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INSTITUTION NOTES

RELIEF OF INCOME TAX ON SUBSCRIPTIONS

THE attention of members is drawn to the following copy of a letter from the Senior Principal Inspector of Taxes. It will be seen that those to whom it applies should ask for Form P358 from their Inspector Taxes and complete and return it to him as soon as possible after 31st October, 1958.

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

October 8th, 1958.

Ref. : C1/SUB/182.

DEAR SIR,

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

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

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

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

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

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

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Yours faithfully,

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

The Secretary,
Institution of British Agricultural Engineers,
6, Buckingham Gate,
London, S.W. 1.

PEST SPRAYING AND DUSTING, WITH PARTICULAR REFERENCE TO OVERSEAS APPLICATION

by A. E. H. Higgins, A.R.C.S., D.I.C., A.M.I.B.A.E.
(Imperial College of Science and Technology).

A Paper read at an Open Meeting of the Institution on Tuesday, 14th October, 1958

SUMMARY

MAN'S health and food supplies are becoming more and more dependent upon the economical chemical control of pests and diseases. Such control must be applied efficiently wherever a problem is met. Each problem must be considered on its merits and a decision taken as to whether dry application (dusting) or wet application (spraying) is to be employed, and it is important that the right equipment is selected. This is often the most difficult decision to make, as many factors must be taken into consideration ; *i.e.*, terrain, type of crop, availability of water and of labour, facilities for maintenance and often the question of cost.

Attention is drawn to the fact that in many instances the design of new machines has enabled the use of chemical control to be introduced where it was previously found impracticable.

The types of equipment being operated overseas are discussed, with the criticisms which are most frequently made by the user.

THE use of chemicals to protect man and his crops from the attack of insects and various diseases dates back a very long way in history, but there has been a gradual increase in the use of chemical control since the nineteenth century, and considerable development has taken place since the last war in the application of chemicals—*i.e.*, in spraying and dusting machinery. It is estimated by some authorities that the depredations of pests and diseases at present take a very heavy toll of crops throughout the world, accounting for something in excess of 25 per cent. of the total. Consequently, it is very important in devising new chemical methods for the control of pests and diseases to have regard, not only to the toxic potentialities of the chemicals and their formulations, but also to take into account the method and manner of their application. It is important not only that these chemicals should be applied in sufficient quantity and in a suitable condition which will ensure that they act effectively, but also that in achieving these ends there is a minimum of wastage. Equally, consideration must be given to the cost of chemicals, equipment and labour, as well as to various other important items such as the area involved, the type of crop, the terrain, the availability of water, the prevailing weather conditions and a host of other local factors.

When we come to consider the use of spraying and dusting equipment overseas, the first and probably one of the most important aspects is the type of crop and the method of cultivation employed. Tropical crops differ a great deal from the kind grown, for example, in this country. The methods of cultivation and the areas involved differ very greatly. Roughly, one can split up the types of agriculture into those carried out by European growers, Government-sponsored agricultural schemes, commercial plantations under European supervision, and the peasant farmer growing a food crop or a cash crop and living entirely on a hand-to-mouth basis. There are not only large areas which may sometimes be grown under good cultural conditions—*i.e.*, straight rows, with adequate spacing between rows and reasonable soil and growing conditions—but also there is the peasant agriculture consisting of small plots of little more than quarter-of-an-acre. These are often hacked out of the bush and dotted about within a small area, very often with mixed cultivation and irregular planting conditions. Spacing is inadequate and there is very little attempt at straight lines. Quite apart from the differences in cultural methods which have to be employed with tropical crops, it is very important to bear in mind such things as transport and accessibility and the overall important factor of the availability of water. The availability of water is, of course, one of the deciding factors in applying sprays as opposed to dusts. Until the introduction of what we have come to call low-volume spraying, the application of chemical control in many tropical areas was almost entirely confined to the use of dusts.

The Use of Low Volume

It was not until the development of nozzles and machines, which were capable of applying sprays at relatively low dosage rates—that is to say, something of the order of 10–15 gallons to the acre or less—that chemical control became practical in many of the overseas territories. This does not mean to say that there was no spraying in the overseas areas at all. Nevertheless, since the introduction of the more modern techniques which have taken place over the last 10 years or so, there has, in fact, been a very great increase in the amount of chemical control carried out. Therefore, the demand for equipment to apply these chemicals is increasing and also the question of design and the purposes for which it can be used are becoming more and more important. Whereas I think it is true to say that most of the equipment available on the British market prior to the last war was designed for the home and European markets, much of the equipment available to-day is designed to meet needs in our overseas territories and many manufacturers are looking at specific problems with a view to meeting particular requirements.

