outweigh any probable extra cost of the more thorough work. Accordingly, disease control has to remain the primary measurement of this work, even though it is agricultural engineering, and we have concentrated on this aspect recently.

Measuring Disease Control

Field scale measurements of blight control are difficult and expensive. Such results as there are[2] show that the differences between machines cannot be detected easily. This is quite surprising in view of the apparently large physical differences between the performances of various machines.

Miss Kerssen's results suggest that these physical differences have a negligible influence on the biological endpoint of the application of the fungicide.

One feature of field experiments is that normally no control can be obtained over the incidence or distribution of the infecting agent ; that is, the innoculum potential is uncertain and erratic. Consequently, greater replication of the experiment is needed, and this introduces still further sources of variability, and such experiments usually have a low precision.

The physical performance of many field machines is also notoriously dependent upon weather and travelling conditions. In all, it seemed unlikely to us that we could gain an understanding of the process of blight control by working in the field, and so we turned to laboratory experiments.

Laboratory Experiments

McCallan and Miller[3] have shown that blight spores are killed by very tiny traces of copper amongst other fungicides. Therefore, one would presume that a complete but light spray cover on all the leaves must give 100 per cent. control and that a less complete cover would probably give a less complete control. Poor cover from an ineffective machine might be a reason for its ineffectiveness, although it has not been proved in the field yet that sparse cover does lead to poor control over blight.

We studied this point by spraying King Edward plants in polythene bags in the laboratory in such a manner that the spray cover before redistribution varied in the range 1 to 25 per cent.[4] We did this with fine, medium and coarse spray and used the equivalent of 1 gallon an

* *National Institute of Agricultural Engineering.*

acre up to 150 gallons an acre, with the fungicide concentration varied in inverse proportion to the volume of spray applied.

Afterwards, the sprayed and unsprayed plants were infected with a spray of blight spores and stored in a plastic greenhouse. The disease—*i.e.*, number of lesions on the differently treated plants—was assessed, with the result in Table II :

Table II

Spray Cover	*Disease Control*
1%	6%
5%	9%
25%	27%

About half the leaflets became infected on the unsprayed plants.

So we get the result—the better the cover the greater the control, as one might have expected in the absence of redistribution. These results are in accord with part of the results from a Swedish experiment done in a similar way.[5]

These results are interesting, but the following criticisms of them were made. Firstly, there was no rain and no redistribution of the fungicide. Secondly, the infection was applied artificially ; and thirdly, we did not use field scale spraying machines.

Combined Laboratory–Field Trials

Therefore, we contrived to produce a method to overcome these objections and still avoid the difficulty associated with full-scale field trials.

Again, potted King Edward plants were taken and placed in a field of nearly mature King Edwards just before it was sprayed by a field sprayer. Immediately afterwards, the sprayed plants and other unsprayed plants were taken and placed in a nearby blighty field for a night in a position where they were surrounded by plants bearing blight lesions. On one occasion a little rain fell during this night. Sprayed and unsprayed plants were then placed in a glasshouse and the infections resulting from the one night exposure to the disease were counted some six days later. Other plants, similarly sprayed or unsprayed, were also given laboratory infections. So we have natural rain, reliable and regular infection which was natural or artificial, and real machines, and so probably the results are related to one phase of practical field spraying. Examples from results obtained so far are given in Table III.

Table III
Disease Control with Different Field Machines

Machine and Treatment	*Field Infection*	*Laboratory Infection*
	Disease control relative to corresponding unsprayed plants	
Mistblower at 6 gals. an acre	49% (Rain)	38% (Dew)
Sprayer at 60 gals. an acre	26% (Rain)	46% (Dew)
Drop-leg sprayer at 100 gals. an acre	No record	65% (Dew)

The control over laboratory infection here was rather better than the previous laboratory results. This could indicate that field spraying was better than our laboratory spraying. I am fairly sure, however, that the reason for the improvement over the results of Table II shown in Table III lay in a heavy dew falling on the plants in the laboratory during the later trial, and this acted like rain and redistributed the copper. Laboratory and field results in this experiment are not significantly different from each other.

