JOURNAL AND PROCEEDINGS OF THE

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

VOL. 15 NO. 4 - OCTOBER 1959

From crop drying to pest control electricity can do a thousand things on the farm...

AUTOMATIC HAMMER MILL
BENCH WARMING
BULB FORCING
BARN HAY DRYING
BROODING
CLEAN MILK PRODUCTION
CROP DRYING
CLEANSING PROCESS
DEEP LITTER
EGG PRODUCTION
FARMHOUSE AND COTTAGE
FARM LIGHTING
GRAIN DRYING (IN SILO)
GRAIN DRYING (IN SACK)
GRASS DRYING
GREEN CROP CONSERVATION
GREENHOUSE HEATING
HAY DRYING
HEDGE TRIMMERS
HEN YARDS
HOP DRYING
HORTICULTURE
HOT WATER AND STEAM
INCUBATION
IRRADIATION
LAMPS
LAYING BATTERIES
LAWN MOWERS
MOTORS
PASTEURISING
PIG REARING
PLATFORM GRAIN DRYER
POULTRY HUSBANDRY
PROCESSING

PROPAGATION
REARING
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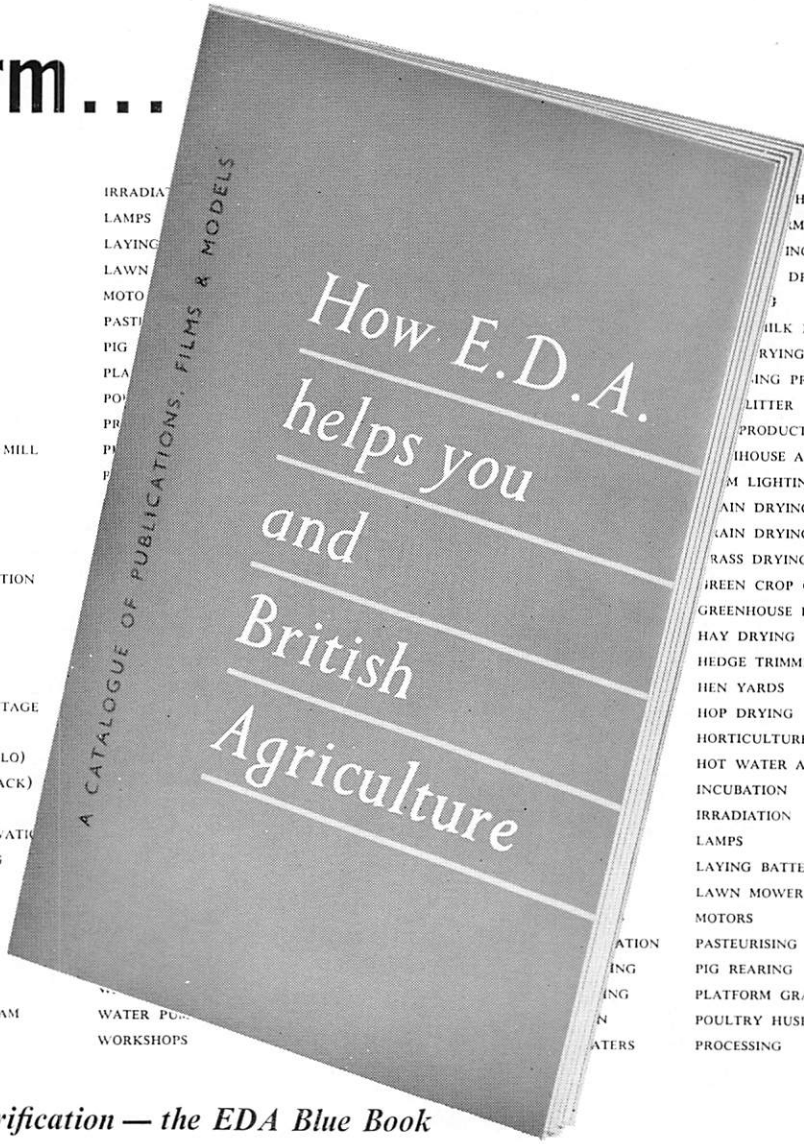

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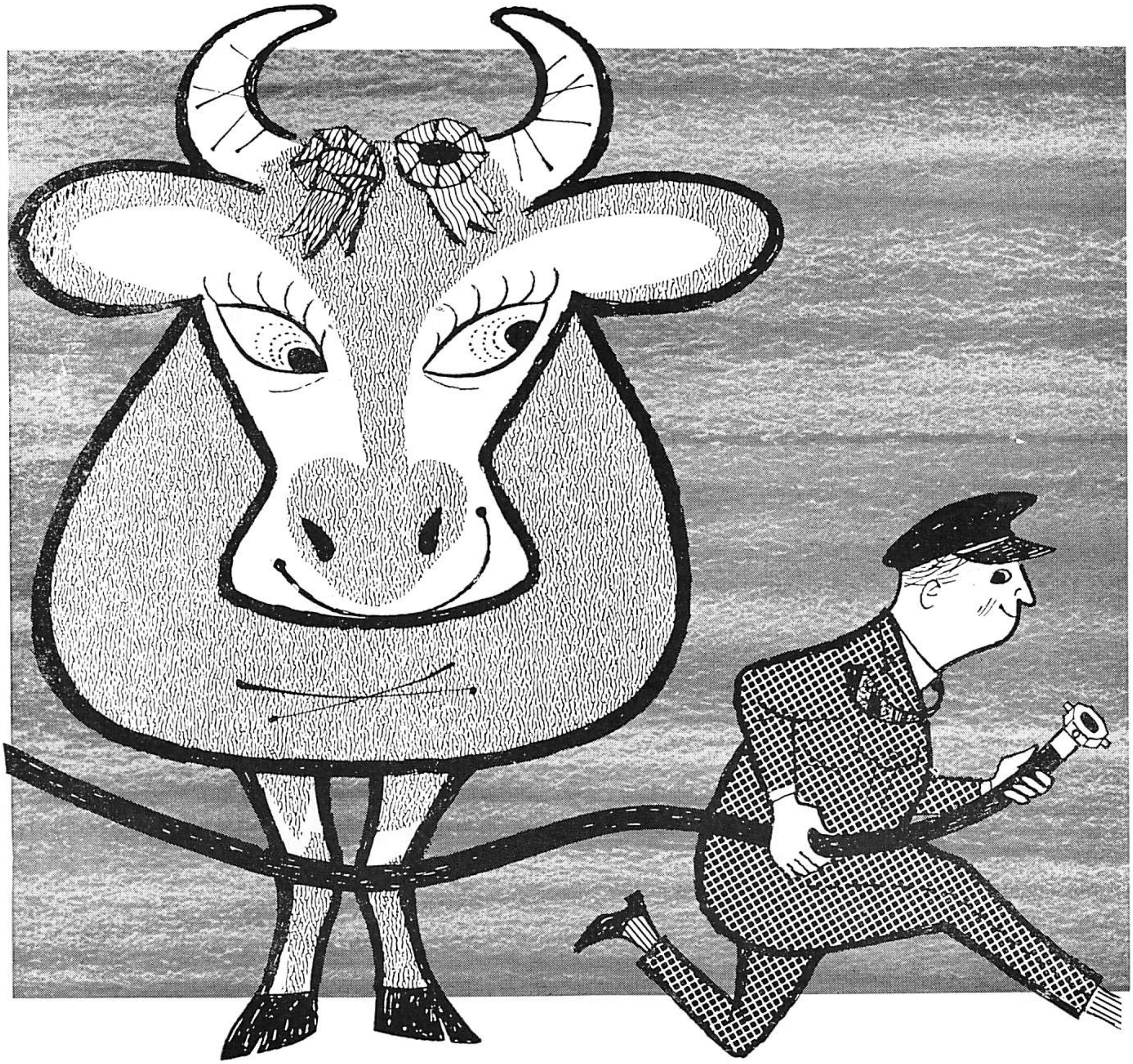

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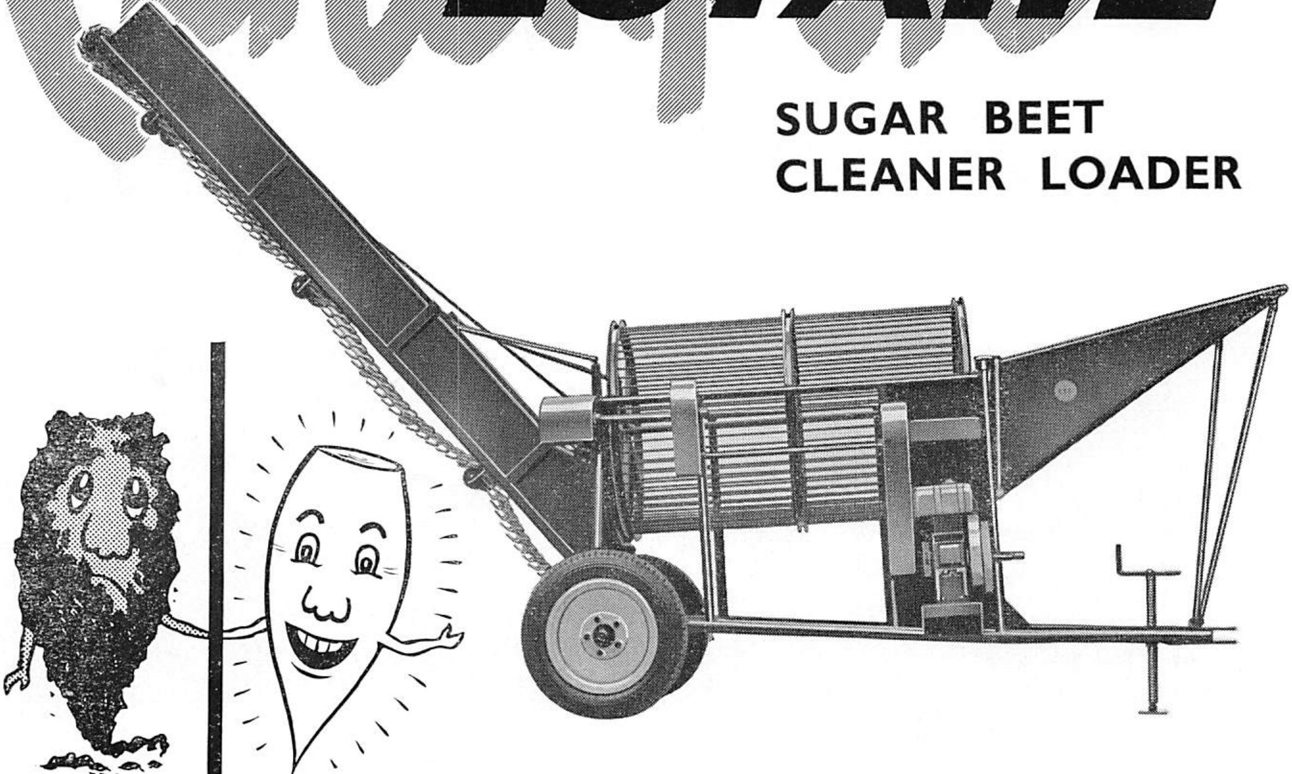

JOURNAL AND PROCEEDINGS OF THE INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

VOLUME 15 - NUMBER 4 - OCTOBER, 1959

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Published by the Institution of British Agricultural Engineers, 6, Queen Square, London, W.C.1
Telephone : Terminus 0140

Price : Ten Shillings and Sixpence — Published Quarterly

INSTITUTION NOTES

The views and opinions expressed in Papers and individual contributions are not necessarily those of the Institution. All Papers in this Journal are the copyright of the Institution.

Title of the Institution

AT an Extraordinary General Meeting of Corporate Members, held on 10th November, 1959, it was decided that the Institution should in future be known as the INSTITUTION OF AGRICULTURAL ENGINEERS. The founders, in 1938, had wished for that title, but were prevented from adopting it because of certain similar titles registered with the Board of Trade at that time. These registrations have now been withdrawn.

Before the Extraordinary General Meeting was held, the views were sought by post of all Corporate Members, at home and overseas, who could not attend the Meeting, and these views were made known at the Meeting before the vote was taken. Of the 430 replies to the questionnaire, 348 were in favour of the change, 64 against, and 18 had no preference. The vote at the Meeting was unanimous.

Membership designations will now be M.I.Agr.E., A.M.I.Agr.E., etc.

The issue of membership certificates has been delayed because of the possibility of the change of title, but a new design is about to be considered and every effort will be made to issue the certificates at an early date.

Subscription payments made on or after 1st January, 1960, should be in the name of the Institution of Agricultural Engineers.

National College of Agricultural Engineering

The first meeting of the Board of Governors of the new College will take place shortly. No further information can be given to members at present, but progress will be reported from time to time in the Journal.

Careers Lectures

Following upon his lecture in London last year, Dr. P. C. J. Payne is to speak at two centres in Scotland on January 8th and 9th, 1960, the meetings being organised by the Scottish Centre. The Council is anxious that this information should be widely disseminated, and asks that members in a position to do so should help the Centre by making known the meetings to young men interested in the industry, and to those who help and advise them.

Portrait of Founder-President

At a recent meeting of the Council, it was proposed that in this anniversary year present and past members of the Council would wish to mark in some way the services of Lt.-Col. Philip Johnson over that whole period of time, and that this might take the form of a portrait. The proposal was welcomed, and an artist has been commissioned. The portrait, when completed, will hang in the Committee room at 6, Queen Square.

The announcement was made by the President at a dinner given by the Council, at which Colonel Johnson was the guest of honour.

Open Meeting at Smithfield Show

Mr. E. S. Bates will present his Paper on "Developments in Tractor Transmission Systems and their Lubrication" at the meeting to be held in the Cromwell Hall, Earls Court, at 3 p.m. on Wednesday, December 9th (during the Smithfield Show). Members requiring a pre-print of this Paper should apply to the Secretary. Tea will be available after the meeting.

PRESIDENTIAL ADDRESS

by W. J. NOLAN, M.Inst.Pet.

Presented at an Open Meeting in London on 13th October, 1959

Introduction

THIS month marks the 21st Anniversary of the Institution of British Agricultural Engineers. Although the Institution had but a small beginning in 1938, it has steadily progressed through the years to the established position of authority and prestige which is acknowledged to-day. This year two events of great significance to the Institution have taken place.

The first was the confirmation of the Institution's professional status by the grant of Incorporation.

The second was the vital part played by the Institution in securing for this country its own College of Agricultural Engineering.

I am particularly pleased to have been a member of the small party present at the original meeting held on the 25th February, 1938, when a scheme for an Institution of Agricultural Engineers was formally proposed, and it is also pleasant to note that those who were present on that occasion are still members. They are : Colonel Johnson, W. Lupton, A. C. Nicholson, Alexander Hay and H. J. Hine.