The Suitability and Maintenance of Equipment

It is, however, of the utmost importance that the equipment is of the right type and that those responsible for using it have a proper understanding of the technicalities of the machines they are handling. During recent trips made to East and West Africa, more than once machines were seen which had been purchased for a specific purpose and subsequently were found to be totally unsuitable. On the other hand, machines which were quite adequate for the purpose intended had in many instances been abandoned as a result of lack of information and knowledge of their proper use and maintenance. This brings us to an important consideration—that of maintenance and repair, which is a widespread problem in overseas territories and is by no means confined to spraying and dusting machinery. Spare parts are not generally available locally, and although they can be ordered from the U.K., considerable delay is inevitable and more often than not the wrong item is received. Some agents will undertake simple repairs, but very few have proper facilities. In other than the larger towns, repairs are usually limited to local native metal-workers or tinsmiths and sometimes a garage, where work only of the most elementary kind can be undertaken. If, therefore, equipment other than the simplest expendible types is contemplated, provision must be made for adequate maintenance and repair. In order that he may carry them out effectively, it is also equally essential that the person responsible for this maintenance and repair has the necessary tools, knows how to use them correctly and has at least some idea of the basic principles on which the machine is constructed.

Comparative Advantages of Dusting and Spraying

Turning now to the equipment itself, the first thing to decide, of course, is whether application is best carried out by dusting or by spraying. The use of a dust has a great advantage over liquid, in that the water supply question does not arise. Furthermore, the chance of phytotoxic damage due to over-dosage is generally lessened, and it is advantageous with unskilled labour in under-developed countries that dust can be seen applied to foliage and the operator is able to watch exactly what is happening, whereas with a low-volume spray, in particular, it is not always quite so apparent.

Simple application equipment for dusting can often be used which is both cheaper and easier to maintain than spraying equipment, and it also often meets the needs of the small peasant farmer very much better. On the other hand, dusting can only be applied when favourable weather conditions prevail, and in tropical areas these are only generally found during the dry season, early in the morning or late in the evening. The morning is probably more suitable when foliage is still damp with dew and the dust has the best chance of adhering, but it must be remembered that the onset of the attack of pests, and therefore the need for chemical control, all too frequently coincides with the rainy season. As a result, dusts are rapidly removed by tropical rain, and then both time and materials are wasted and further applications have to be made. It can be argued that rain tends to wash the toxicant down into inaccessible parts of the plant, which may be of advantage in controlling some pests such as stalk borers, but this is of little value where good overall residual cover is required. In addition to rain, the action of wind must be considered. This is especially important in a dense crop where much of the dust is rapidly removed by abrasion as the foliage of individual plants knock and rub against one another. Finally, it is cheaper and often far more practicable to transport concentrated spray materials rather than large bulks of dust, and it is very difficult to store dusts under tropical conditions and ensure that they remain dry.

Storage of Dusts

This question of storage has probably resulted in more condemnation of dusting equipment than anything else. No machine, however well designed, will cope with a dank, caked mass such as occurs very often in the tropics after insecticidal and fungicidal dusts have been stored for a period between seasons. In this connection it would seem advantageous if machinery manufacturers and chemical manufacturers could work in closer liaison, as much of this trouble could be overcome if the dust were supplied broken down in small amounts in sealed plastic bags holding roughly the amount required to fill the container of the machine. A bulk supply of material in this form of packing can be opened and used as needed without any serious deterioration if not all is required at once.

Hand-Operated Dusting Machines

There is still a considerable demand for a well-designed and well-made rotary hand-duster either of the front-carried or back-carried variety. The back-carried machine is usually preferred overseas, in that dusting operations are often carried out in the early morning for reasons which I have already given. In pushing through wet foliage the machine very often becomes saturated with dew when carried on the chest, with the consequent troubles that arise from moisture entering and preventing the proper discharge of the dust. Much better protection is given if carried on the back. A very important part of equipment is, of course, the gearbox. This must be well designed, light in operation and proof against the entry of dust into the gears and, where possible, it should not require lubrication. I regret to say that many dusters of this type suffer from the fact that the gear-train is often so heavy in operation that one is reduced to a physical wreck if one attempts to operate the machine continuously for a period of 15 minutes or more. It is therefore important that the user must recognise that a well-designed and well-made gearbox will in itself cost a considerable sum of money, and that if he is seeking equipment which is easy and reliable in use, then he must be prepared to pay for that equipment and not necessarily look for the cheapest. I think, perhaps, this can best be summed up by the words used by Dr. Kearns when talking about the same problem at the Colston Research Society Symposium on Insecticides and Colonial Agricultural Development in 1953, when he said : " A hand rotary duster must last for ever, stand up to corrosive powders, never require repair and cost nothing." This statement would appear to apply equally well to spraying machinery as well as to dusting machinery.

Other Dusting Equipment

Larger types of dusting machines are occasionally required, usually taking the form of stretcher or pole-carried machines, sometimes, of course, barrow-type machines that can be pulled or pushed are also wanted. These are mainly required for tall bush and tree crops, and the great difficulty in their use is in getting the dust into the foliage rather than being carried away by wind and air currents. Also, with tree crops particularly, considerable heights are often involved, but, as I shall be speaking about this problem later, I will deal with it more specifically under Spraying. The demand for larger types of machine, which can be either mounted on a vehicle or trailed behind it, only arises with certain specific problems such as locust control where large areas may have to be dealt with as rapidly as possible.