Although equal amounts of copper were applied in all treatments, differing fractions were wasted through drift and run off. We have not yet attempted in the example of potato blight to take account of and allow for these differences, although they are another aspect affecting the efficiencies of the various sprayers.

Thus we have only a limited number of results of low accuracy so far and we are in no position to conclude the study. It is being extended this year (1961) to include aeroplanes and dusting machines. Also we now have a rain machine for studying retention and redistribution and the effect of these on the control over the disease.

Despite this incompleteness at this stage, it is necessary to discuss the practical interpretation of such results as we have.

Interpretation

A. Biological.

The innoculum potential in a field is dependent upon a number of factors which may well vary in importance with different methods of applying both the fungicide and the fungus. Here we have so far used only one method of applying the fungus—as a coarse aerosol on to slightly damp leaves both in the laboratory and in the field. Quite different results might be obtained with rain-borne disease spores. This restricts the applicability of the results.

However, they still do indicate the effect of spraying in reducing the number of successful infections during one bout of infection ; that is, under conditions where unsprayed plants suffer 100 new infections, sprayed plants would suffer between 35 and 74 new infections, according to the results of Table III.

Consequently, if this difference perseveres through several periods of infection the unsprayed plants would rapidly become widely infected and the sprayed plants would lag further and further behind them. Eventually, the unsprayed plants would be killed and the sprayed plants would then require a further period for the disease development on them to catch up. This is the delay in blight development which affects the yield loss (Table I).

Consider the simple compound interest curve of blight development :

$$du = ku\,dt \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where du is a measure of the number of new infections in time dt in a crop, and where u is a measure of the number of infections already present in it. This is a simplification of the fuller expression referred to by Large[6] :

$$du = ku\,(1 - u)dt.$$

k is a constant for given conditions and is a measure of the rate of self-propagation of the disease. In our experiments the spores were supplied from external sources rather than from within the treated crop. Nevertheless, the numbers of resulting disease lesions which we measured were also a measure of the several multiplication factors for the differently treated plants. If the multiplication factor had a value k on unsprayed plants, it was reduced to 0·35k on those which were well sprayed and to 0·74k on those not quite so well sprayed. So the rate at which the disease multiplies is reduced by spraying and consequently the build-up to dangerous levels is delayed. So we need the relationship between this delay in build-up and the various values of the multiplication constant.

Equation (1) has the solution :

$$u = u_o e^{kt}$$

where u_o is the initial number of infection sources present. Therefore, the time taken for the disease to build up to a final level u at which tuber development ceases is given by :

$$T = \frac{1}{k} \log_e \frac{u}{U_o} \qquad . \quad . \quad . \quad . \quad . \quad (2)$$

Thus the time required is inversely proportional to the multiplication constant. It takes some eleven days for unsprayed plants to go from the level 1 per cent. blight to 50 per cent. under conditions favouring disease development.[6] Under the same conditions, the sprayed plants should take from 15 to 30 days to cover the same course. A method of spraying which gives twice as good a control as another in our type of test will probably cause the disease to take twice as long to develop from similar initial conditions to the same final conditions. This is also a simplification of one aspect of the process of disease propagation through the field. It does, however, suggest how the figures which we obtain with a single bout of infection might be translated into more practical terms for the continuous and frequent infections which occur in the field. But there is one important reservation to make.

This discussion presumes that the role of the fungicide in this example is to foil new infections, and the measurement we make is of the success of the fungicide in doing this. However, there is the possibility that the fungicide has other equally important roles to play—*e.g.*, in preventing the formation of new viable spores by existing infections. The machine used to apply the fungicide might affect this latter process in ways which differ from the effect that the machine has on controlling infection from viable spores originating from somewhere outside the sprayed field. We have not yet measured the effect that different machines have on the amount of infection which originates from a primary disease focus within the sprayed field, but we hope to do so shortly.

B. Mechanical.

We wish to know that one type of machine is better than another, but more importantly we should like to know why it is better. The drop-leg sprayer performs best in this test. Unfortunately, this was using Bordeaux, whereas the other machines were using copper oxychloride, so no comparison between machines is significant.