The growth of the Institution has been due largely to its educational policy. At the birth of our Institution education was rceognised by our founders as being important above all other things to the agricultural engineering industry. The foresight and energy of our founders has had highly beneficial results.

First came the inauguration of the National Diploma in agricultural engineering, and, more recently, the examination for Graduate Membership of the Institution.

A logical development of this recognition of the need for more education facilities is the provision of the College of Agricultural Engineering. It was most appropriate that the announcement was made during this anniversary year.

Another vital factor in our growth has been the formation of local centres throughout the country, to which I should like to refer later, and at this point I would like to take the opportunity of paying a tribute to all members, both at home and overseas, for their strong and continuing loyalty to the Institution. Its strength has grown with their continued support, and, with an increasing membership, the scope of the Institution's activities will be enlarged, to their own benefit and that of the agricultural engineering industry.

From the earliest days (with the exception, of course, of the war years) the Council has endeavoured to present at " Open Meetings " in London, Papers of a high standard covering most of the specialised interests of members, and we are most grateful to the many eminent men who have prepared and presented them.

While much has been done in a comparatively short period, finance has necessarily been a limiting factor, and these early years must be regarded, in a sense, as a period of consolidation.

The Institution anticipates that with an increase in facilities for education in agricultural engineering, which will be provided in particular by the National College, more people will enter the industry and take part in its increasing activity in research and also in the development of new machines. As competition from abroad is increasing, further education and the training of agricultural workers in the efficient handling and maintenance of new machines is doubly important. Only education and training will ensure that new capital investment does produce more food at an economic cost.

The rise in the productivity of our land since pre-war days has been made possible by mechanisation, and I should like to give a brief outline of the activities of the oil industry in agriculture, because the interdependence of these two industries is an asset in the national balance sheet. It is a happy coincidence that I should be given the opportunity to say something about the oil industry in the year it celebrates its centenary.

Historical Achievements

As a prelude, may I make a reference to events in the history of oil that coincided with John Fowler's achievements.

Many of you will recall the John Fowler Memorial Lecture so ably presented by Mr. D. R. Bomford, a Past President of the Institution, in which he paid a tribute " to the memory of a man who, 100 years before (in the early 1850s), successfully applied mechanical power to the land for the first time in the history of the human race." It was about the same time that crude mineral oil was discovered. Until then, the world had relied on vegetable and animal products for any lubricants it required.

The discovery in 1850 by Dr. James Young, a Glasgow chemist, that oil substances could be obtained by the distillation of cannel coals and shales, and the drilling of the first bore hole for crude oil by Col. Drake in Pennsylvania in 1859 laid the foundation of a vast industry. The developments that were to follow were destined to bring about some remarkable changes in our way of life.

To-day, oil and natural gas together provide more than two-fifths of the world's source of energy, and from the latest information it has been estimated that the free world's consumption of petroleum products by agriculture has risen from 5 million tons in 1939 to about 19 million tons in 1958. This increase is due mainly to the growth of mechanisation on farms in North America and in Europe, which, between them, use more than 90 per cent. of the tractors in the free world.

Our agricultural engineering industry has achieved remarkable successes in international markets. Tractors, agricultural machines and implements are being exported to well over 100 markets overseas. The value of the agricultural engineering industry's production, which was approximately £3 million in 1939, had reached £85 million by 1950, and by the end of 1958 it amounted to £142 million, of which expoits accounted for £94 million. What a wonderful record that is.

Oil Industry's Developments

The oil refining industry in the United Kingdom has been expanded rapidly since the war. Oil to-day makes an important contribution in many sectors of Britain's economy, and its productive capacity is geared to meet the increasing needs of British industries. In addition, the oil industry provides a wide variety of products for consumer markets, transport and agriculture.

It is also an important customer of industry itself, particularly in engineering and shipbuilding.

The oil industry's marketing system is so arranged that farms throughout Great Britain, however remotely situated, can obtain deliveries of petroleum products within a very short space of time.

One must not overlook the fact that manufacturers of tractors and implements are themselves big consumers of oil. They require a very wide range of products for use in foundries, for the numerous machining operations and for the protection of their finished production against corrosion whilst in store or in transit to overseas markets.

Consumption of petroleum products by our own agricultural industry was relatively small in the early 1920s, the main off-take being kerosene of lamp oil quality for domestic lighting and heating, as well as for stationary hot bulb ignition engines and tractors.

At that time the advantages of using gasoline were well known, and the effect of the country's taxation policy, storage regulations, etc., led to a demand for engines designed to burn a less volatile fuel.

During the 1930s, British manufacturers developed engines with higher compressions than had formerly been used, and the importation of American and German designed tractors, together with the appearance of crawler-type machines fitted with diesel engines, influenced the country's fuel and oil requirements.

Although international markets have recognised all the technical advantages of the disel engine, taxation policies and conditions in different countries have an influence on the fuels—and therefore on the type of engines—used in agriculture. In the United States, Canada, and indeed in many countries in the world, gasoline is tax-free for farmers ; hence we find that the bulk of tractors are powered by gasoline engines. In our own country, where gasoline is taxed on the same basis as for road vehicles—*i.e.*, at 2/6 per gallon—the demand for a tax-free fuel, vaporising oil, understandably increased. However, the demand for vaporising oil in recent years has receded, because of the increased use of diesel power.

The extent to which this is being used to-day in agriculture is illustrated by a highly significant fact. It is that the free world's consumption of diesel oil for tractors has exceeded that of vaporising oil (power kerosene).

Research

The oil industry's research programme is very progressive and the ceaseless activities of its research centres have conferred numerous technical and economic advantages upon the users of petroleum products. The programme includes research into quality control, the search for new applications for base materials and chemicals, the development of new processes and the improvement of existing products, all of which are aimed at reducing consumers' operating and maintenance costs.

A research centre also does considerable work on formulating blends of available components to meet the energy requirements of home and overseas markets that may be influenced by geographical reasons or changes in manufacturers' designs. To meet the increasing demand for diesel power, the performance of fuels and lubricants must be observed under the most careful control conditions.

In recent years, the use of additives has increased, with the result that the testing of lubricating oils has now become highly specialised, and it has materially helped the development of the modern high-speed diesel engine. Another contribution out of research has been the development of EP transmission oils for hypoid gears and, more recently, the introduction of lihtium-base greases that have the essential properties for use over a wide temperature range. They are also water-resistant.

Research workers have a happy way of understanding each other, and the outcome of such close co-operation is one of benefit to industry. I would like to give you a typical example of this co-operation. Research workers have discovered that radio-active materials can be used for new avenues of investigation in agriculture and engineering. Many of you will remember that at the last " Open Day " of the National Institute of Agricultural Engineering a demonstration was shown for the first time as to how radio tracers could be used to help in the investigation of wear problems associated with tractor engines working in dusty conditions. The technique of using radio-active materials was developed originally by one of the oil industry's research centres. By employing a radio-active compression ring it is possible to determine the rates of wear of this component with and without anti-wear additives in the oil whilst an engine is running on a test bed.

Prior to this discovery, conventional methods of investigation involved running an engine for long periods, dismantling and assessing wear of cylinders and piston rings by changes in measurement and weight. Although this form of procedure produced valuable information, nevertheless it was time consuming and repeatability of tests was not always entirely satisfactory.

To-day, a more advanced method is used to study corrosive and abrasive wear with a higher degree of accuracy, and the technique can now be applied to a moving vehicle. The vehicle's engine is of the 4-cylinder type, and two pistons each have one radio-active compression ring.

By means of a specially-designed pump, the total volume of oil is circulated once every three minutes through a detector ; thus, to-day the performance of lubricants can now be studied over a wide range of road conditions and speeds throughout the year. The value of this research development has already been established as being one of outstanding commercial advantage, as undoubtedly the life of the modern I.C. engine has been enhanced to give a much longer running period between overhauls.

No doubt, the N.I.A.E. will adopt a similar technique and use radio tracers in a tractor working in dusty conditions or travelling through a dust tunnel.

The future may reveal that research workers in agriculture and engineering have found other uses for radio-active materials in investigations that may well revolutionise some aspects of farming.

New Developments

I must not fail to mention that research and development has led to a number of successful applications of agricultural chemicals in overcoming difficulties which, in the past, have either hindered cultivations or severely damaged growing crops.

A recent development from research has been the introduction of two liquid seed dressings which, when used with a specially-designed machine, has made it possible for seed merchants to treat seeds at a rate approaching 4½ tons per hour. Its main advantages are the treatment with a higher degree of accuracy and the elimination of the danger of harmful mercury-laden dust being released in the atmosphere or contaminating the mill.

Another aspect so far not mentioned is the development of petroleum chemicals as a source of raw material for the production of many new products by the growing plastics industry. It was not until the late 'thirties that organic chemicals from petroleum were used. The stimulus of war-time demand, which could not be met from older sources, laid the foundation of this new industry. In the United Kingdom the use of petroleum chemicals is growing rapidly and something approaching half the production of all organic chemicals is petroleum-based.

The use of plastics is accepted and many applications can now be found in agriculture. Many products from ethylene have now become household words—*e.g.*, D.D.T. for insecticides, ethylene glycol for anti-freeze liquids, and Terylene fibre, P.V.C., as well as emulsions for paint.

The extensive use of ferrous materials has faced technicians with many problems of corrosion brought about either by weather and/or chemical action. Admittedly, ferrous materials have many production and economic advantages ; nevertheless, it cannot be denied that corrosion has become a very costly business.

Let us consider, for example, a combine drill. Would it not be possible to use plastic materials to replace some of the components that are attacked by corrosion. Plastic materials could also be used for new designs of mechanical handling machinery to give added protection against damage to market produce.

The problem caused by other types of corrosion that reduces the useful life of tanks for spraying agricultural chemicals, or the storage of liquids and fuels, may one day be solved by the use of epoxy resins. The value of the application of this material has already been firmly established by its use for the lining of metal food containers.

A more recent development has been the production of foam polystyrene. This material has excellent heat and sound-insulating properties, and possible use for such material may be found in buildings where it is important to reduce heat losses. One remarkable factor about foam-polystyrene is that it is extremely light—a cubic foot only weighs 1 lb.

Future Trends

Market research and future trends will reveal that agriculture is capable of expanding and supporting further increases in the mechanisation of farming methods —in particular, in livestock farming and in the backward areas within the Commonwealth. The outcome of further work in research and engineering will undoubtedly produce machines and implements of new design, including engines of higher efficiency and new forms of transmission using rotary hydraulic power. The oil industry will carry on doing what it has done in the past ; that is, to meet the ever-increasing demands of the markets here in Britain and overseas without difficulty.

Because of the world's annual increase of consumption of petroleum products by agriculture, occasionally one hears the question " Can enough supplies be maintained ? " The answer is " Yes "—after all, it is as vital to the countries where oil is found to see that the flow is maintained and increased as it is vital for the consuming countries to receive it.

A fact which should not be overlooked is that the world's reserve of oil in relation to production has steadily been rising year by year, although the amount of production is expanding. There were proven oil reserves at the beginning of 1959 sufficient for about 40 years' supply at the current rate of production. Indeed, the ratio of proven reserves to current production has consistently increased over the years. Proven reserves, moreover, do not constitute total reserves, but merely those uqantities which it is known can be made available at current levels of economic cost and technical knowledge. Exploration is continuous and on an extensive scale.

I would like to emphasise that the potentiality of supplies has never been better and that with the world tanker capacity which is available the oil industry is enjoying greater flexibility in supply and transportation than ever it has had before.

In conclusion, may I return to strictly Institution affairs. I am very glad indeed to be able to take advantage of this opportunity to express the thanks of the Institution to our local centres. The Committees, and particularly the Hon. Secretaries, must take a very great deal of the credit for our growth and influence.

When one reflects upon the work necessary in arranging such excellent programmes of meetings, providing " platforms " to enable specialised interests to be discussed, in interesting new members, in liaison with appropriate bodies within centre areas, and many other matters, one can only feel, as I do, that the Institution does, indeed, owe them a debt of gratitutde.

The expansion of the Institution and the complete achievement of its aims and objects can best be attained by a further increase in membership, particularly by companies suitably qualified to become Affiliated Organisations of the Institution.

I would like to express, on behalf of the Council, our appreciation of the practical assistance rendered by those companies who have been elected as Affiliated Organisations, and, in addition, our thanks to those companies which, through their generous support, have enabled the Institution to offer scholarships for the National Diploma in agricultural engineering.

Finally, may I say how deeply I appreciate the honour of being elected your President, and that during my term of office I shall try to follow the notable examples of my predecessors in serving the interests of the Institution.

FARM SAFETY REGULATIONS

Brief reference was made in the Paper published in the July issue of the Journal to the various Farm Safety Regulations which are either completely or partly in force.

The Ministry of Agriculture, Fisheries and Food has published explanatory notes on each of these Regulations, which give their requirements in very full detail. Copies of these leaflets are available free of charge from the Ministry at Whitehall Place, London, S.W. 1.

Mr. J. C. GOUGH

In June of this year Mr. J. C. Gough retired from the Ministry of Agriculture, Fisheries and Food after 39 years of service.

Mr. Gough, a past Vice-President of the Institution and prior to that its Honorary Treasurer, has played a very active part in fostering the growth of the Institution, and his help and advice have at all times been valued by the Council.

From 1940 to 1956, Mr. Gough was head of the Machinery Inspectorate of the Ministry, and after the passing of the Agriculture (Safety, Health and Welfare Provisions) Act, 1956, was appointed the first Chief Inspector. As such, he was responsible for advising on technical and enforcement aspects of Regulations formulated under the Act.

Mr. Gough's services as a Consultant on safety measures are now available. He has recently been appointed Agricultural Safety Adviser to the Agricultural Machinery and Tractor Dealers' Association.

THE PROBLEMS OF A DEVELOPMENT ENGINEER

by T. SHERWEN, M.I.Mech.E., M.S.A.E., M.I.B.A.E.

A Paper presented at a Meeting of the Western Centre on 9th March, 1959

IN discussing the problems of a Development Engineer, I think we must first attempt to define some of the types of development work. Development is that work which is necessary to convert a new idea into a saleable reality. This can be roughly divided up into three stages :

1. The translation of the idea into working form, or mock-up.
2. The stage in which the project is improved and modified, so that it can be made with available materials and manufacturing techniques.
3. The pre-production stage where the final form and cost are found and assessed to ensure that the article can compete adequately in the market.

This simplifies the case, but it must be realised that the subject is so vast that any attempt to deal in detail with it is far beyond the scope of this Paper.

There are also various forms of engineering where the above pattern of development does not hold good, and these are mainly in the aircraft and nationalised industries where normal economic considerations do not apply.

The post-war period has been a very difficult one for the development of new projects, as costs of labour, material and taxation rose steadily for the first 10 years.