Electro-Dusting

A recent advance in the technique of dusting is the introduction of electro-static precipitation, or what has come to be known as electro-dusting. As the dust leaves the discharge outlet of the machine an electro-static charge is imparted to the individual particles. This is brought about by the dust passing through an ionized field which is created by a coronal-type electric discharge taking place between a central probe and the metal outlet. This results in the charged dust particles tending to follow lines of electro-static force giving good dispersion of the dust cloud. Also, deposition takes place on all the surfaces, irrespective of the fact that they may face towards or away from the direction of the dust discharge. Furthermore, it is thought that electro-chemical forces hold the dust particles on to foliage surface. This has been borne out in field trials where not only very much improved cover on both sides of leaf surfaces has been obtained, but also the dust has with-stood weathering very much longer. It will endure rain and abrasion by wind very much better than deposits applied by the normal impaction method. The equipment for this technique can usually be fitted to any conventional power-operated duster by the addition of the equipment to produce the electrical discharge. This consists basically of a primary electrical source, usually a suitable generator driven from the duster engine, a special transformer and the discharge probe.

Spraying Equipment

Turning now to the question of spraying machinery, we find that interest is centred mainly on smaller equipment, principally knapsack, as well as stretcher and pole-carried machines. There are, however, still a very large number of hand sprayers in use overseas, not only to give protection from agricultural pests, but more important still to give protection to man himself against many of the insect-borne diseases. Space spraying in dwellings with hand sprayers is standard practice. These are often regarded as expendible items, and therefore the cheaper they are the better. The result of this policy is, however, that instead of producing the fine air-borne mist required to knock down flying insects, much of the material is wasted by the crude form of nozzles employed, causing spitting and heavy drops which fall to the ground. Owing to their light, flimsy construction, pump barrels are easily dented, rendering the sprayer useless and, especially in the hands of unskilled labour, pump rods become easily bent and distorted. The question asked to-day, of course, is why not use aerosol dispensers ? It is found, however, that in the hands of native house servants they are far too expensive and wasteful when used in the average bungalow regularly every evening. There is, therefore, a demand for a hand sprayer which will give a fine, mist-type of spray which will remain suspended, such as that produced by the aerosol dispenser without giving rise to spitting or undue fall-out. It must at the same time be robust and easy to operate. Hand sprayers are also used occasionally in agriculture where small areas may be involved, but more usually knapsack equipment is favoured. The reason for this is the importance of mobility. Often the simple hand-operated knapsack sprayer is preferred for low-volume application in conjunction with the fan-type jet. This kind of sprayer works especially well with unskilled peasant farmers, as it is possible to build up spraying pressure with a few rapid movements of the operating lever, which can then be easily maintained by further occasional pumps whilst they concentrate on the application of the spray. The compression-type sprayer is also used very widely, but with the introduction of low-volume spraying it has been found difficult to maintain even dosage owing to the falling-off in pressure during the operation of this sprayer and the inconvenience of re-pumping before it has discharged its total contents. This difficulty has been overcome by the introduction of the pressure-retaining sprayers. Also, the addition of a pressure reducing valve which can be used between the container and the nozzle will ensure that the total contents of the sprayer are discharged at a reasonably constant pressure throughout. These sprayers in particular are very suitable for battery operation. They are, however, criticised on the grounds that they are complicated and difficult to maintain and are not suitable to put in the hands of unskilled native labour. With adequate supervision and instruction they can be, and are, used quite successfully. Weight is very important, as many of these sprayers are heavy and uncomfortable to carry on the back.

Materials Used in Construction

Corrosion is another very important factor, for sprayers are often used with various chemicals—*i.e.*, fungicides as well as insecticides—and corrosion problems arise very quickly in the tropics during storage from one spraying season to the next. This aspect has, of course, concerned many other authorities and, in particular, the World Health Organisation. They have laid down specifications for certain equipment, including compression-type sprayers, which were based on requirements from actual spraying units in the field. Brass, silicone bronze, galvanised iron and stainless steel are listed. The last-mentioned is greatly preferred by the field units, and for this reason most of the equipment now used is constructed in stainless steel. Recently, in order to meet W.H.O. requirements, some British manufacturers have also turned to this metal. There is, however, no reason why other materials such as plastics should not be utilised, providing they meet the same specification requirements. Plastics have been increasingly employed for spraying machinery components and have certain well-known advantages. In particular, plastic containers can be constructed which are often lighter than those made in metal and will withstand abuse better, being less liable to denting. If constructed in a translucent material, the liquid level can be observed at any time. For this reason, the use of plastics would appear attractive, but there are still certain difficulties, such as cost and the fact that, although they stand up well to corrosion, some of the solvents used in the formulation of insecticides may attack this material. Their future utilisation, however, looks promising, and with the development of improved materials and techniques by the plastics industry it may well be that more and more will be introduced for the construction of spraying machinery.