However, it is worth recording that the superior effect of the drop-leg sprayer might have been due to the nearly complete spray cover given by it. It will be remembered from Table II that greater cover lead to better control against spores applied as an aerosol.

The cover obtained with the drop-leg sprayer was recorded visually with a fluorescent tracer, Saturn Yellow, and it was found that 82 per cent. of the upper sides of the leaves were " well " sprayed—the criterion of well sprayed is subjective and arbitrary in this context. On the other hand, only 23 per cent. of the undersides were well sprayed. The other machines sprayed the undersides of the leaves to a negligible extent.

Although underleaf cover has been presumed to be important in the past, it is now largely ignored in commercial practice. Bjorling[6] has shown how most of the spores arrive on the upper surface of the leaves and how, despite the more favourable environment beneath the leaves, the incidence of infection was some seven times greater on the upper surface in his experiments.

Furthermore, Hirst's data[7] on the spore content of the air suggest that rain washes spores from the air nearly completely. One might infer, therefore, that the arrival of spores on the leaf is dependent upon rain whenever the spores are airborne and arise outside the sprayed field. Accordingly, redistribution of the spray chemical may play an important part on controlling such primary infection, whereas the complete spray over obtained with drop legs may be of more value against secondary infection from sources within the sprayed field when aerosol infection might predominate. It will be remembered that all our tests used infective material in the form of an aerosol. We have not yet tested the effect of rain-borne infection or of aerosol infection on to a deposit which has previously been redistributed by rainfall.

Accordingly, the interpretation of the limited results obtained so far cannot be complete enough to warrant any practical suggestions for spraying. We do feel, however, that we may be gaining an understanding of the processes whereby the initial infection and its subsequent multiplication are limited by various types of spraying machine. This should eventually provide us with pointers towards the best machines to use.

Costs

The various costs of the work have to be placed on the debit side of the balance sheet.

By means of a number of assumptions on work rates, labour requirements, machine maintenance and depreciation, and by reference to contract prices for work and to the price of chemicals, it is possible to prepare Table V showing the approximate costs to be put against the spraying for two applications.

The wheel damage figure of 3 per cent. is an average taken from Large's Paper[1]. Aeroplanes are thus 3 per cent. or so better off in any comparative trials. It would be reasonable to expect that a lightweight duster on narrow tyres causes less damage than a sprayer, but no figures are available for this.

Table IV
Costs of Treatment as Percentage of £150 per acre Crop

	Application Costs— Labour and Machine	*Wheel Damage, 10-row boom*	*Chemical Costs*
Dusting	0·4	3	1·3
Low volume spray	0·8	3	1·3
High volume spray	1·6	3	1·3
Aeroplane	2·6	–	1·3

The main point from Table IV is that, allowing for the boom damage, aeroplane spraying is the lowest-priced treatment. It is therefore quite essential to be certain about this figure of 3 per cent., which, of course, varies with boom length and the stage of the crop. I should also like to know much more about the affect of boom and wheel damage on both the real and apparent incidence of blight. These figures must surely change our views about aerial spraying, which is normally criticised on the grounds of high cost.

Apart from the boom damage, the costs of different treatments are not dissimilar—about 5 per cent. of the crop gross value, and Table I can now be reconstructed to show the net rise in yield which can be expected.

Table V
Net Improvement in Percentage Yield from Spraying

Date when blight destroys the plants in unsprayed plots	*Loss without treatment*	*Delay in blight attack*		
		1 week	*2 weeks*	*4 weeks*
July 31	50%	7	17	32
Aug. 18	28%	3	10	19
Aug. 31	13%	1	4	8
Sept. 15	4%	−2	−1	−1
Sept. 30	0%	−5	−5	−5

This form of table makes effective spraying seem very much more valuable—twice as valuable as average good spraying.