Let me explain this with an example. A firm wishes to launch a new plough on to the market. Now, those models on sale already have probably been designed pre-war, and all the tooling and development costs have been amortized years ago. Therefore, the only increase in price that has been necessary is that of labour, overheads and materials. The new plough, however, must carry these same costs, in addition to tooling and development, and the latter can be a large item.

Under these circumstances, the share of the market which this firm can expect will be quite small, and this tends, as we know, to increase the cost still further ; added to this, the farmer as a customer is often slow to be convinced of the advantages of something new, and this retards the initial sales, which again aggravates the position.

One solution to this problem is a radical new approach to the implement and operation, which, in turn, needs courage and a long-term outlook, coupled with a good experimental department.

To see that this can be done successfully, one has only to look round at the Royal or Smithfield Shows, where one can also see the results of the opposite course of action in the number of firms who have perished or been taken over in the last decade.

Dealing with stage 1, the initiation of the idea can occur in several different ways ; it can be just an idea in the mind of a designer, or it can be a suggestion by some outside person. Sometimes the concept appears as the result of discussion by an engineering team ; this often occurs when the idea is needed as a solution to a particular problem, or it may take the form of an improvement to an existing article.

This shows that ideas may not necessarily stem from the designer, but, once born, they need his supervision thereafter throughout their development life.

You will notice I have referred here to the designer instead of Development Engineer. Now, I think this point should be clarified ta this stage.

In all development work the person who bears the ultimate responsibility should be technical. The mixture of completely non-technical administration of Development Engineers has been responsible in the past for many pathetic failures of what could have been successful projects.

If the project needs only one engineer, then he must be a designer. If, on the other hand, there is an engineering team, the person in administrative charge should have sufficient design ability, apart from technical training, to stimulate original thought in the other members of the team. Thus, we see that a good Development Engineer must also be a good designer if he is to do justice to the project concerned throughout its development life.

I have already dealt with some of the ways in which an idea can be initiated ; however, once it has taken its place in the engineering department as a project, it must be nursed by one person.

During this period it may be necessary to bring in outside specialised knowledge, such as electrical or metallurgical, etc., but these should be used as means to an end and should not be allowed to alter the main concept.

At this stage the Development Engineer—who I propose to call the D.E. for short—must be constantly on the alert to avoid pitfalls. It is only too easy to do one of two things—(1) make up the very first scheme which is drawn, and (2) go on drawing scheme after scheme without making anything up !

The correct compromise to these two problems will vary in each case, and the D.E. must pick the right time to make prototypes, and this then results in the most economical development programme in the shortest time.

Another serious problem which is far too prevalent in this country concerns firms who have no Experimental Department and who do not understand the meaning of the word " development," and they expect an article to be designed one day and available on the market the next week.

The true development of the article takes place after it has been placed on the market, and ultimately costs the firm far more in lost goodwill and a large Service Department than it would have done if developed properly in an Experimental Department.

Many agricultural problems are such that they cannot be solved piecemeal ; for example, silage.

Any new implement in this field must fit into a complete pattern of harvesting, and if this does not exist then the implement, however good in itself, will fail commercially. For instance, the mounted buckrake worked admirably in conjunction with the mower and pit storage ; it also had the advantage of low capital cost.

The success of this system has delayed the advent of the forage harvester, which, in spite of its greater rate of work, is much more costly and really needs more power than that available from the smaller popular tractors.

Now that the forage harvester has become simpler and cheaper, it will gain ground, but will necessitate wire mesh trailer tops, which then will not discharge their load when tipped.

This, in turn, will need moving bed trailers, which will have to come if the forage harvester is to take its full place in the market.

All these problems, like those discussed above, although not directly technical, should be assessed before starting the design of a project, and only if the basis is sound should the project continue.

If a firm's products are going to be in the forefront of their class, the D.E. must keep abreast of new developments in materials, methods of joining these and fabricating them. For example, the use of plastics is creeping steadily into all parts of the engineering world ; PVC as a protective coating has proved very valuable, and the new types of materials such as PTFE and nylon have opened a new world in unlubricated bearings.

At the same time, he must not accept all these new things too readily, as experience has shown that there are many pitfalls to be avoided until their behaviour under all circumstances and over a reasonable life is known.

One of the chief snags of plastic materials in engineering is their lack of stability, both as a result of temperature changes and moisture absorption. Much progress is being made at the present time in the introduction of other elements to these materials to improve their characteristics, but progress is bound to be slow, as it is not always possible to accelerate age tests, and the final answer may well not be known for some time.

In many cases, it pays to make a small mock-up of one part of the project to prove its operation before carrying on with the scheme. I have known several prototypes that have not worked because of some simple small trouble which should have been proved first by itself.

In the same vein it is highly desirable to test each portion of a prototype separately before assembly of the whole machine ; one example of the results of not doing this sticks in my mind. A prototype loader was being tested out and the framework had been propped up with a timber strut across the bonnet of the tractor during assembly.

When everything was assembled and ready, the engine was started and the control lever pulled up. Then, to the astonishment of everyone present, the frame moved smartly down until the fork reached the ground, whereupon the tractor front-end leapt into the air !

The hydraulic jacks had been made as pull instead of push types, and there were some very red faces when they were returned for conversion the following day to the large concern who supplied them !

One very special problem which affects the Agricultural D.E. more than his colleagues in other industries is the development of seasonal machines such as mowers, seed drills, etc. For this type of work a very flexible organisation is needed if the project is to come to fruition in a reasonable time.

Let us say that the drawing office work and the prototype have taken 6–9 months to complete, and then field tests begin. Now, with any design which is new and not merely a copy of an orthodox product, some troubles may arise that require rapid thought and some very quick engineering, so that the implement can go back on test while this is still possible. Believe me, it is very easy to lose another year before further trials.

Another variation of this problem is the implement whose working conditions vary widely in different parts of the country, as, for instance, potato digging. I once spent two years on digger development and the tests ranged from Cornwall to the Clyde, and after a reasonable performance compromise had been reached we discovered that the total annual home sales of this type of digger were not then large enough to make one worthwhile batch !

Before passing on to the later stages of development work, I would like to mention another type of project initiation with which I happened to be associated. A trailer and hitch design had been developed in the U.S.A., and it was intended to put this into large-scale production in this country. An American-built prototype was tested over here and gave reasonable results, so preparations were made to produce a large batch.

In due course, these started to reach the customers and then teething troubles appeared ; the engineering side of these was dealt with, but it soon became apparent that the method of hitching was not going to be acceptable on the market. Fortunately, I had in the meantime been working on an alternative automatic hitch mechanism, so that when the problem of a design change arose, in order to overcome sales resistance the development side was well advanced.

Here, however, was a different problem, as large quantities of parts were already in existence, so the change had to keep the amount of redundant parts to the minimum.

It is interesting to note here that, due in part to a natural desire to recoup the losses incurred by this change-over, the design of this trailer remained unchanged for many years, and it was not until nearly ten years afterwards that an opportunity presented itself to design a similar trailer from the word " go." This freedom resulted in a design with certain technical improvements and a works cost saving of some 12 per cent.

In contrast to this development was another undertaken at short notice. In order to assess performance and use with a large prototype tractor, a 5-ton trailer was required.

On this project it was decided to use several of the existing production parts meccano-wise, so after some intial quick loading calculations I spent every day for one week at the manufacturers' plant. The 3-ton tipping jack was duplicated and a commercial axle and brakes utilised. The rest of the trailer was designed as it progressed, and was completed in one week.

This prototype was lucky and the method is not recommended for beginners !

The second stage of development is probably the least exciting, involving as it does a great deal of hard, patient work in forming the foundation of a well-engineered article. This stage has one particular problem all of its own, and that is to determine the method of manufacture. Now, we all know that the number to be made of a given part controls whether it shall be fabricated, cast or forged, etc., so it is essential at an early stage for the D.E. to know how many implements can be sold per year. Usually, however, when he asks the Sales Department for this figure he in turn will be asked for the probable cost. This is rather like the problem of the chicken and the egg, and is only solved by the co-operative guessing of all concerned.

In large organisations the sales figure can be prepared by the market research boys on orthodox products, but where the implement is new and unorthodox other solutions must be found.

One way out is to make a prototype and arrange a series of demonstrations to selected groups of farmers, who will then give their opinion. Another way is to show the prototype as such at a major show, and gauge the reaction of the customer.

The answer to this problem must be reached, however, regardless of which way, as no engineering development work can start until the D.E. knows which price class the implement is to fit and in what volume it is to be produced.

This is the stage where experience is invaluable—the type of hard-won experience which only comes through having launched and brought up many projects on the market.

This will enable the D.E. to take short cuts and help him to decide how much of a gamble certain courses of action represent. Amongst the many problems which have to be solved is that of selection of materials ; this is closely linked with how the project is to be made and also what degree of corrosion, if any, will exist during use.

These three problems will probably have to be solved simultaneously, as they are so interdependent, and superimposed on all these decisions will be the cost factor.

In stage two a completely different type of problem may confront the D.E., and that is where a new use or purpose may arise during the development of a project.

For instance, if the item has been designed as a purely agricultural implement, and then during the test period it is found to be of great use in an industrial sense. This ha happened several times, and the D.E. must then exploit this chance and use his ingenuity to see how the project can be suited to both uses with the minimum alteration.

This event often increases the sales, and thus enables the tooling and development costs to be spread over a larger quantity.

At an early part of stage two a specification will have to be decided. This may be influenced by the type of products that the firm already market ; for instance, if they make only one size of tractor then the size and rate of work of the implement must suit that tractor.

Much of the information for this will come from the Sales Department, but the final specification should be agreed in conjunction with the D.E., whose job it is to advise the Sales Department on the probable cost of various features that they would like incorporated. It is important that agreement is reached on this point, otherwise if any problems are later experienced with sales it always descends on the D.E.'s shoulders !

During stage two the D.E. will also have problems other than engineering ones during discussions and while the design is being thought out various suggestions may be made, perhaps an improvement or another method of making a particular part. These suggestions may come from any source, field test, a farmer, one of the draughtsmen or a director, but wherever they come from or however impractical they may sound, they must all be weighed carefully and impartially and dealt with tactfully and according to their merits.

This often demands the judgment of Solomon, because a suggestion may come at the eleventh hour and would obviously upset the development programme if it had to be incorporated, and yet it might be such that this would be well worth while.

The impractical suggestion is a great problem, as this may come from a source which must not be offended ; also, the D.E. knows that every member of the team must be encouraged to think constructively and he must guide their thoughts accordingly.

Another small facet of this problem is recognition. If an idea is used in the work the fact should be acknowledged. Nothing breeds discontent in a team so quickly as using people's ideas without a word. After all, it is only human nature to be proud of the fact that you have contributed something to a successful project.

Patents are another difficult question which fall—at any rate, in a small firm—on the D.E. First of all, he must find out if there are any other patents in existence on the project he is about to develop ; this can usually be done by reference to pamphlets and literature of competitive machines. If patent numbers are quoted, then he must obtain copies of these and study them.

I am assuming here that the firm is not large enough to support its own patent man, as in this case, of course, it is his job to get all this information and advise the D.E. on these matters.

These patents may have lapsed, in which case work can proceed, but this means that the firm itself cannot obtain patent protection. Similarly, if other implements are on the market unpatented and using similar features, the same conditions exist.

The most difficult situation arises when only patent application numbers are quoted because it is then impossible to find out what is protected, and even whether these applications will be granted, and if granted whether they are valid or not.

There are many ways of trying to solve this problem, ranging from a shrewd assessment of the competitive machine, which could enable the D.E. to guess what they have sought to protect, to direct contact with the firm concerned with a request for information, so that possible infringement can be avoided.

The correct course of action will probably be different in each case, and must be guided by circumstances, but it is surprising how co-operative some firms are when a frank and fair approach is made.

As you know, patent applications may take up to three years before they are granted and published, and this has the effect of drawing a veil of uncertainty over the subject for this period, and, in fact, is used by some firms solely for this purpose. This, of course, can be used as a protection by the D.E. on new work, knowing that when the subject matter of his applications is published he will by that time have accumulated know-how and be two jumps ahead of his competitors.

Some developments are difficult and expensive to protect, especially where the work is of a protracted nature, as progress may not be sufficiently advanced to justify full home and foreign applications in the twelve-months period from the provisional application.

An awkward decision then has to be made, whether to take a gamble, which throughout the world can cost several hundred pounds per patent, or whether to re-lodge the application and obtain another twelve months' breathing space, which at the same time loses this period on the priority date.

Some firms neglect patents altogether and trust to ingenuity and speed of preparation to keep several jumps ahead of competition. This may be all right with certain articles, but is a dangerous course of action where a big programme is contemplated.

We are now approaching stage three, and will assume that the project is sufficiently near completion for plans to be made for its production.

These days it is common practice for all concerns to buy out at least some engineering parts from specialist producers ; the percentage of such parts may be high, and very often it is convenient to sub-contract the complete project. Let us assume that this is the case, and that the commercial arrangements have been made ; the D.E. must now get together with the production engineers of that firm to discuss the project with them and find out exactly how they are going to make it. This will enable him to make the conversion from the experimental drawings, which have been used up to now, into full production drawings. This method saves time, but does not necessarily produce the best commercial bargain.

A more economic but longer way is to produce the production drawings and put the manufacture out to tender ; then when the tender has been given, any small alterations which may be required are done to the drawings. Care must be taken to see that the firm to whom the contract is awarded is by its reputation and past performance suitable to tackle the job.

A problem which is bound to crop up now is the question of tolerances. The prototypes will probably have been hand-built and work satisfactorily because certain components have been made to suit their mating parts. Now all this will cease, and a set of production parts from the stores must be capable of being assembled without any hand fitting. This is also important with spares, as these may have to be sent where there are no engineering facilities and must fit without trouble.

You may think that the answer to this is to have tight tolerances throughout, but this is not so, as fine tolerances are expensive, and each one must be examined on its own merit and made as coarse as possible, consistent with satisfactory working and interchangeability.

Some people consider that a set of drawings should specify every single aspect of the product, but I have found by experience that if the contracting firm has a good manufacturing record then this is not necessary.

During all this preparation for production the D.E. must keep an eye on things, and in fact he must be ready to sort troubles out until the product has been on the market long enough to lose any teething troubles which may occur.

Finally, the Agricultural D.E. must know the farming operations concerned intimately. It is essential that he should have performed them, or at least tried to, himself, as only then can he fully appreciate what is involved. This in effect means that he must be in close contact with the farming community and do at least some of the initial tests himself.

I have dealt in this Paper more with the types of problems which exist rather than the problems themselves ; these would become technical and not of so much general interest.

You may think after all this that the life of a D.E. is one big problem ; so it is, but the sense of satisfaction when the goal is achieved is his reward, and do not let us forget that a large part of the world's prosperity to-day is due to the efforts of Development Engineers.