Power-Driven Knapsack Equipment

Another type of knapsack which is becoming extensively used overseas is the motor-driven mist blower. These have been mainly developed on the Continent and are now being adopted in many fields of work, particularly where good projection is required. This is especially important where bush or tree crops are concerned, as these machines will enable the spray to be carried some 30–35 feet vertically in reasonably calm wind conditions. Another great advantage is that the kind of nozzle employed in these machines is less liable to blockage than the more conventional forms. With adequate supervision, successful operation has again been achieved by unskilled labour in overseas territories, and such machines have proved invaluable in many specific problems ; *e.g.*, cocoa spraying and tsetse control. They are, however, complicated pieces of equipment and therefore require adequate knowledge for their use and maintenance. Usually, small two-stroke engines of Continental make power these sprayers, and it does seem particularly unfortunate that no British engine manufacturer has so far produced a light two-stroke engine in the 50–90 c.c. range which will equal the performance of these Continental engines. It is, of course, very important that these power units be constructed in a light alloy, as the weight of this type of sprayer is the heaviest in its class. This equipment is criticised very often as being too cumbersome for use in under-developed countries and too tiring in operation over long periods in rough country. Unfortunately, recent models have tended to become heavier and bulkier.

Tractor-Trailed or Mounted Sprayers

The use of tractor-mounted or tractor-trailed machinery is the exception rather than the rule. The employment of tractors is gradually becoming more in evidence, and as mechanisation proceeds so they will be introduced more and more, but the difficulty in using tractor-trailed machinery is that so often the low clearance is likely to cause too much damage in densely and irregularly planted crops. Furthermore, crops are very often grown on slopes too excessive for the use of tractor-trailed machines, and on some soils they become bogged down very quickly. It must also be borne in mind that, with many crops, shade trees are important and these frequently form obstacles to their use. Tractor-mounted equipment, on the other hand, is becoming increasingly important, especially the mist-blower or low-volume type. The mist-blower is, of course, very valuable where tall tree crops have to be sprayed—in some instances up to heights of 60 feet or more. An example of this is the spraying of coconut palms for the prevention of nut fall. It would be quite out of the question to use any form of hydraulic high-volume sprayer owing to the difficulty of water supply and the impossibility of getting large machines into these crops. Again, it must be remembered that frequently the use of tractors is precluded because contour and tie-ridging are so often used in overseas countries for both soil and water conservation. Tractor-trailed or mounted machinery is, therefore, at present somewhat restricted to large plantations such as the Gezira scheme and possibly to some of the large coffee estates and mixed farms in European settlements (*e.g.*, Kenya). As mechanisation is gradually introduced, the demand for the tractor-mounted mist-blower will probably increase.

Finally, it is becoming more and more apparent that the essential features looked for by the user are, firstly, that the machine will do the job ; secondly, simplicity in use and ease of maintenance ; and lastly, reliability and soundness of construction.

DISCUSSION

Opening the discussion, DR. R. A. E. GALLEY (Tropical Products Institute) said he had recently returned from an international congress in Lisbon on the subject of malaria, and, apart from a few questions he wished to put regarding electro-dusters, would confine his remarks to the public health field.

Space spraying against malaria on the lines referred to in the Paper was confined almost entirely to urban areas.

To meet the real problem of rural malaria, however, it was necessary to rely on residual spraying of the insecticides, in order to provide a deposit which will last for several months and kill the adult mosquitoes when they enter the building. The idea was to spray the deposits on to the walls and thus break the transmission of the malaria, but, for a uniform deposit, one had to concentrate very carefully on where the nozzle was put in relation to the wall. So, for malaria control generally, machines which have to be pressurised constantly were not liked, while the procedure of one man pumping and another man spraying was uneconomical in labour.

Dr. Galley added that he had been rather disappointed at the Lisbon conference to note that, although spraying equipment manufacturers from other countries were present, he had not seen any from the United Kingdom. Yet it is at such conferences that manufacturers can learn of requirements and problems.

MR. J. BALL (Plant Protection, Ltd.) gave details of progress in Ghana, where, with only one cash crop, which is currently being attacked by a small insect, the authorities have been experimenting with machines and have evolved methods giving them really first-class control. Spraying experiments have lasted for three years and have covered 700,000 acres. With a decision now reached on a Government spraying scheme, moreover, some 14,000 men will deal with 2,250,000 acres of cocoa per year. The scheme will pay because it will mean from 100 to 600 per cent. increases in the crop. Mr. Ball also felt the Paper had been rather cautious about shoulder-mounted mist blowers, which, in his own view, would really alter the picture in tropical agriculture, and he wondered if Mr. Higgins had one or two specific machines in mind when saying that recent models have tended to become heavier and bulkier, since he himself had the impression that the latest machines were being reduced in weight and improving in performance. The Ghana authorities were allowing farmers who have bought mist blowers to go to a Government school for a five-day course of training, which included instruction on how to use the equipment, explanations of the difference between two and four-stroke engines, and a question session at the end.

An adequate supply of spare parts at a reasonable price is an important thing in such countries, after which fitters should be brought together and trained to maintain the mist blowers. Manufacturers here might note that, despite the idea that British-made goods can sell everywhere, Continental manufacturers can offer such machines on the spot at lower prices. A really competitive outlook is needed in what is already a very competitive business.