The only question is—which spraying or dusting method and which formulation of which spray chemical gives the four weeks' delay and which gives only one week's delay ? One hundred gallons an acre at 100 p.s.i. may tend towards the larger figure when using copper as a fungicide. But this type of spraying is a little more expensive and slow, so we do not want to do it except where necessary, and specially effective spraying is necessary only in early seasons of blight. (I must emphasise that we have no data yet on dusting or aeroplane spraying in the present series of tests, or on alternative chemicals or, most importantly, against the rain-borne phase of the infection. So we have a long way to go yet.)

Unreliability

I shall not attempt to even mention most of the factors which are more difficult to fit into a balance sheet, but timing must be considered. Dr. Storey's results[9] indicate the very high importance of timing the application accurately. This need to apply the spray at the moment when it is required raises the question of speed of work, and also the question of the form of the contract arrangement between the farmer and the contractor, particularly the air spray contractor. In blighty weather, it is sure that many farmers will ask for spraying to be done simultaneously. To avoid this difficulty, a regular spraying cycle seems to be called for so that the contractor can plan ahead and promise dates, providing the weather stays fine. This weather factor, in turn, leads to the need for an aircraft which can work in all weather and for ground machines which can keep going when the soil is softened by rain.

A good machine might be one which can get round the whole farm in not much more than a day in any weather. The dusters are accordingly good, aeroplanes and mist-blowers a little more doubtful, but they all have the advantage of covering the ground quickly as soon as a warning is given. With a large acreage to do, the large volume sprays may be too slow unless a frequent routine application is made all over the farm. This appears to be the present practice in Holland, for example, but it does not appear to have been economically justifiable on a wide scale in England.

Conclusions

I should like to recapitulate on the main points of this essay and on the conclusions which are justifiable at present.

1. We have first to fit the machine to the job and to the quality of work demanded of it. In areas where blight is early, the machine which provides longest protection is valuable almost irrespective of its cost. In areas where blight comes infrequently or late, superlative protection is unnecessary, and the best machine may be the cheapest one which gives a week or two delay.

2. I think it is very difficult to get answers from field scale experiments on blight unless you are prepared to provide a uniform infection equally to all the plots. So we turned to semi-field scale measurements and have this to say about our results. The most effective machine in our sort of test will probably also be the most effective machine for field work, but we cannot yet translate our figures into a prediction of the blight build-up.

3. The evidence from the semi-field test is also far from complete, and we should like to examine other types of machine and re-examine them all in the early stages of a blight epidemic. However, the machine which held off blight best in the test so far was a sprayer fitted with drop legs and four atomiser nozzles per row, and it put on Bordeaux at 100 g.p.a. and 100 p.s.i. Also, the laboratory results show that, without rain, disease control was proportional to spray cover in the example. On the occasions when infection occurs without rain falling, a dense spray cover is therefore necessary when using a contact fungicide.

4. Apt timing of the spraying is probably necessary, and so a machine which can cover the ground quickly will be better for some people's requirements than a machine which is effective when it is on time, but too slow to be on time always. The natural aim of the work is to find out which type of machine is effective and then arrange so that it can work as quickly as is necessary.

5. The cheapest machine is the duster because of its high rate of work, if you discount boom damage, and the aeroplane if you take account of the 3 per cent. crop loss probably occurring through boom damage and

reckon this to be equivalent to a 3 per cent. reduction in gross income. There is a little field evidence available on how good the aeroplane is at keeping blight off, although we have none ourselves. Miss Kerssen[2], for example, shows that they have performed as well as the ground sprayers used in her experiments. The arrival of a systemic fungicide for blight may make the aeroplane as effective as any sprayer as well as the cheapest machine.

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ELECTIONS AND TRANSFERS

Approved by Council at their Meeting on 22nd June, 1961.

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FROM STUDENT TO GRADUATE

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EXAMINATION RESULTS

The 1961 Examinations for the National Diploma in Agricultural Engineering and for membership of the Institution were again held at the Essex Institute of Agriculture, Chelmsford, by kind permission of the Principal, Mr. B. H. Harvey, B.Sc., N.D.A., N.D.D.