THE MECHANICAL PROPERTIES OF SOIL IN RELATION TO THE DESIGN OF CULTIVATION IMPLEMENTS

by P. C. J. PAYNE,* M.Sc., B.Sc., A.M.I.B.A.E.

A Paper presented at a Meeting of the West Midlands Centre on 27th October, 1958

IT is the ultimate object of the present work, much of which has been carried out as a combined operation between the N.I.A.E. and Wye College, to produce basic theories to explain the stress/strain relationships when an implement moves through soil. These theories should be comparable to, though necessarily less exact than, those of aerodynamics. Eventually, this should enable the theoretically ideal implement shape for any given purpose to be produced on the drawing board with the minimum of expensive field trials. This is not to suggest that there is great room for improvement in existing implements as they are now used. Far from it ; the evidence which is available suggests that most are already designed to give a good performance on the majority of soils that they are likely to be used on in this country. It would, however, remove one of the dangers inherent in all traditional skills, born of experience and intuition—namely, that only part of the possessor's know-how passes to his successors and competitors. Moreover, it should cheapen the production of implements designed for new purposes or techniques. For instance, it is the author's personal belief that it will eventually be necessary to design a set of implements for use at double or treble to-day's speeds.

So much for the ultimate goal. It has up to now only been possible to produce a partial solution even for the simplest flat vertical tines[1] and it is not proposed to say any more about that to-day, though other workers are now coming into the field and offering solutions for other shapes[2]. Rather it is proposed to discuss firstly what is known of the mechanical properties of British soils, and then to consider the effect of various shapes and implement properties on the magnitude and direction of the soil forces acting and on the amount of soil disturbed.

THE MECHANICAL PROPERTIES OF SOIL

Strength

As an implement moves through soil a strain must be set up. It is therefore necessary to study the shape of the soil's stress/strain curve. In common with other granular materials, soil nearly always fails in shear. For small stresses the strain is also small and largely within the elastic limit ; that is to say, the stress/strain relationship is almost linear, and with removal of the stress most of the strain would be released. The presence of roots has been found to increase the relative importance of this elastic range. After the range of elasticity has been passed the soil's behaviour becomes nearly plastic ; that is to say, an increase in stress is accompanied by a much more than proportional increase in strain. When the point of maximum stress has been passed the strain will continue to increase, though accompanied by a reduction in stress. The maximum shear stress is termed the shear strength of the soil and is regarded as the point of failure. One way in which soil differs from most other engineering materials is that after the point of maximum stress is passed the strength does not fall to zero, but for root-free soils continues at about 75 per cent. of the maximum value and falls to about 50 per cent. of this on soils to which roots contribute a considerable proportion of the maximum. In cultivated organic soils the critical horizontal displacement at which the stress ceases to be proportional to the strain appear to be about ½ to ¾ in., though unexpectedly high draughts for tines working in saturated beach sand have led to the belief that the range of proportionality must then be much smaller. If this is true, it means that in future more attention must be paid to the shape of a stress/strain curve, as well as to the value of the maximum stress.

It has been stated that, however soil is stressed, the failure is always one of shear. When a sample is subjected to two mutually perpendicular compressive stresses of sufficient magnitude to produce failure, the plane of maximum shear stress will in theory be inclined at an angle of $\left[\frac{\pi}{4} - \frac{\phi}{5}\right]$ to the direction of the maximum principal stress, where ϕ = angle of internal friction for soil. It has been found that most reasonably uniform top soils, especially light ones, do, in fact, exhibit such a shear plane.

For practical purposes, soil strength (maximum shear stress) may be assumed to possess two components—a cohesive one which is independent to the normal stress and a frictional one which is directly proportional to the normal stress. When found by experiment, the angle of internal friction is more correctly termed the " angle of shearing resistance." Thus the shear strength of any soil is defined by the equation :

$$s = c + \sigma \tan \phi$$

where s = shear stress.
c = cohesive stress.
σ = normal stress.
ϕ = angle of shearing resistance.

This equation was first postulated by Coulomb in 1773, and together with the knowledge of the average inclination of the shear surface to the principal stress forms the theoretical basis of most of the present work. The chief difference between the shear strength of soil and

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metal lies in the relative importance of friction due to the low vlaue of soil cohesion.

The foregoing is largely standard soil mechanics theory. It is now necessary to consider how far cultivated top soils may be assumed to follow the theory. The first essential is a method of measuring shear strength, and since the clod formation or macro-structure of cultivated soils is relatively much more important than that of a sub-grade which the civil engineers are normally concerned, it was considered that the standard strength tests which involve removing a sample would be unsuitable. It was therefore necessary to develop an *in situ* method—hence the N.I.A.E. torsion shear box[3]. Though this instrument has a number of theoretical faults, it is still thought to give results best suited to the present investigations, and much thought is being put into ways of improving it.

In Fig. 1 a strength envelope (maximum shear stress against normal load) has been constructed for that famous Rothamsted field, Broadbalk. It will be seen that Coulomb's equation may be regarded as holding, though it must be pointed out that this only applies when the range of normal load is not too wide.

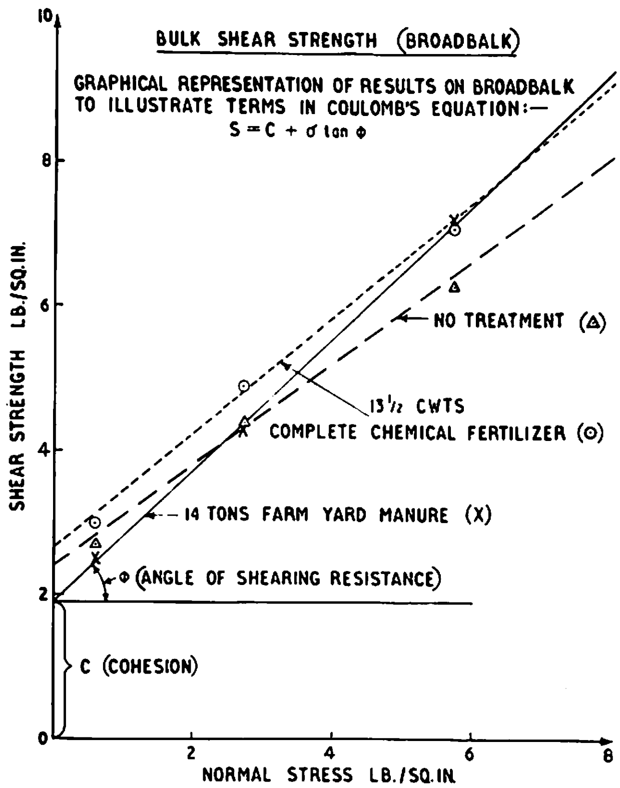


FIG. 1

With the torsion shear box the strength properties of over 150 top soils have now been investigated, and it is believed that a reasonably accurate picture of the likely range of conditions has been obtained, though more soils are continually being studied.

Fig. 2 shows histograms of the strength parameters for most of the soils that have been measured. It will be seen that the angle of shearing resistance may be assumed to lie between 30 and 40 degrees on the majority of soils, and the cohesion to range from 1–15 lb. per sq. in.

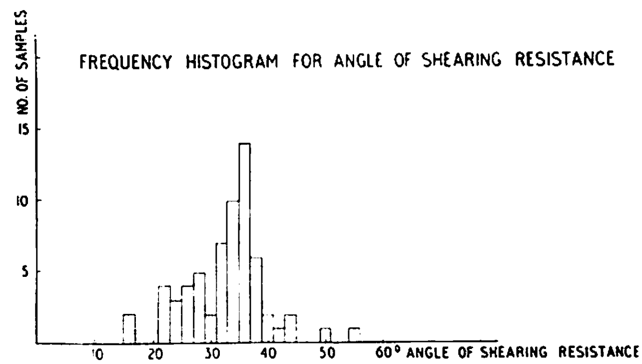


FIG. 2a

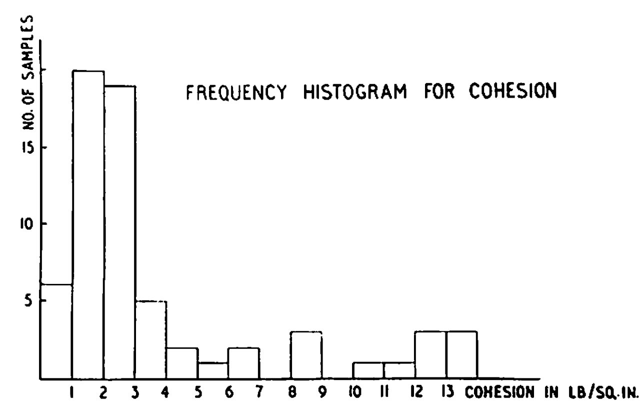


FIG. 2b

From this it will be concluded that the wide variations of draught from one soil to the next must be due largely to variations in cohesion, while the changes in the amount of soil moved by a given implement on different soil types are small because of the relatively constant value of the angle of shearing resistance. The small variation is amount of disturbed soil has been confirmed very conclusively in recent experimental work. This consistency in the angle of shearing resistance is of great value from the designer's point of view in applying soil mechanics theories, since it means that he can know with reasonable accuracy for most soils the extent of the zone disturbed by each part of the implement and the direction of the resultant forces.

Most agricultural soils are intermediate in type between the very highly frictional sand and sandy loam and the almost exclusively cohesive properties of a puddled clay. Incidentally, a dry, crumbly clay in good structure may have as high a frictional value as a sand. The techniques generally regarded as good husbandry are all the time tending to increase whichever strengh component is lacking. Organic matter increases the cohesive strength both because of the tensile strength of the undecayed fibres and presumably because of the aggregation brought about by the humus. It has been possible to demonstrate the increased strength due to undecayed fibres, but great difficulty has been experienced in showing by direct comparison how the humus affects it. It can, however, be shown that soil possessing good structure has a higher coefficient friction than one lacking in structure. Efforts to demonstrate the effects of lime on the strength properties of soil have so far met with little success.

Over-riding all these structural effects is, of course, the importance of moisture content. On almost all soils the effect of increasing moisture content is to reduce the cohesive strength while leaving the angle of shearing resistance relatively constant. In fact, the average value of cohesion from April to September for a clay may well be twice that during the winter six months. Fig. 3 shows curves of moisture content against cohesive strength for a clay and a sandy loam.

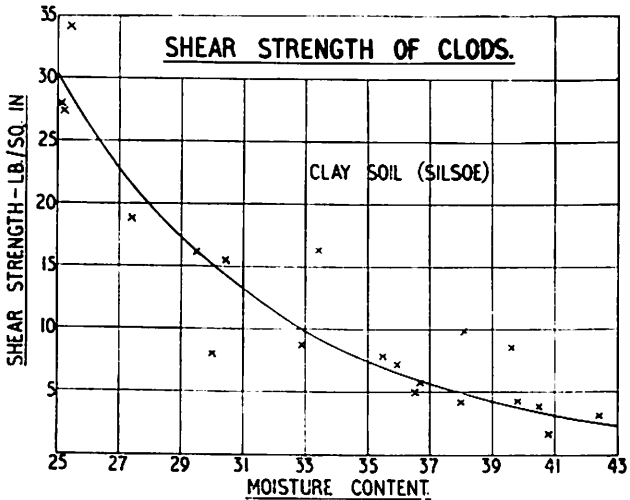


FIG. 3a

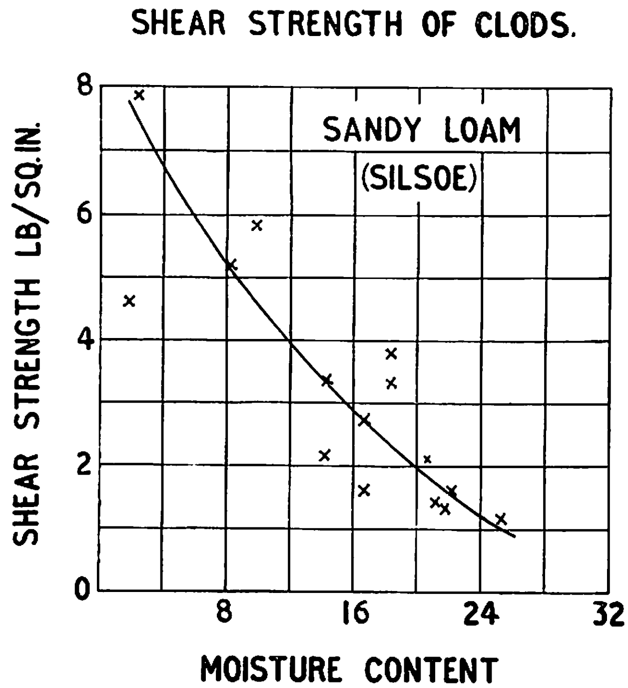


FIG. 3b

In what has been said up to now, it has been assumed that a sample of soil large enough to render individual particles and clods unimportant is being considered. This assumption is probably safe enough for large implements whose function, like ploughs, is the moving of large sections of soil, or, like rippers and mole ploughs, is the passage through large volumes of soil. However, there is a group of implements whose function is either the breaking or packing more closely together of clods. Here no such simple treatment will hold and the strength of individual clods has to be considered. Another section of the work has been concerned with these problems, but it is not intended to discuss them further to-day.

Soil/Implement Sliding Resistance

In discussing shear strength soil/soil interfaces have been considered, but attention must also be given to soil/metal interfaces. These have been found to possess a similar pair of components to those of shear strength,[4] though the one comparable to cohesion termed " tangential adhesion " is often very small under field conditions. The component comparable to internal friction termed " sliding resistance " is important both in that it contributes directly to draught and in that it affects the orientation of the stresses and hence the amount of soil disturbed. It is difficult to evaluate, but in this work has been measured by finding the value of two mutually perpendicular stresses acting on a vertical plate inclined to the direction of travel.[5] On most soils the tangential adhesion appears to be negligible, while the angle of soil to metal friction is of a similar order to the angle of shearing resistance, with a tendency to be slightly smaller. For practical purposes, it need rarely be considered as larger, or scouring would cease and then soil/implement sliding resistance can be regarded as equalling soil shear strength.

Soil Density

Work has to be done in lifting the soil and in accelerating the displaced lumps ; hence the third mechanical property which must be investigated is the soil density.[6] Its exact value, however, is unimportant, relative to the two previous soil properties, since as long as implements continue to be moved at little more than horse speed the accelerations are small. This remark may not apply to ploughs where the mass of soil moved is considerably larger and certainly would not apply to earth moving equipment ; nor might it apply if the working parts of implements were made to strike the soil at much higher speeds than are customary.