MR. R. C. AMSDEN (Chesterford Park Research Station) believed the question of maintenance in jungle areas to be very important and one that is not appreciated nearly enough by manufacturers in this country. As to a supply of literature for instructing people in the proper use of equipment, it should be written in the local language, since it is of no use in English to natives using another language. The foreign competition in this market is looking to such small details, and with success. The speaker further urged manufacturers to pay more attention to the possibilities of plastics, which are so often the better material, but so often completely ignored. In respect of the difficulties of projecting spray upwards, too, it was surprising that industry here has apparently not thought of using the gas turbine as a light-weight source of power for various methods of application. One thing lacking here, finally, is a supply of proper performance sheets for the vast variety of spraying machinery now available.

MR. P. HEBBLETHWAITE (N.I.A.E.) commented on the technical aspect of electro-static dusting, saying that it can safely be stated that it is possible thereby to get a higher proportion of dust on to the under-surfaces of the leaves and, to precipitate on the leaves a larger proportion of the fine particles in a dust mixture than would otherwise be the case. Generally the charge on the particles does not exist for more than a few minutes, and therefore any increase in durability of the dust deposit results from the above two factors, rather than from a lasting electrostatic attraction. Electrostatic charging equipment can be made to work under humid conditions; however, individual examples have not been properly made in this and other respects and therefore the principle must not be judged on the basis of field testing with one machine.

MR. R. T. KNOTT (W. T. French & Son, Ltd.), who referred to corrosion troubles with knapsack sprayers, suggested that, where pre-pressurised models are concerned, the operator may be carrying a small bomb around on his back, which might blow up and kill somebody. Chemicals produced nowadays are thought to be affecting brass more than formerly. In some recent cases of sprayers exploding during use, investigations have shown the cause to be corrosion resulting from the fact that the sprayer was not washed out properly after use.

MR. H. J. PLEASANCE (Colonial Spraying Machinery Centre) contended that there is a dual responsibility for manufacturers to find out what the user is going to put in his machine, and, on the part of the chemical companies, to make sure he has the right equipment to handle the chemicals being applied.

MR. W. NOLAN, chairman at the meeting, speaking on power units for mist blowers, expressed the belief that British manufacturers are fully capable of producing a two-stroke engine in the 50/90 c.c. range to equal the performance of Continental types. The factor upsetting the performance of an engine is not a matter of how well it is made, or its weight, but the way in which it is lubricated. As to blending the oil into the fuel, nobody has yet agreed on the ideal formulation, one maker insisting on a ratio of 12 : 1 and another on 1 : 18. Trouble in the field has come either through starving the engine of oil or oiling up plugs through over-generosity.

MR. R. COURSHEE (N.I.A.E.) declared the point that equipment manufacturers have used materials which are not resistant to corrosion from chemicals to be explicable, in that it is a deliberate policy, because manufacturers have to make a living. He had lately seen a knapsack sprayer with a galvanised lining which would be heresy from the corrosion viewpoint, but which was, nevertheless, good economics.

MR. HIGGINS disputed this argument, and, pointing out that a manufacturer has a reputation to uphold, said it was unlikely he would produce a machine deliberately in the knowledge that it will become useless in a fairly short time.

LT.-COL. J. R. HOBBS (Kestrel Engineering Co., Ltd.), dealing with the question of cost in production, remarked that, if they were given a free hand, manufacturers could make their machines last for ever. But, with the competition they are facing, they cannot afford it. In trying to break into the American market, and submitting an estimate for 200 knapsack sprayers, the speaker had quoted prices 25 per cent. under the trade price here, including delivery in Korea. He found his tender to be seventh on a list of twelve. As to underlying causes, the World Health Organisation is all right for the world, but American specifications are put forward overseas, and the Americans win every time.

A SIMPLE ROLLER CUTTER FOR TRASH DISPOSAL

by D. V. CHAMBERS,* B.Sc., A.M.I.B.A.E.

IN areas of marginal or unevenly distributed rainfall the problem of reducing the loss of soil moisture during dry periods is of considerable importance to the farmer. The loss of the equivalent of 2–3 ins. of rain by way of evaporation may very often result in the difference between a good crop and total crop failure. One approach to the problem is to maintain a cover over the soil in the form of a mulch in order to reduce soil temperatures and evaporation, as well as improving the organic matter which indirectly increases the water-absorbing capacity of the soil.

With the above factors in mind, a simple and inexpensive cutter-roller was designed and made from readily available materials at a cost of less than £20.

The roller consists of a hardwood log 8 ft. 6 ins. in length and 12 ins. in diameter, to which are bolted at intervals round the circumference six lengths of 3 in. × 3 in. × ¼ in. mild steel angle-iron, sharpened to a cutting edge. Two stub axles of ½ in. diameter (made by welding a disused crawler track pin on to a piece of ½ in. steel plate) are bolted to the ends of the log by means of eight 4 in. coach bolts. The stub axles run in two cast-iron bearings, which, in turn, are bolted to the frame of the roller, which consists of 3 in. × 3 in. × ¼ in. mild steel angle-iron welded in the form of a harness. The frame or harness has a conventional hitch to the tractor drawbar.

The main advantage of this piece of equipment lies in its simplicity and cheapness, and the fact that it can be made on the farm with the aid of gas welding equipment.

The roller should travel at about 4 miles per hour ; depending upon soil conditions, it may be necessary to add ballast to ensure that all trash is cut into short lengths. The roller has been used for cutting light bush regeneration in pastures. The draught of the roller is comparatively light ; a 23-h.p. tractor dealt with the load quite comfortably in third gear.