NATIONAL DIPLOMA IN AGRICULTURAL ENGINEERING

Second Class Honours	*Centre of Training*
† RUTTERFORD, R. H. (King's Lynn, Norfolk)	Essex Institute of Agriculture.
WAKEHAM, G. F. D. (Deal, Kent)	,, ,,

Passes	
BUXTON, J. R. (Aylesbury, Bucks.)	Private Study Concession.
CARPENTER, J. L., B.Sc. (Doncaster, Yorks.)	King's College, University of Durham.
CATT, W. R. (Tenterden, Kent)	Essex Institute of Agriculture.
DEBATTISTA, J. (Malta, G.C.)	,, ,,
EVANS, D. J., B.Sc. (Penzance, Cornwall) ..	,, ,,
GRAY, H. J. H. (Dingwall, Scotland) ..	West of Scotland Agticultural College.
‡ HALL, A. E. (Doncaster, Yorks.)	Essex Institute of Agriculture.
HELLIER, J. A. (Ripon, Yorks.)	,, ,,
KETTLEBOROUGH, R. (Doncaster, Yorks.) ..	,, ,,
† LEWIS, J. P. (Shrewsbury)	,, ,,
‡ MASON, R. T. C. (Cirencester, Glos.) ..	,, ,,
MUNDY, M. J. (Woking, Surrey)	,, ,,
‡* NAYLOR, K. F. (Kettering, Northants.) ..	,, ,,

* Dunlop Scholarship Winners, 1960/61.
† Shell-Mex & B.P. Bursary Winners, 1960/61.
‡ Intermediate N.D.Agr.E. obtained at N.W. Wiltshire Area College of Further Education.

The Examiners were agreed that the standard of candidates was, in general, higher than that of previous years. There were no " borderline " passes. Although the attainments of the two candidates with the highest marks were impressive, the exceptionally outstanding merit required for the award of the Johnson Medal, last awarded in 1958, was not present, and the Medal will not be awarded this year.

GRADUATE MEMBERSHIP EXAMINATION

Passes	*Centre of Training*
BANKOLE, M. A. (Nigeria)	Chelsea College of Aeronautical Automobile and Agricultural Engineering.
BURTT, N. J. (Welbourn, Lincs.)	Kesteven Farm Institute.
COX, A. A. (Dublin)	Chelsea College of Aeronautical Automobile and Agricultural Engineering.
CRIDLAND, R. A. (Marlborough, Wilts.) ..	Lackham School of Agriculture.
ELWES, E. H. (Cirencester, Glos.)	Lackham School of Agriculture.
HENCHY, J. W. (Kenya)	Essex Institute of Agriculture.
HOLLAND, A. G. (Newcastle, Staffs.) ..	Entered under Regulation 6c.
von KAUFMANN (Kenya)	Chelsea College of Aeronautical, Automobile and Agricultural Engineering.
MACKIE, W. W. (Glasgow)	Entered under Regulation 6c.
MACPHEE, D. C. G. (Milnthorpe, Westmorland)	West of Scotland Agricultural College.
NG, H. H. (Malaya)	Chelsea College of Aeronautical, Automobile and Agricultural Engineering.
ROSS, J. R. (Metheringham, Lincs.)	Entered under Regulation 6c.
SHEPPARD, D. R. (Fordingbridge, Hants.) ..	Lackham School of Agriculture.
THOMAS, K. M. (Codsall, Staffs.)	Harper Adams Agricultural College.
WOODWARD, J. L. (Rayleigh, Essex) ..	Lackham School of Agriculture.

The Examiners expressed their satisfaction at the improved standard of candidates for this examination. There was a higher percentage of passes than in previous years.