EFFECT OF IMPLEMENT PROPERTIES ON IMPLEMENT PERFORMANCE

The results of the experiments now to be described have all been obtained by pulling life-sized implements through real soil and recording the forces acting with resistance strain gauge and pen recording gear.[5] The areas of disturbances were measured on the surface during frequent stops. Real implements have not been used because it was believed that the complexity of their shape would make the interpretation of the results impossible. Instead, flat, rectangular plate tines were used, and these could be tilted at any required angle. By varying one or other implement property, such as depth/width ratio of the tines or their rake angle, it is hoped to build up a picture which can be applied to far more complex shapes and with less danger of missing the principles on the way. It is hoped that these results and those to come will eventually form the basis of the general theoretical solution, but, meantime, they should be of value in themselves to designers and in many cases, at least qualitative, theoretical solutions are suggested.

Soil Failure around an Implement

It is believedt that an implement forces a passage for itself by straining a succession of thin laminae of soil to failing point. Each lamina reduces the strain by sliding a short distance. Further movement of the implement then increases the strain on another lamina—identical in shape to the first—until it, too, slides. Thus the stress will momentarily be reduced to a value corresponding to the soil's residual strength. The effect of these successive failures and transitional periods must be to give the draught a wave form with a definite periodicity. Experiments have proved this to be the case, though the lack of uniformity in real soil often makes the amplitude irregular.

Depth/Width Ratio for Vertical Tines

In order to understand how the depth/width ratio affects the draught and volume of soil moved by a rectangular tine, it is first necessary to describe the pattern produced in front of it by the shear surfaces forming the laminae. Fig. 4 is an isometric view of the

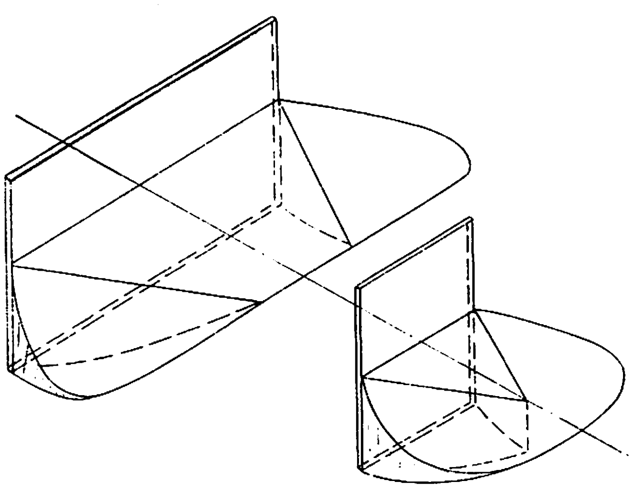


FIG. 4

theoretical shear surfaces for a wide (at least twice as wide as it is deep) and a narrow (no wider than it is deep) tine. It will be seen that for the wide tine a slightly curved shear surface rises from the bottom of the tine and terminates on the surface of the soil. The crack appearing on the surface runs parallel to the face of the tine for the complete width and then encircles a relatively small wing of soil on each side of the main block. There are also two vertical converging shear surfaces running from each side of the tine. These vertical surfaces are unimportant in the case of wide tines, but for the narrow tines they are extremely important, since they meet and isolate a wedge-shaped block of soil on the face of the tine. This wedge behaves as if it were part of the tine and has a knife-like action, splitting in half the two sides of the surrounding wings, which now have united in front of the wedge to form a crescent-shaped body and leaving them one on each side. One further feature of the wedge is of interest. It slides slowly up the inclined surface at its base and is continually renewed from the bottom. Thus, like ploughs, tined implements carry out inversion of the soil, though to a smaller extent.

All this was predicted from theoretical considerations and has since been confirmed on numerous occasions in the field. The cleavage surfaces do not, of course, follow the exact pattern predicted all the time because of the macro structure, and they are frequently hidden by rolling clods, but with a little careful excavation the main features can usually be found. The lighter the soil the easier it is to find the shear surfaces, but the narrow-tine wedge is nearly always exhibited. As was stated earlier, continued movement of the tine only produces a repetition of the same pattern, and the succession of compressions and failures so produced results in a continuously mounting and falling draught. This produces a wave form in continuous draught recordings, which is particularly well demonstrated by the continuous pen recording apparatus used. On damp sands the succession of similar failures is very clear, but on wet clay they tend to merge into each other.

For analytical purposes, the draught of narrow tines is considered[1] as consisting of three parts. The first part acts on the bottom of the wedge and forces it to slide up the face of the tine. It is proportional to the width of the tine. The second part acts on each side of the wedge and is proportional to both the width and depth of the tine. The third part acts on the tip of the wedge and is proportional to the depth of the tine. It has been termed the point resistance. For wide tines only the component acting on the bottom surface is important. This explains why for any given depth the smaller the width the higher the draught per unit area of tine surface.

Depth/Width Ratio for Raked Tines

Fig. 5 shows in isometric projection the cleavage pattern produced in the soil for tines 6 ins. deep and raked at 20, 90 and 160° to the horizontal respectively. The tines in the top row are each 2 ins. wide and the bottom row 4 ins. wide. Unlike the previous slide, this does not depict the pattern predicted in theory, but represents the mean results as measured on four different soils. A close similarity between these results and the theoretical pattern is immediately obvious, the principal difference being that the crescent and wedge are lengthened in the direction of travel when the tine is raked forwards (bottom edge leading) and the crescent is foreshortened when the tine is raked back. Furthermore, no wedge is apparent on the surface when the tine is raked back. It should be pointed out that the width of upheaval is greater than the width of the tine and may be regarded as the limit of useful work as far as bursting and seration are concerned.

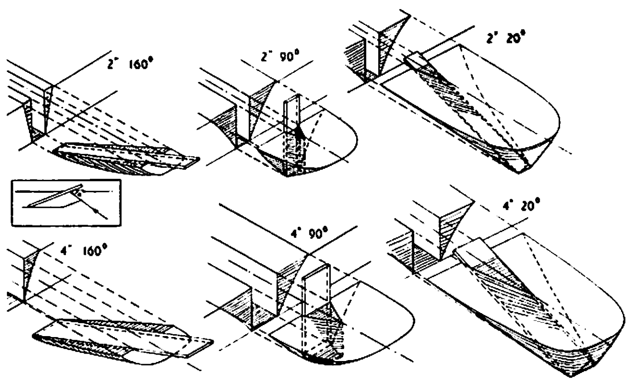
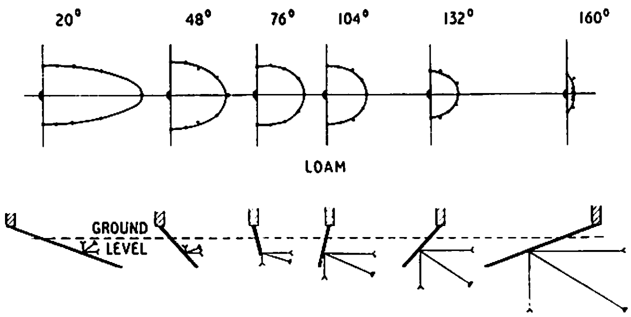


FIG. 5



MAGNITUDE AND DIRECTION OF RESULTANT SOIL FORCE AND SHAPE OF CRESCENT CAUSED BY RAKED TINES

FIG. 6

In Fig. 6 a plan view of half of the crescent has been plotted for a 2 in. tine at six different rake angles from 20 to 160° on clay loam. Below the plan views the side elevations of these six tines have been drawn with the vertical, horizontal and resultant forces plotted vectorially. It is obvious here that the trends shown in the isometric projections are continuous. On all the soils studied the trend in the magnitude and direction of the forces have been the same as those depicted here ; that is, the resultant force on the tine has a downward component assisting penetration for rake angles of less than about 50° (65° for beach sand), but for greater rake angles has an upward component. The value of the resultant force increases about five-fold between rake angles of 20 and 160°.

From Fig. 7—a graph of the relationship between the angle made by the resultant to the horizontal and the rake angle—it is clear that the relationship comprises two almost linear portions with the gradicnt change occurring very close to the 90° rake ordinate. For forward-raked tines 1° change in rake angle brings about approximately $\frac{2}{3}$° change in the direction of the resultant. For backward-raked tines the equivalent change in the resultant is only $\frac{1}{5}$°. When the horizontal draught is plotted against rake angle for different soil types, as in Fig. 8, it is apparent that for rakes of up to 50° (the rake

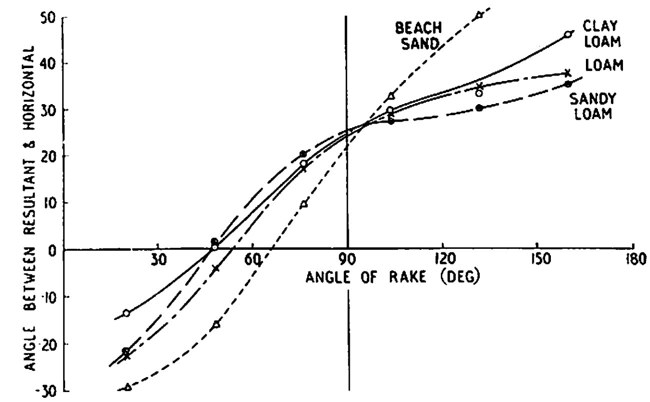


FIG. 7

DRAUGHT—ANGLE OF RAKE

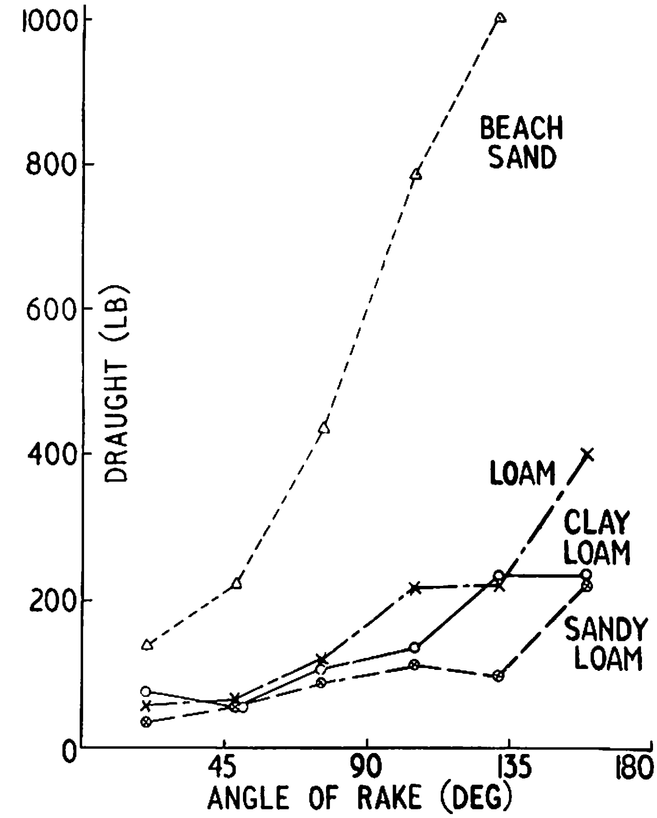


FIG. 8

at which the resultant force first possesses a downward component) the draught is very insensitive, but thereafter the gradient steepens rapidly until at 160° the draught is five or six times that at 20°. This insensitivity of draught for rakes of less than 50° suggests that cultivator tines with their curved portion raked at a maximum of about 50° are as near the optimum as can be found.

If the theoretical approach (outlined in the first section of the Paper) based on a knowledge of the inclination of the cleavage surface to the principle stresses is correct, then, for tines wide enough to bring the soil into plastic equilibrium, the sideways distance from the tine to the crescent should be independent of the width of the tine for all rake angles. This has been found to be sensibly true with tines of more than 2 ins. wide. As has been mentioned, this dimension is of particular value, in that it denotes the effective width of cultivation by a single tine. In Fig. 9 the draught per unit width of disturbed area has been plotted against the width/depth ratio of the tine and shows that all ratios are of almost equal efficiency at soil bursting, though forward-raked tines are much more efficient than backward-raked ones.

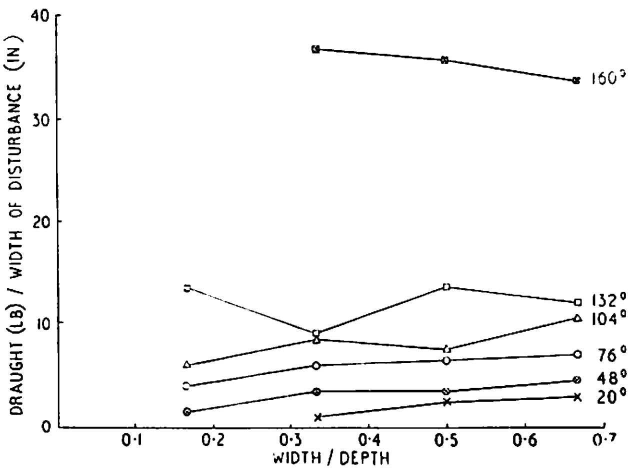


Fig. 9

Frontal Shape

One method of reducing draught might be supposed to be the provision of a sharpened cutting edge like the prow of a ship. However, it would be expected from theoretical considerations that this would have little effect if it were no sharper than the soil wedge which is formed on flat tines, because it simply means replacing the surfaces of soil/soil sliding with one of soil/metal. On the other hand, really sharp prows with an apical angle of, say, 10°, though perhaps impracticable from the wear point of view, might be expected to give considerable improvements in draught. This has not been found to be the case. In fact, the reduction pressure due to the sharpening is often more than offset by the increase in area of contact. In another experiment carried out by the N.A.I.E., it was shown that the triangular tine with an angle of sharpening of 70° had almost equal draught, whether drawn with the apex leading or trailing. Furthermore, Zelenint quotes the results of Dalin as showing very similar trends. The volume of soil moved by sharpened tines has not yet been studied, but in theory the effect of sharpening to dimensions similar to those of the soil wedge would only be expected to bring about very small changes.

Skin Friction

Skin friction is the word used to describe the drag on the sides of a tine which lie in or nearly in the direction of travel. It has been studied intensively for parallel-sided tines by Zelenin, whose results suggest that it does not generally constitute an important part of draught. These results show that it depends only upon the area of contact and the soil-implement sliding resistance. Its value, from Zelenin's results[7] is about ⅓ lb. per sq. in. on clay soils and decreases on lighter soils. In present work it has been studied with the friction wedge, and its value found to be about ¾ lb. per sq. in. If it is considered economic to eliminate this component of draught 5° relief has been found adequate on most soils. Under certain circumstances—for instance, when mole draining—it may be desirable to render the slit more stable, and then the sides may be smeared at additional pressures by providing the tines with a slight increase in cross-section towards the rear. The increase in pressure would be directly proportional to the increase in skin friction which may represent a doubling or trebling for 5 or 6° of taper.

All the draught and skin frictions quoted would, of course, be reduced quite drastically if the tines were not wide enough to stress the soil to a plastic condition. As has been mentioned, it has been found in practice that the assumption of plasticity begins to break down with tine widths of less than 1½ to 2 ins.