It is considered that the roller could be improved by the following modifications :

1. Increase in the diameter of the log from 12 ins. to 18 ins. in order to increase the weight and provide for a further two cutting blades, which would tend to reduce the amount of vibration during work.

2. The substitution of self-aligning bearings for the cast-iron bearings, since this would simplify the aligning of the stub axles to the ends of the log ; alternatively, the front axle from a disused truck could be adapted to form two suitable stub axles.

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FERTILISERS, ASSOCIATED MACHINERY, AND FUTURE TRENDS

by JAMES D. HENDRY, B.Sc. (Agric.), N.D.A., A.I.B.A.E.

A Paper presented at a Meeting of the Scottish Centre of the Institution in February, 1957

EARLY in the 19th century the various elements present in plants had been established. Carbon, hydrogen and oxygen, combining to form the various carbohydrates which comprise the great bulk of plant tissue, were shown to be derived from the atmosphere and from water, and not from organic matter in the soil. Nitrogen, which goes to form proteins, etc., was shown eventually to be derived by most plants from the soil, and from this source also came the various minerals such as lime, phosphate and potash which are essential for the build-up of plant tissues.

Leibig had the brilliant idea that if extra minerals were applied to the soil crop increases might be obtained, and he proved that this was so. He thought, however, that nitrogen was obtained from the air, and it was an English squire, John Lawes, who demonstrated that plants responded to nitrogen also when added to the soil. Lawes also followed up the use of acid on bones (a popular fertiliser at that time) to render the phosphate in them more available to plants, with experiments on rock phosphate. From this he produced superphosphate and set up the first factory to produce what is now the major source of phosphate to the farmer.

At this time also guano, the dried excrements and remains of sea-birds, rich in nitrogen and phosphate, started to arrive in this country from Peru and gave excellent results while supplies lasted.

To begin with, nitrogen supplies came largely from nitrate deposits in Chile and from a gasworks bi-product known as ammonia liquor, from which sulphate of ammonia was later produced. Eventually, methods were worked out to tap the enormous resources in the atmosphere (four-fifths of its volume), and now most of our supplies are from this source.

Potash beds were first discovered in Germany, and it started to be used in quantity as a fertiliser after 1870.

In the late '70s the value of the phosphate derived from iron ore, and present in steelworks slags, was discovered, and basic slag appeared on the market.

Since then fertiliser consumption has risen steadily, and the following table indicates this development :

FERTILISER CONSUMPTION IN U.K.

Year.		*Nitrogen* (N). *Tons.*	*Phosphate* (P_2O_5). *Tons.*	*Potash* (K_2O). *Tons.*
1913/14	..	24,400	183,000	23,400
1921/22	..	35,880	130,000	26,942
1931/32	..	56,830	121,830	49,586
1937/38	..	68,200	142,610	71,918
1955/56	..	291,300	385,800	305,400

The jump since the last war is very striking.

From figures obtained from experiments on all crops in all parts of the country, the most profitable fertiliser dressings have been arrived at, and from these the following figures are obtained for total fertiliser use :

N. *Tons.*	P_2O_5. *Tons.*	K_2O. *Tons.*
451,000	559,465	341,405

If, however, we were aiming at being self-supporting for food supplies, we might have to grow more of the highly productive crops used by market gardeners and reclaim more land. This would all lead to even higher use of fertiliser.

I do not propose to deal with machinery used in fertiliser manufacture, but to take you right on to the farm to consider the task of getting on to the land in the cheapest and most effective way these large quantities of plant foods.

We have, of course, our livestock, and the dung we get from them is also an important source of plant foods as well as a builder of humus, which is so beneficial to soil structure. It also stimulates biological activity, which is necessary to break down vegetable matter in the soil to the simple substances which plants can assimilate. I shall discuss the handling of bulky organic manures later.

Meantime, let us consider the task of handling the sum total of some 11 million tons of lime and fertilisers which our farmers are using annually at the present time. Of this total, lime in its various forms accounts for 7 million tons, some 80 per cent. of this being spread now by contractors. I suppose this has been an obvious development with a material which can be applied at almost any time of the year and which is relatively cheap per ton.

Around two-thirds of the total fertiliser tonnage now applied is in the form of compounds, the great bulk of which are now granulated. With these application is generally made by the farmer just before the crop is put in and a large increase in contract work cannot be foreseen.

With phosphate and potash fertilisers, however, such as mineral phosphate, basic slag, muriate of potash and their combinations, application can be made over the winter and spring months without much risk of loss, and into this field contractors are now entering.

The machinery used by contractors comprise mainly motor lorries with moving bottom and rear spinner distribution and tractor-drawn distributors with similar mechanism. Much excellent work is done, but these machines are heavy and can cause severe tracking and even damage to drains. Moreover, where the material being spread is of variable fineness they do not make an even job, the coarser particles being thrown farther than the fine.