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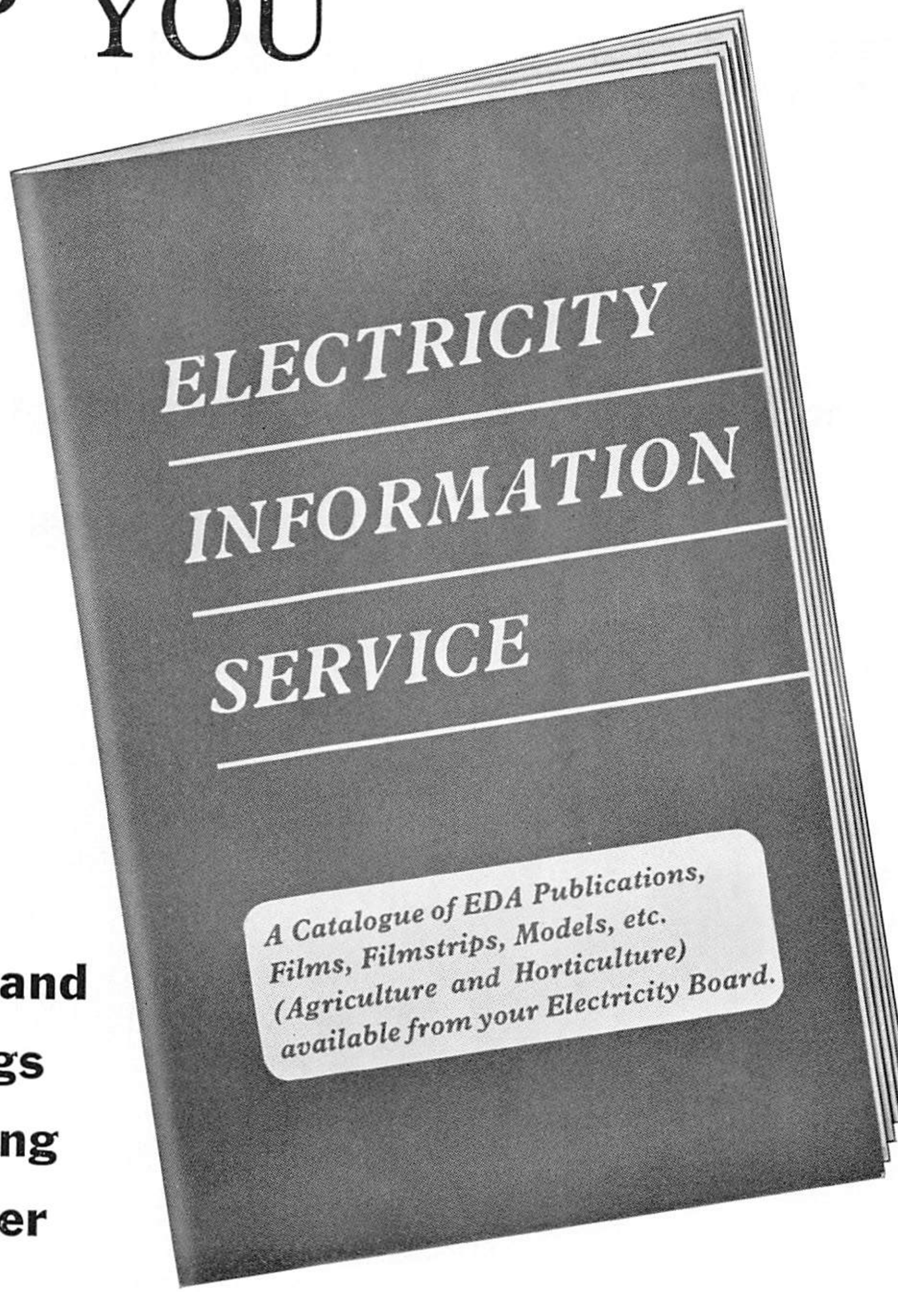