Soil/Implement Sliding Resistance

Sliding resistance between soil and implement[4] is the last variable to be discussed in this Paper. If a way of reducing it could be found, the draught of almost all implements could be lowered. This includes interfaces where soil/metal is not immediately obvious, such as the leading face of vertical tines. Nichols[8 9] and Wells[10] both came to the conclusion that it probably offered the greatest opportunity to reduce draught by changing an implement property. The results of the present work on tine-like shapes suggest that where the amount of soil moved is unimportant the angle of approach has a more dramatic effect than could be expected from a small reduction in the angle of friction and where the amount of soil moved is important any reduction in friction would orientate the stresses to reduce the amount of useful work, though possibly not in proportion. The improvement in ploughs would, of course, be great not only because of smaller draughts, but because of improved scouring. Unfortunately, it has not yet been possible to compare the sliding resistance of many different materials, but those comparisons which have been undertaken suggest that mild steel has a particularly high value and that wood has no particular virtue in this respect. A short investigation[11] carried out by the Agricultural Test Department at the N.I.A.E. also tends to disprove the idea that the reason for the good scouring properties of the old wooden mole board was because of a low sliding resistance. One body of a semi-digger plough was covered with a veneer of wood and pulled through five local soils known to have poor scouring properties. On the whole, the steel bodies scoured better than the wood veneered one. On the other hand, theoretical considerations[12] suggest that it was the shape of the old wooden mole boards that led to improved scouring. It has been shown[12] that slatted mole boards, as occasionally used, would be likely to have the desired effect by virtue of the increased normal load. This would apply as long as the angle of shearing resistance is greater than the angle of soil/implement friction.

Practical Use of Soil Mechanics in the Designing of a Real Implement

The principles applied in the design of the N.I.A.E. winch sprag[13] show how useful a knowledge of soil mechanics can be in a real design problem. It also illustrates the dangers of drawing board design. The idea is really an extension of the principal of weight transference from front to rear tractor wheels, though the result was not arrived at by that reasoning. The object was to increase the anchoring force of a conventional sprag without increasing the size of its buried parts. It was realised that the sprags normally used mobilise only the cohesive strength of soil, while taking no advantage of its frictional strength. To remedy this, two things are necessary. Firstly, the sheared soil in front of the spade must be prevented from rising, so that a normal load may be transmitted to the shear surface. This was achieved by attaching a horizontal plate to the upper end of the spade. Secondly, the tractor and sprag must be so arranged that the resultant of the weight and the rope tension is co-linear with the resultant force on the shear surface as depicted in Fig. 10. To achieve this arrangement without the use of soil mechanics might have needed months of expensive field work, whereas, in fact, the first prototype proved to have the right range of adjustment to cover the wide range of soils on which it has been tested. The new sprag performed almost exactly as predicted. The work was not without its pitfalls, however, because though the expected improvement per inch of penetration was achieved, the conventional sprag not having a horizontal plate digs itself in deeper on wet clay soils, thus eliminating some of its disadvantages. It was concluded that the new sprag offers improvement of up to 100 per cent. in anchorage on light soils with incomparably less soil disturbance. On really wet clays its performance is only equal to that of the conventional type because of the digging in achieved by the latter.

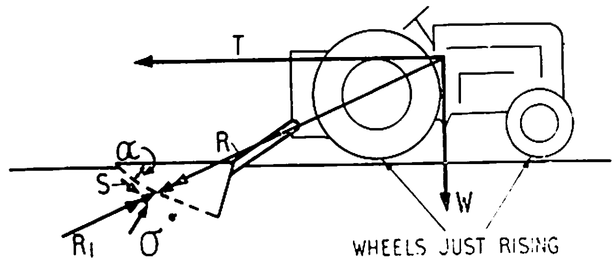


Fig. 10

REFERENCES

1. Payne, P. C. J. *J.Agric.Engng.Research*, 1956, I, 23.
2. Söhne, W. " Einige Grundlagen fur eine Landtechnisch Bodenmechanick," N.I.A.E. translation No. 53, 1958.
3. Payne, P. C. J., and Fountaine, E. R. *J.Soil Sci.*, 1952, III, 136.
4. Payne, P. C. J. *J.Soil Sci.*, 1956, VII, 235.
5. Rogers, O. J. J., and Tanner, D. W. N.I.A.E. Tech.Memo., No. 106, 1955.
6. Brown, N. J., Fountaine, E. R., and Payne, P.C. J. *Imp. J.Exp.Agric.*, 1954, XXII, 138.
7. Zelenin, A. N. " Fizicheskie Osnovie Teorii Rezaniya Gruntov " (" Basic Physics of the Theory of Soil Cutting "). Moscow, Leningrad, 1950.
8. Nicholls, M. L. *A.S.A.E. Trans.*, 1925, XIX, 173.
9. Nicholls, M. L. *Ibid.*, 1932, XXVI, 51.
10. Wells, A. A. Cambridge Univ., Ph.D. Thesis, 1950.
11. N.I.A.E. Annual Report, 1951/52.
12. Payne, P. C. J., and Fountaine, E. R. N.I.A.E. Tech.Memo., No. 116, 1954.
13. Payne, P. C. J. *J.Agric.Engng.Research*, 1956, I.

(*continued from page 94*)

List of Standards mentioned in this Review

B.S. 1495 : 1958—Agricultural tractor details for light and medium tractors.
1562 : 1957—Agricultural mower parts.
1744 : 1951—Tests for agricultural tractors.
1773 : 1951—Hydraulic lifts for agricultural trailed implements.
1841 : 1951—Attachment of mounted implements to agricultural wheeled tractors.
2468 : 1954—Glossary of terms relating to agricultural machinery.
2659 : 1955—Dimensions of agricultural cultivator tines.
2687 : 1955—Agricultural discs.
2947 : 1958—Steel roller chains and chain wheels for agricultural and similar machinery.
2968 : 1958—Hydraulic spray nozzles for insect, fungus and weed control and for like purposes.

BRITISH STANDARDS IN AGRICULTURAL ENGINEERING

by R. BERRY,* A.M.B.I.M.

STANDARDISATION applied knowledgeably and selectively makes good sense, whether as an essential part of the economics of manufacture or as promoting the efficiency and full utilisation of the tractor and machine in the field.

Reduction of unnecessary variety in the design of components required for the same purpose can not only cut down costs in design and production, but can considerably ease the problems of storage and supply. Standardisation also provides the basis for concentration of production by the specialist maker of components and by the machine maker, within a range of models, by allowing longer production runs. Dimensional standards promote interchangeability of parts of different make during the life of a machine, and so can be of direct assistance to the former at a critical time. A standard of quality or test performance agreed at national level provides the maker and agent with an accepted criterion for unbiased claim of good quality, and the user with a basis of assurance and comparison. Sound standardisation can benefit every field of activity in agricultural engineering.

The production centre of standards in this country is, of course, the British Standards Institution, an organisation which works under a Royal Charter, financed by funds provided by industry, by the Government and from its own resources. A section of this independent technical Institution, although small in relation to the whole organisation of some 3,000 technical committees, has been producing standards for farm tractors and machinery for the past twelve years. In addition, a further section has prepared many standards for dairy equipment.

British Standards are not confined only to material quality, dimensions and tolerances, but, as the case demands, deal also with performance requirements, methods of test and the standardisation of technical terms.

There has recently been a quickening of interest in the usefulness of national standards in agricultural engineering, and a demand has developed, both from makers and farmers, for more specifications to be prepared. It is timely, therefore, to inform members of how standards for farm machinery are prepared, of the standards already available, and of the current work of the B.S.I. technical committees.

These B.S.I. technical committees are formed from engineers and technicians nominated by trade organisations from their member firms, from Government and research bodies, and from the N.F.U. It is a measure of the importance given to the production of standards that firms and other organisations release their technical experts from this work for as much as two or three days within each month on different committees, giving their services free. The quality of the knowledge provided is of a high level—for example, the manufacturer's representative is usually the firm's tractor or implement designer—as there is a well-developed sense of competition between firms at these meetings, recognising the need to support opinion with technical proof and practical experience. Indeed, the B.S.I. " forum " is recognised amongst committee members as an extremely valuable medium for the exchange of information and the development of design. It is obviously to the advantage of a manufacturer to have each feature of his own product within the requirements of a national standard, but to achieve this, where makers' designs differ, he must substantiate his claim fully as being technically sound in the face of critical examination. The result is that the standard to a large extent is made up of many individual features, which together provide the best overall design. Some modification of the draft as an " ideal " is, of course, necessary sometimes, due to problems of existing production, usage, and the supply of spares which may arise from an entirely new standard design. The final standard must be agreed by all interested parties.

The need was recognised some four years ago for collaboration between the B.S.I. technical committees in this field and those of the Farm Equipment Institute of America, which latter body initially prepares American and Canadian standards, whereby to avoid unnecessary differences in the standards prepared. Due account was also taken of the opportunity afforded by a reciprocal exchange of technical data to further the general development of design. Since that time, there has been a constant flow of information in both directions to the benefit of all concerned. Information received by the B.S.I. is sent to members of the relevant committees. Similarity of British and American standards not only assists trade between the countries—for example, the adoption of similar three-point linkage design—but also assists those firms with American associates and provides the buyer with a more open market in a competitive field.

It should be stressed that the policy of the B.S.I. in all its work is to avoid restriction of design, and only those affecting interchangeability and essential quality are normally standardised. It follows that effort is largely concentrated on components and not on the standardisation of a complete machine.

Draft specifications prepared by the committees are sent to all interested organisations and individuals, not only in the United Kingdom, but throughout the world. Criticism is invited and is carefully considered before the standard is finally published. British Standards are not

**Senior Technical Officer, British Standards Institution*

allowed to become out of date, but are reviewed every five years for possible improvement in the light of new developments.

Nor is the work of standardisation in agricultural engineering confined to national needs. The very active International Organisation for Standardisation has technical committees working on standards for tractors and machinery components which will provide specifications agreed on a world basis. The B.S.I. represents the United Kingdom in the I.S.O. by appointing a team of members from the national committees concerned. The I.S.O. subjects include tractor tests ; three-point linkage ; tractor components, including p.t.o. and drawbar ; tractor tyres and wheels ; mower parts ; discs ; spray machines ; and a three-language glossary. Many of the developing I.S.O. standards are based on the relevant British Standard.

Before dealing with the standards specifically prepared for tractors, machinery and implements, it must be stressed that there are a great many general engineering standards which play an important part in the design and production of all machinery in this field. A small selection of these would be : Basic steels and non-ferrous metals ; rubber ; screw threads, bolts and nuts ; bearings ; belting ; chains ; gears ; shafts ; oils and fuels.

The work in the purely agricultural engineering field has been most successful in the standardisation of tractor components and publication of the well-known Test Code. The main hitch dimensions of the tractor three-point linkage were standardised in 1951, together with requirements of lift heights and adjustment ranges. This standard was adopted almost at once by all the leading tractor makers. It was then thought inadvisable —indeed, impossible—to standardise the positions of the forward link points, which control, of course, the axis of movement of the complete linkage. Without this basic feature standardised, however, implements would connect to the three-point hitch, but would not necessarily be interchangeable functionally. Implement makers found continued difficulty in designing to suit all makes of tractor, but a specification covering the forward link points has now been agreed by tractor and implement designers, and an extension to this standard will soon be published.

The tractor component standard deals with the power take-off, its size, design, speed and direction of rotation, and the master guard ; the positional relationship between p.t.o. and drawbar ; the drawbar hitch ; the size, speed and direction of rotation of the belt pulley ; and zones of clearance round the p.t.o. and round the pulley to ensure operation under varied conditions and with different types of implement. This latter feature required a lengthy investigation. The fixing dimensions of tractor front wheels are standardised and a recommended reduced range of tyre sizes is listed.

A recent agreement has standardised the tractor hydraulic pressure and the hydraulic coupling (self-seal) design, so that tractor and implement half-couplings to the standard will now assemble irrespective of make and will also be interchangeable functionally.

Work to further extend the tractor detail standard proceeds continuously, and the future programme includes rear wheel fixings, the two-wheeled trailer hitch, ground speed drive p.t.o.'s, and the positions of the tractor controls.

The tractor test standard has just been revised, one major addition being a test of power at the power take-off, at the standard speed of 540-r.p.m. and, of course, at other speeds the maker may require. The results of this test will not only be of value to the individual tractor maker, but also of very great interest to the designer of p.t.o. driven implements.

In the implement component field there are already standards for discs of all kinds, providing interchangeability of fixing dimensions whilst reducing unnecessary variety. Mower knife sections are standardised similarly with the knife back and fingers. A basic requirement of quality of steel is specified in both standards, but complete specification of material would restrict development. The fixing dimensions of cultivator tine points and hoe blades are standardised by specification of the lower part of the tine, but not the design of the attachments or " tools " themselves. The bush roller type of driving chain has been standardised and complete interchangeability in a small range of sizes has been achieved in practice. Detachable driving chains (square link) will shortly be standardised as regards dimensions and test loads. This new standard will reduce the number of different sizes from 60 to 18 and will still cover all normal needs. A recent standard for spray nozzles provides for these to be interchangeable, not only as fitting to the lance or boom, but also functionally, due to comprehensive tests for discharge rate and uniformity of distribution by use of a patternator. The B.S.I. has also produced a very useful glossary of terms and definitions.

Other standards being prepared, in a very full programme of work on implements, concern the p.t.o. shaft and guard, implement and trailer wheels, and lubricating nipples.

In preparing standards, the B.S.I. works on a policy of agreement on technical grounds, and avoids decisions based purely on " weighted " interest in a particular subject. Adoption of British Standards is not mandatory, but experience has shown that the basic good sense of standardisation, the " streamlining " effect of modern production techniques, and a growing demand by distribution and farmer interests, are all steadily promoting their use.

It is the B.S.I.'s task to prepare standards—which task sometimes presents considerable difficulty—but the extent of real benefit to be gained in practice from the printed standards depends entirely on the extent of their adoption within the industry. The service is there ; it is for the agricultural engineer to use it to the full.

(continued on page 92)

SOME TECHNICAL AND ECONOMIC ASPECTS OF FARM ELECTRIFICATION IN EAST ANGLIA

by E. C. CLAYDON, N.D.Agr.E., M.I.B.A.E.

A Paper presented to the East Anglian Centre of the Institution on 24th June, 1959

THE rural area of the Eastern Electricity Board represents nearly 90 per cent. of the 8,000 square miles of the territory served by the Board. There are about 31,600 farms in some 6,750 square miles, of which 10,000 had a supply of electricity in 1948 when the Board was formed. Rapid progress since that date has resulted in over 25,000 farms being on supply at the present time. It is planned to connect a further 2,000 farms in the next two years, by which time some 85 per cent. will have supplies. The remainder will include an appreciable number who do not, for various reasons, wish to be connected.