On the first problem, that of weight on the land, a well-known manufacturer of such machines brought out a few years ago a lorry on tracks which seemed an excellent machine. It was withdrawn, however, as it would no doubt present difficulties in transportation and in track maintenance. Tracks, however, could surely be more widely applied to trailer spreaders with advantage. Have we fully explored the various methods of weight distribution—*e.g.*, mammoth balloon tyres or a simpler form of track when applied to a trailed vehicle as opposed to a driven one ? What possibilities would there be in heavy belting running on rollers if soil build-up could be avoided ?

On the second point, of uneven spreading, one answer lies in uniform texture of the material being applied. With lime and phosphate, however, fineness of grinding has a bearing on speed of action in the soil, and it is difficult to throw fine material any distance with a spinner. It is thrown out in a cloud, which drifts off in a wind to a varying distance. It will generally come to rest on dry land, but that land does not always belong to the farmer paying for the material ! Granulation might be an answer, but is probably too costly as carried out at present. If a suitable binding substance could be found, it might be possible to mix this in at normal temperatures and get the desired effect. The cementing material would have to break up rapidly in the soil to permit a return to small particle size.

Aerial Distribution of Fertilisers Discussed

Failing such a solution, I feel that the engineer should endeavour to produce a more efficient spreading mechanism for contractors' machines.

Before leaving contractors, I would like to mention one further field in which they are operating. This concerns the spreading of gasworks ammonia liquor during the spring and summer months, principally on grassland. From this liquor most of our sulphate of ammonia was at one time produced, but this process is now uneconomic in face of synthetic production of the fertiliser. The liquor, therefore, is now an embarrassment at many gasworks, and this useful source of nitrogen is in many cases being lost.

Contractors are spreading the liquid using simple machines comprising a tank with gravity feed distribution through pipes, which discharge at 9–12 in. spacing on to the land.

I now turn to the handling of fertilisers by farmers themselves. Fertiliser can arrive at the farm either as a so-called straight, supplying just one of the " big three " nutrients—nitrogen, phosphate or potash—or as a compound with two or, more usually, all three nutrients combined in varying proportions to suit individual crops. These compounds can be simply the powder straights mixed together and bagged after a setting period or granulated into fairly evenly-sized particles. The trend at the present time is to employ high-grade materials to arrive at compounds with higher proportions of each nutrient. This cuts down on handling and on storage.

Regarding the use of straight fertilisers, these are, of course, cheaper to buy than compounds supplying the same quantity of nutrients. The ready-made compound is convenient in use, particularly when granulated, but could the engineer be of assistance in helping the farmer more easily to handle the straights should he wish to do so ? I am thinking particularly of a mixer which might also have other applications—*e.g.*, concrete and cement, cereal seed dressing and food mixing. To prevent contamination, the design could incorporate exchangeable hoppers for the different jobs. Filling from a loft with facilities for bagging off at ground level would appear to be the most convenient layout for inside use.

Farm-mixed fertilisers have generally to be applied immediately, but advances have been made in conditioning straights which should prevent caking during the few days or weeks before application.

Fertiliser is generally packaged now in 1 cwt. paper bags, which are very convenient to handle and keep well if storage has been careful. Unfortunately, many farmers still store bags of fertiliser too haphazardly, and the resultant deterioration in condition tends to put them against the practice. It cannot be too strongly emphasised how great a help it is to all in the industry when farmers take delivery of fertilisers early. This prevents the rush of loading and delivery which takes place every spring and which causes headaches to the merchants and anxiety to farmers.

Let us now consider the machines available to put this fertiliser on to the land in such a way as to get the best possible use of it by the crop. A good deal of work has been done in recent years on fertiliser placement and the value of some form of concentration has been demonstrated for most of our arable crops. This means tha the ordinary fertiliser distributor is being more and more relegated to use on grassland. If more use was made of it on grass our production could be greatly increased, but that is another subject.

For cereals the old method of sowing of seed and fertiliser was by hand over the open furrow, followed by harrowing to cover. Depth of sowing was irregular, and when corn drills were developed they effected a great saving in seed. At first, however, fertiliser was still broadcast, and the wastefulness of this was demonstrated with the introduction of the combine-drill, which puts seed and fertilisers down the same spout. This led to some double the response to phosphate as compared with broadcasting and to an increased response to potash on potash-deficient soils. Nitrogen, being more mobile in the soil, is just as effective broadcast as placed in a special position in relation to the seed. I wonder, however, if we are correct in banding seeds and if they would not be better broadcast, if we could devise another method to ensure even depth of sowing.

With the potato crop, too, the agricultural engineer has developed machinery which has led, we hope, only temporarily to inefficient fertiliser use. There are still many planters available with no provision for sowing fertiliser in a band or bands close to the tubers, which means that the manure is broadcast before planting. This can mean a loss in crop of up to several tons per acre. When using planters having no fertiliser attachment (and this is an expensive extra on some machines, where it should be standard equipment), the best course is to open the drills first and sow the fertiliser over them before planting.

With root crops, the results of experiments have not been so consistent, but indications are that the best placement is in a band or bands to the side of and below the seeds. There is need here for close co-operation between the field experimenter and the engineer to develop the best machine.

On grass land the broadcast distributor still reigns supreme and through the years quite a number of mechanisms have been employed. Four types in common use to-day might be mentioned.