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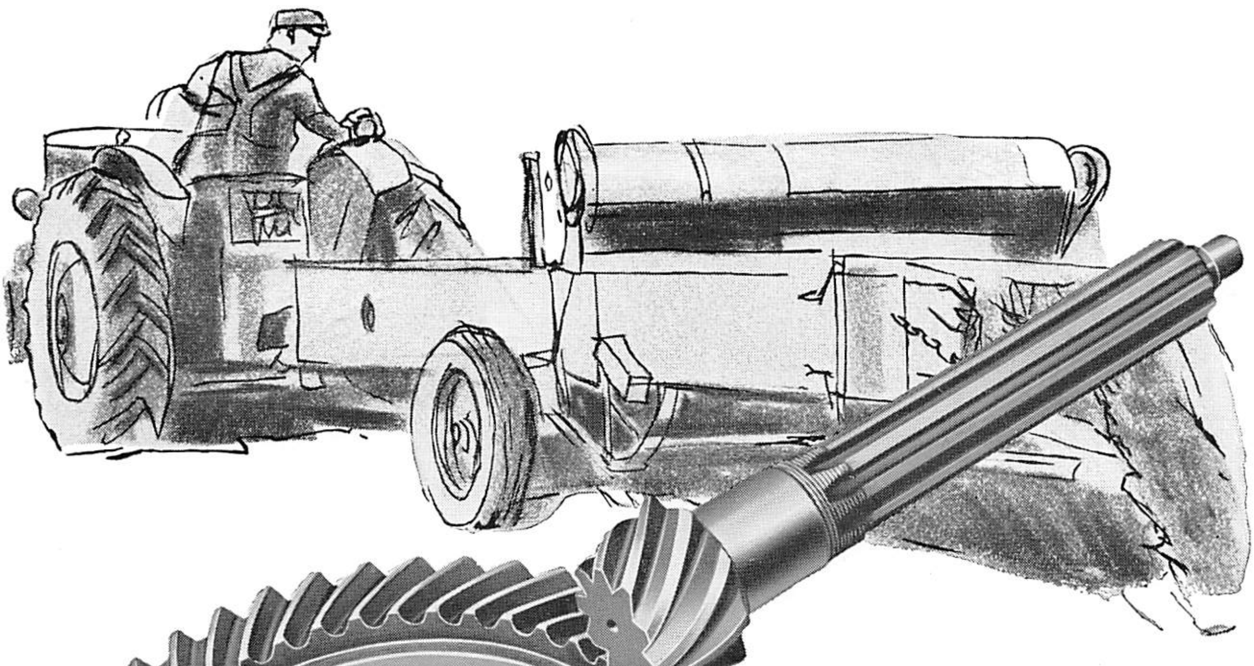

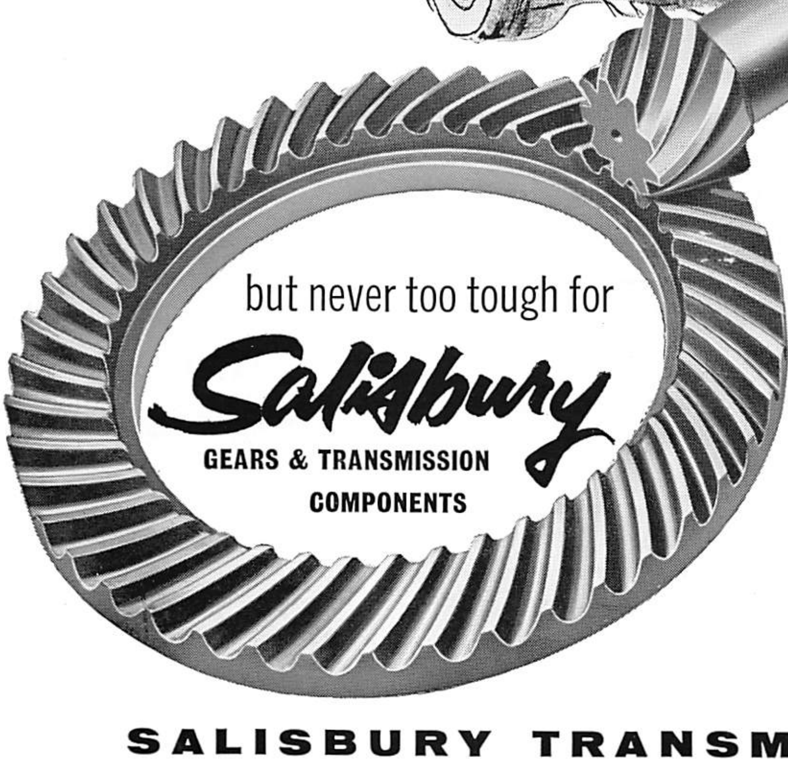

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