Distribution System

The high costs involved in establishing a distribution system over such a large and sparsely populated area have resulted in the adoption of single-phase construction for rural development wherever possible, since by this means a reduction in expenditure of some 20 per cent. can be expected. Efficient operation with sound construction at the lowest possible cost is the policy, and three-phase 11,000 volt lines constitute a " backbone " to the system, from which single-phase " spur " lines are erected to afford individual supplies to farms and small groups of premises.

The diagram on page 94 illustrates the system which is necessary to bring electricity to the farm. First there is the power station, constructed at a cost of many millions of pounds, and from which radiate the overhead lines of the " super grid " at 275,000 volts. These lines can transmit power for distances up to 150 miles and cost about £25,000 per mile to construct. The more usual " grid " lines at 132,000 volts are used for transmitting loads of 90 mega-watts and can link distances up to 50 miles at a cost of £10,000 per mile. The grid sub-stations, of which Thorpe is an example, cost approximately £½ million and transform the supply from 132,000 to 33,000 volts, at which voltage it is taken by overhead lines or underground cables to major distribution sub-stations up to 15,000 kilo-watts capacity, costing in the region of £85,000. Here the voltage is transformed down to 11,000 for our main rural distribution system, consisting largely of overhead lines costing up to £2,000 per mile ; underground cables can cost over twice as much. Pole-type sub-stations are generally employed for individual supplies to farms, and their transformers vary in cost from £125 to £450, according to size. The " mains voltage " lines which run from these transformers to the farm buildings cost roughly 12/6 per yard overhead or over £2 per yard underground.

So far as farm supplies are concerned, although it is true that the costs of each connection are reflected to some extent along the whole chain to the power station, it is the 11,000 volt system and below which are chiefly concerned. A brief description of this system is therefore given.

Construction of 11,000 volt lines is to the Standard of B.S. 1,320, and it is doubtful whether this design, with its simple horizontal cross-arms, can be improved upon for economy or unobtrusiveness. The supports are mainly imported red-fir poles, pressure-creosoted, although a few lines have been erected on home-grown larch and pre-stressed concrete poles. Conductors have in the past been of copper, but for economic reasons steel-cored aluminium or aluminium alloy is almost invariably employed to-day.

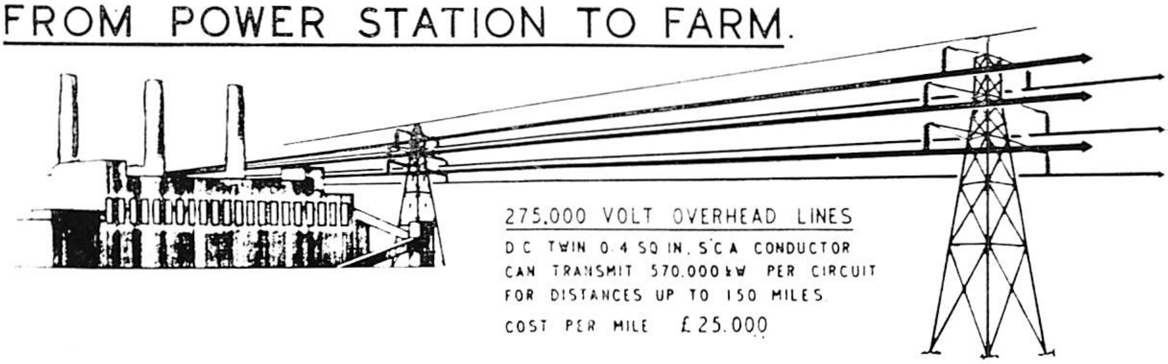
Farm sub-stations are normally of simple construction and consist of a transformer mounted on a single pole. They are connected direct to the high-voltage side and to fuses on the low-voltage side. The neutral is generally earthed at the first low-voltage pole by means of driven copper rods.

Aluminium conductors are used extensively for low-voltage lines, and at present-day metal prices are roughly 50 per cent. cheaper than copper. It is important to exercise care and to reserve tools such as draw-vices for sole use with aluminium if corrosion is to be prevented Connections to copper are avoided where possible by the use of aluminium service lines. Formerly, paper-insulated, braided, weatherproof conductors were used for services, but now polyvinyl chloride insulation is employed.

It will be appreciated that an extensive overhead high-voltage network and numerous small transformer sub-stations must increase the hazard of breakdown through a variety of causes, many of which, such as lightning, are beyond the Board's control. Precautions are taken, therefore, to safeguard the main systems from disturbances in the secondary systems. Lightning is the greatest cause of supply interruption in the Board's area, followed by birds and wind-borne material such as straw and tree branches. Surge protection is generally by means of rod gaps. Arc suppression coils are used to minimise the number of supply interruptions. Transformers are fused individually only when they are connected to a main distribution line ; elsewhere they are connected solidly to the lines. As has been mentioned earlier, in general, earthing is carried out by driven copper rods, but in high-resistivity districts on sand, chalk and stone, protective multiple earthing has been used with encouraging results.

Various administrative and labour-saving economies have been introduced. Pole-hole boring machines and

FROM POWER STATION TO FARM.



275,000 VOLT OVERHEAD LINES

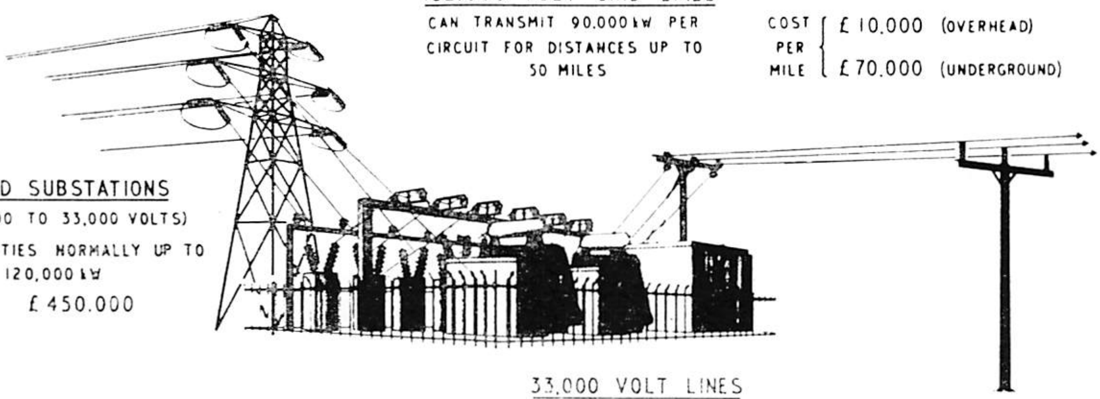
D C TWIN 0.4 SQ IN. S'C A CONDUCTOR CAN TRANSMIT 570,000 kW PER CIRCUIT FOR DISTANCES UP TO 150 MILES

COST PER MILE £25,000

132,000 VOLT GRID LINES

CAN TRANSMIT 90,000 kW PER CIRCUIT FOR DISTANCES UP TO 50 MILES

COST PER MILE { £10,000 (OVERHEAD) / £70,000 (UNDERGROUND)



GRID SUBSTATIONS

(132,000 TO 33,000 VOLTS)

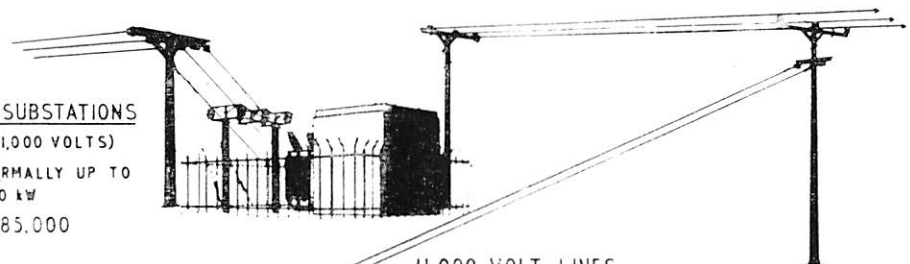
CAPACITIES NORMALLY UP TO 120,000 kW

COST £450,000

33,000 VOLT LINES

ARE ECONOMIC FOR LOADS UP TO 15,000 kW FOR DISTANCES NOT EXCEEDING 15 MILES

COST PER MILE { £3,000 (OVERHEAD) / £12,000 (UNDERGROUND)



INTERMEDIATE SUBSTATIONS

(33,000 TO 11,000 VOLTS)

CAPACITIES NORMALLY UP TO 15,000 kW

COST £85,000

11,000 VOLT LINES

ARE SUITABLE FOR LOADS LESS THAN 5,000 kW FOR DISTANCES LESS THAN 5 MILES

COST PER MILE { £2,000 (3 PH 0.1 in" OVERHEAD) / £750 (1 PH 0.025 in" OVERHEAD) / £5,000 (UNDERGROUND)

POLE TYPE SUBSTATIONS

TYPICAL CAPACITY FOR FARM SUPPLIES. 5 - 50 kVA

TYPICAL CAPACITY FOR VILLAGE SUPPLIES. 25-100 kVA

	1 PH	3 PH
kVA	£	£
5	125	-
10	140	-
15	175	-
25	200	340
50	250	400
100	-	450

THESE FIGURES ARE ONLY A GENERAL GUIDE AND MUST NOT BE REGARDED AS BEING APPLICABLE TO ANY PARTICULAR SCHEME

LOW VOLTAGE OVERHEAD LINES

ARE USUALLY ONLY SUITABLE FOR SUPPLYING LOADS NOT EXCEEDING 40 kW IN TOTAL, WITHIN HALF A MILE OF THE SUBSTATION, THE LIMITING FACTOR BEING VOLTAGE DROP

COST PER MILE { £1,750 (3 PH 4 x 0.1 in" OVERHEAD) / £1,150 (1 PH 2 x 0.05 in" OVERHEAD) / £4,000 (UNDERGROUND) mechanical saws are in use, and joint construction with the G.P.O. is practised where possible. A move towards grouping individual and small schemes into zonal methods of development has improved productivity and it is intended to help this still further by more effective grouping and deployment of our labour forces.

Economic Considerations

Rural development has taken place, under the Board's control, in three stages. Two five-year plans ended on the 31st March, 1958. Schemes were costed individually and line rentals were fixed on a generous basis for individual consumers. Large groups were supplied without charge. Increasing costs and the rise in the ratio of farms to other rural premises from 1 : 10 to 1 : 3·5 led to the need for a fresh examination of the system of charges. Costs were pooled and contributions were spread as evenly and fairly as possible over all those who would benefit.

The standard charges, known as rural connection charges, are based on floor area for the farmhouse and acreage for the land. They can be paid in cash or over a period of seven years by quarterly instalments Examples are given in the Appendix.

The standard published tariff for electricity supply to farms caters for most requirements, but individual arrangements can be made with farmers needing a particularly large supply. The most widely-adopted rate is the two-part rate, which comprises a unit charge of 1¼d., plus a fixed charge based on the floor area of the farmhouse and the assessed electrical demand in the farm buildings. The actual quarterly charges are as follows :

	£	s.	d.
Where the area of the farmhouse does not exceed 1,200 sq. ft.	1	4	1
And for each additional 400 sq. ft. or part thereof	0	4	4
For each 5 kVA (or part thereof) of farm assessed demand	3	11	6

The assessed demand is what may be reasonably anticipated as a maximum rate of consumption on any part of the premises. A generous deduction is made from this figure in respect of a crop drier used only during the season March to October.

A variation of the two-part rate is the night and day rate whereby a farmer by paying a small quarterly charge for the rental of a time switch can have his unit charge reduced to 0·9d. per each unit supplied between the hours of 7 p.m. and 7 a.m. This rate is particularly popular with farmers using the supply for crop drying, automatic milling machinery arranged for night operation and dairy sterilising equipemnt of the night storage type.

The reductions in rural electricity charges, made by the standardisation of tariffs soon after nationalisation, inevitably resulted in rural electrification becoming more uneconomic at the existing rates of consumption. It was estimated some years ago that a trebling of consumption was necessary to restore the situation. It is encouraging to note that farm consumption has increased steadily since that date at a rate which may result in an economic balance being struck sooner than was anticipated. Electricity consumption per farm has, in fact, now reached a figure which is equivalent to over 10,000 h.p. hours per annum. Considerably more work is now done by electricity on the farm than by the tractor. One diagram at the end of this Paper shows how electricity consumption has risen since 1949 and how also has the number of farms on the supply increased. Another illustrates how a typical rural programme can involve a Board in a considerable loss at the present rate of consumption. There is a limit to the amount of subsidy which rural consumers can expect to receive from other consumers, and it is hoped, therefore, in the interests of all, that electricity consumption in rural areas will increase sufficiently to reduce the subsidy to a negligible figure. The Board has, therefore, made certain arrangements with the object of achieving this desirable result.

Load Development

The initial negotiations with farmers requiring supplies are conducted by the district representative who seeks to ensure, even at this early stage, that the fullest possible use will be made of electricity. The representative endeavours to follow up his original work by visiting the farmer at regular intervals once supply has been made available. Representatives are also in attendance at the principal markets and maintain local contact with the N.F.U., Y.F.C. and similar organisations. They are backed up by agricultural engineers in each of our sub-areas, regions which approximate to counties in area and function. These engineers provide the representatives with information on new developments, co-operate with them in handling enquiries of a difficult nature and take responsibility for the operation of agricultural exhibitions, displays and demonstrations. All these activities are co-ordinated at headquarters where development is fostered, training courses are arranged, publicity conducted and liaison maintained with interested bodies at national and provincial level.

Farm Applications of Electricity

It is not within the scope of this Paper to deal in detail with applications of electricity on the farm, but certain developments are so closely bound up with the technical and economic aspects of electricity supply that some reference to them will not be out of place. Often the choice of a particular design is dependent upon the nature of the supply at the farm in question and the tariff that can be offered.

An examination of the curve illustrating the consumption of electricity per farm will show clearly the effect of the crop drying load on development. This load, more perhaps than any other, is affected by the weather. The abnormally bad harvest weather last season resulted in a substantial increase in farm consumption. Similar increases have taken place in other years and fine harvest weather has resulted in a decrease.

Crop drying by electricity needs careful attention to efficiency. The drying of grain in ventilated storage bins presents an attractive load, but the merits of other methods of drying are recognised. Electric driers of the batch type can be time switched for night use or process timed so that they can be operated without attention. Less efficient processes involving the use of crude heat attract a useful electrical power load. Similarly, the drying of green crops such as hay, peas on the haulm and clover seed in the barn cannot only give considerable benefit to the farmer, but make a substantial contribution to electricity consumption. The barn drying of baled hay has attracted considerable attention recently. It is a development that has been fostered by the electricity supply industry and offers to the farmer a technique which enables him to make quality hay regardless of the weather. It is particularly suitable for the small farmer who practises strip grazing.

The preparation of animal feeding stuff on the farm is responsible for the consumptoin of large quantities of electricity. One Suffolk farmer grinds between 250 and 300 tons of pig meal a year, and over the past ten years has saved several thousand pounds in the process. The equipment consists of an automatic hammer mill, time switched for operation on the Board's cheap night rate, and an electric mixer for incorporating with the meal the anti-biotic and mineral ingredients. A small cubing machine is now available for use in conjunction with farm mixers.

The development of the poultry industry, particularly in connection with the large-scale production of table birds, has meant an increased demand for electric brooding equipment. A heat storage brooder developed by the Board overcomes the difficulties occasioned by such supply interruptions as are referred to above. Electricity consumption on some of these larger poultry enterprises had reached the impressive total of a million units per annum.

The horticultural side of the farming industry makes considerable use of electricity, particularly in connection with the operation of oil-fired boilers and automatic stokers. The technique of mist propagation, which has been adopted so extensively, is dependent completely upon electricity.

Conclusion

This necessarily brief outline of some of the problems involved in farm electrification has, it is hoped, brought out the necessity for increased farm consumption if the present favourable rates of charge are to be maintained. The supply industry looks to the agricultural engineer to help in this development. There is scarcely any process in the farmstead that cannot best and most economically be carried out by electricity. The Board's staff of agricultural engineers is at the service of all interested to help in the selection of equipment having regard to the supply which is available and the tariff that can be offered.

EASTERN ELECTRICITY BOARD

709 Farms and 2,141 Other Premises—Gross Capital Cost, £560,000 ; Connection Charges, £190,000.

	£	£		£
BULK SUPPLY COST OF ELECTRICITY—			REVENUE FROM THE SALE OF ELECTRICITY	66,900
Maximum Demand Charge	23,200			
Units Purchased	26,900			
		50,100	(*Note.*—The estimated revenue is that expected in the first full year. On the basis of average consumption for such consumers, it does not seem likely that this will be exceeded by more than, say, 20% in the fifth year.)	
INTEREST ON CAPITAL—				
5⅜% on Net Capital		19,900		
DEPRECIATION—				
Amortisation of Net Capital		21,400		
DISTRIBUTION COSTS—				
Operation Salaries, Transport Repairs and Maintenance, etc.		15,600		
CONSUMER SERVICE, METER READING AND ADMINISTRATION COSTS		7,200		
MISCELLANEOUS—				
Payment in lieu of Rates	1,200		DEFICIT FOR THE YEAR	49,300
Rents, Insurances, etc.	800			
		2,000		
		£116,200		£116,200

RURAL CONNECTION CHARGES—FARMS

	Quarterly Charge. £	s.	d.	Lump Sum. £	s.	d.
1. For that part of the premises used for domestic purposes in a single, private residence :						
First 1,200 sq. ft.	1	0	0	24	13	6
Each additional 400 sq. ft.	0	3	0	3	10	6
Maximum Charge	7	8	0	56	8	0
2. For that part of the supply for use on the farm :						
First 5 acres	1	10	0	35	5	6
Each additional acre	0	1	0	1	3	6
Maximum Charge	13	15	0	323	2	6

ELECTIONS AND TRANSFERS

Approved by Council at their Meetings on the 15th September and 13th October, 1959.

MEMBERS

Perrott, A.	Cambs.	Scholes, G.	Yorks.

Overseas

Jefford, A. W.	Papua and New Guinea	Williams, T.	Mauritius

ASSOCIATE MEMBERS

Crompton, B.	Durham	Telford, D. A.	Yorks.
Harries, T. D.	Caerns.	Tomter, A.	Scotland
Parr, E.	Caerns.	Turnock, J. W.	Beds.
Russell, A. M.	Scotland	Walpole, R. A.	Westmorland

Overseas

Campbell, L. G.	West Indies	Jones, R. G. B.	Rhodesia
Chatterji, I.	India	Pells, D. K.	Ceylon

ASSOCIATES

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Babington, C. E.	Notts.	Jones, J. L.	Carmarthen
Birnie, J.	Scotland	Meads, S. C.	Bucks.
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Curtis, R. B.	Bucks.	Percival, J. H.	Berks.
Doe, G. S. W.	Bucks.	Priestley, P. C.	Yorks.
Downton, W. F.	Somerset	Prince, M. H.	Bucks.
Edmunds, I. H.	Caerns.	Roberts, O. E.	Caerns.
Edwards, E. W.	Merioneth	Thomas, H. W.	Merioneth
Evans, J. E.	Denbighshire	Thompson, P. C.	Yorks.
E. Fish	Merioneth	Tweedale, H.	Bucks.
Frost, J. W. F.	Hants.	Wells, G.	Yorks.
Harvey, H. W.	Berks.	Wicks, A. E.	Kent
Heathcote, F. J.	Lancs.	Wrathall, L.	Warwicks.
Hughes, I. M.	Anglesey		

Overseas

Bather, J. A.	Kenya	Hadjigeorgiou, P.	Greece
Bowman, C. O. W.	Ghana	Harper, B. K.	Eire
Edwards, B. R.	S. Rhodesia	Murthy, C. R.	India
Edwards, J.	Nigeria		

GRADUATES

Baxter, K. C.	Surrey	Paterson, I. G.	Wilts.
Betts, R. J. S.	Somerset	Townshend, D. C. R.	Surrey
Crosthwaite, R. P.	Bucks.	Young, G. M.	Wilts.
Middleton, J. S.	Scotland		

Overseas

Alpha, M. B.	Sierre Leone	Thoniappa, T.	Ceylon
Hughes, J. G.	New Zealand		

STUDENTS

Kerr, J. R.	Warwicks.	Roberts, R. J.	Surrey
Partridge, R. T.	Somerset		

TRANSFERS

FROM ASSOCIATE MEMBER TO MEMBER

Weston, L. T. .. .. Glos.

FROM GRADUATE TO ASSOCIATE MEMBER

Bowditch, H. G. .. .. Lancs.

FROM ASSOCIATE TO ASSOCIATE MEMBER

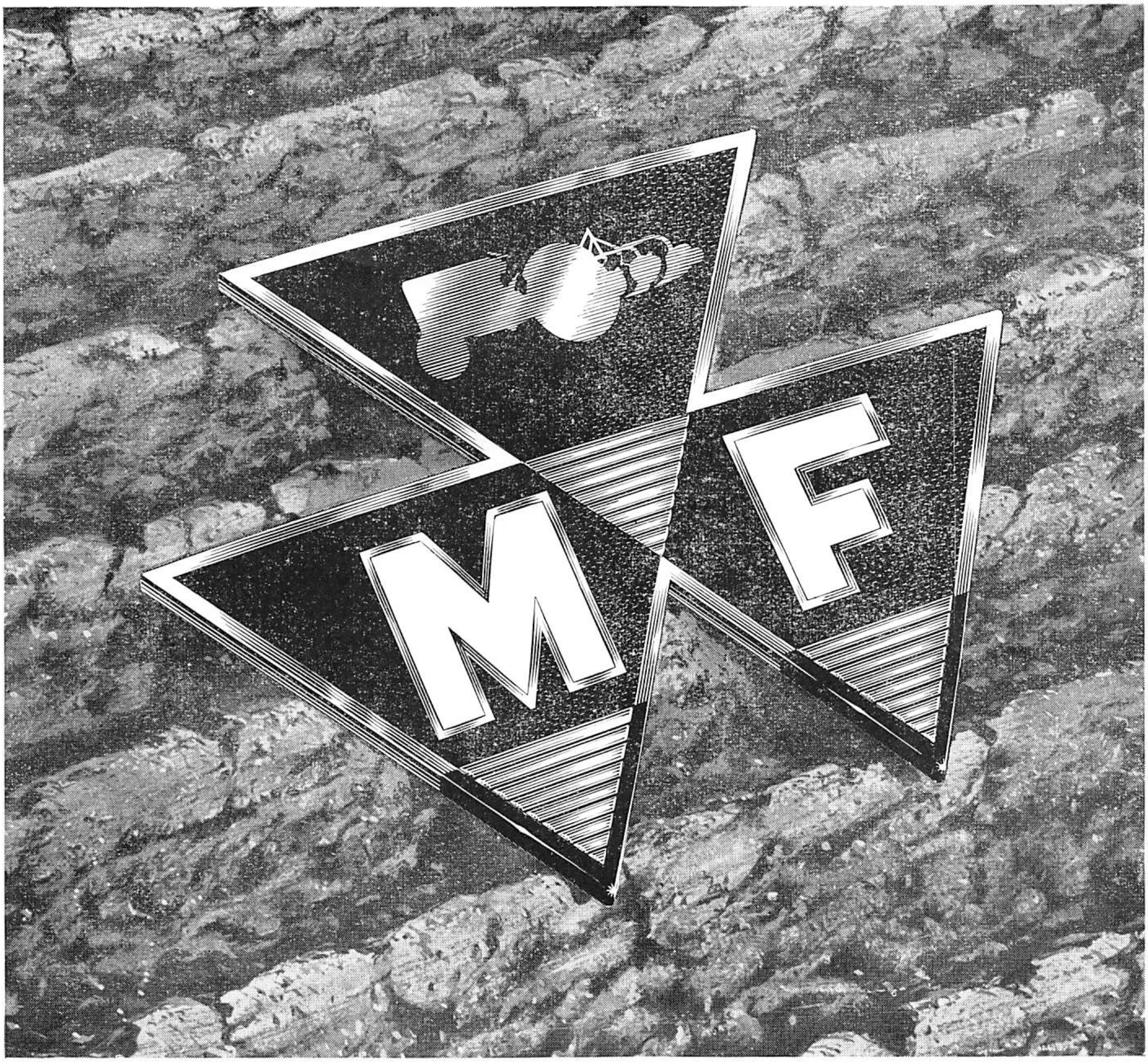
Harris, J. C. W.	Devon	Orchard, E. W.	Warwicks.	Telford, J. A.	Yorks.

Overseas

Blair, W.	Rhodesia	Trotter, A. B.	Austria

FROM STUDENT TO GRADUATE

Coffey, D. M. G.	Scotland	Cromarty, A. S.	Sussex



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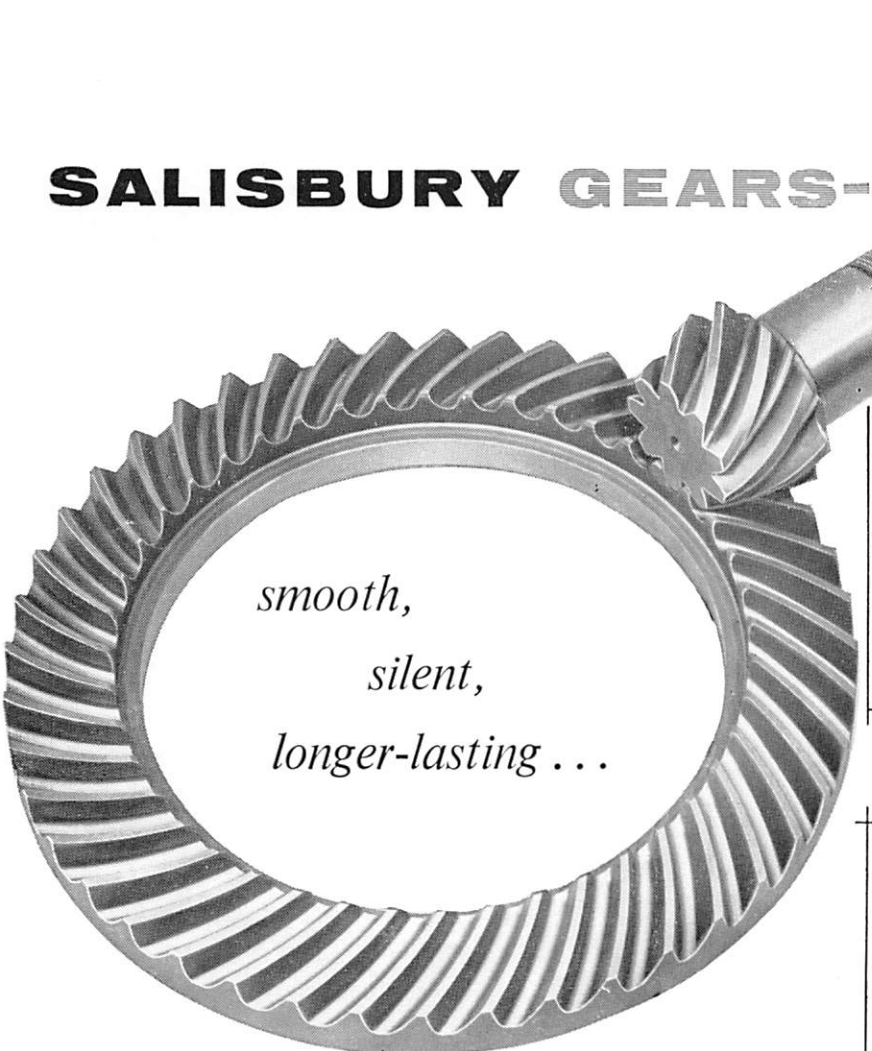

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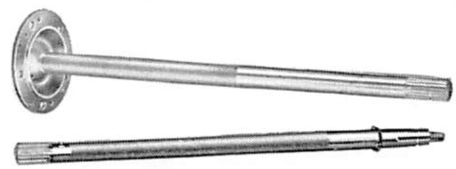

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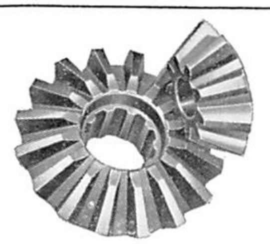

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MEETINGS AT 6, QUEEN SQUARE, LONDON, W.C. 1, AT 2.15 P.M., UNLESS OTHERWISE STATED.

December 9th, 1959

PAPER : " Developments in Tractor Transmission Systems and their Lubrication," by E. S. BATES, M.I.Mech.E., M.I.B.A.E., British Petroleum Co., Ltd. To be held in the Cromwell Hall, Earls Court, at 3 p.m. (during the Smithfield Show).

January 12th, 1960

PAPER : " New Methods in Silage Handling," by F. S. MITCHELL, B.Sc., and N. W. DILKE, N.D.A., National Institute of Agricultural Engineering.

February 9th, 1960

FORUM : " British Standards and Agricultural Engineering." Speakers to be announced later.

March 8th, 1960

PAPER : " Equipment for Milking and Milk Handling," by H. S. HALL, B.Sc., National Institute for Research in Dairying.

April 12th, 1960

PAPER : " Some Aspects of Mechanisation in Under-developed Territories," by W. D. RAYMOND, O.B.E., Ph.D., B.Sc., F.R.I.C., Technical Products Institute, Department of Scientific and Industrial Research, London.

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