Firstly, there is the machine based on a series of revolving horizontal plates at the bottom of the hopper which carry the fertiliser out through an adjustable gate. Fingers mounted on a spindle flick the manure out of the plates on to the ground. The delivery rate is altered by varying the speed of the plates and size of the gate opening. This is a very efficient type, though not ideal from the point of view of cleaning.

A second type consists of two fixed slotted plates forming the base of the hopper, with a third reciprocating between them. Control of the sowing rate is by alteration of the speed and throw of the moving plate.

Thirdly, we have a machine with a spindle revolving in the base of the box with combined auger feed and ejector arms on it. Delivery is through adjustable holes in the base and the speed of the shaft is also variable. This machine is very easy to clean, as the delivery shaft is removable, but can give trouble with blockages when applying somewhat lumpy fertiliser, particularly at low rates per acre. Also, a very well-conditioned fertiliser can run uncontrollably out of the machine.

Lastly, we have the small centrifugal delivery machines, which are proving very popular at present. A hopper delivers a stream of fertiliser on to a rapidly revolving plate with baffles which throw out the material. The efficiency of these machines when handling lime and in windy conditions has already been mentioned, but with an evenly granulated fertiliser they can give excellent distribution and that over an appreciable width. This width of delivery presents difficulty during work in meeting up adjacent bouts, but this can be overcome by using marker poles.

What features do we look for in a fertiliser distributor ? I think we should place them in the following order of importance : (1) Even distribution ; (2) ease of cleaning ; (3) speed of work ; (4) ease of maintenance.

Even distribution is important because any wide deviation from the optimum dressing can mean waste of fertiliser and/or loss of profit.

Ease of cleaning would be placed first by many farmers and is a very important feature. This item can be greatly helped by design to eliminate awkward corners which hold fertiliser and to permit of easy dismantling where necessary. A related question is corrosion prevention, and this boils down to avoiding contact between fertiliser and corrodable surfaces such as gearing and screw threads. Non-corrosive metals or plastics might be used, but the former are expensive and the latter not too suitable as wearing parts. I wonder how far a combination of plastic for non-wearing parts and stainless metal for wearing parts might be feasible. The cost, of course, would be an important point with the farmer.

Cleaning by oxy-acetylene flame might be mentioned, as I understand special equipment is now available for this very efficient method.

On the question of speed of work we can get this by fast forward speed or wide spread. Both these factors lead to rapid fertiliser output, and to avoid frequent stops for re-filling the machine should have a good capacity. Ten cwts. or more would not be too much, particularly where a heavy dressing is being applied.

In the ideal machine, then we want accurate work with fertilisers in reasonable condition, fast work with few stops, easy cleaning, the minimum of corrosion and easy maintenance.

A suggestion which might make a point for discussion would be that a more positive feed might be employed. At present, gravity replacement of sown fertiliser is almost universal, with the exception of moving floor trailers. There was a machine made where the box carried the fertiliser upwards against a revolving spiked roller, and this machine could handle any type of fertiliser. A snag was the delay in delivery at the start owing to the manure settling in the box.

I should like to make brief mention now of liquid fertilisers and their possibilities. I have already dealt with ammonia liquor, which may have greater application in this country. In the United States ammonia, with 82 per cent. nitrogen, is injected from tanks into the soil, where it is well retained by the colloidal particles without much loss. Liquid complete fertilisers based on urea, ammonium phosphate, phosphoric acid and potassium salts are also becoming increasingly used over there, though no definite yield advantages have yet been established. They are, however, easy to store, transport and apply and may justify use on this basis. Special placement in the soil may also be easier than with solids. The problem of corrosion is increased and also the possibility of scorch when applied to grass and other growing crops.

In recent years much has been learned about and there has been greater interest in the minor and trace elements in plant nutrition, and it may well be that they will assume greater importance in the future. I mention this aspect of the subject more as a point of interest than as an engineering problem. Even now boron is being applied regularly to the turnip crop and cereals are being sprayed with manganese. The soil's magnesium supply is being considered in connection with certain losses of livestock attributed to a deficiency of the element in the blood of the animals. I do not, however, foresee much difficulty if we have to, as might happen, apply regular amounts of these elements as part of our fertiliser programme.

I should like to turn finally to the task of handling the vast quantity of dung produced annually by our livestock, cattle in particular, and also pigs and poultry. I would say right away that I do not subscribe to the belief in any magical quality in this material, though it may contain certain growth-stimulants apart from its content of normal plant foods. I have already mentioned the value of dung in forming humus, which renders good drainage and also moisture-holding capacities to the soil. We must remember, however, that we can grow crops without humus, without soil in fact, which can yield as heavily as any raised by the usual method.

Furthermore, much can be done to maintain reasonable humus levels by ploughing in of good grass swards, green crops and crop residues. As long as we have our stock, and in particular have them under cover, we shall have their manure to handle, and the engineer has already done much to lighten this task.

Mechanical handling, both for loading and spreading, is well covered. The principal machines used are tractor-attached fork lifts, moving floor trailer spreaders with revolving beaters to spread the manure, and smaller machines which spread from ehaps in the field.

On dairy farms the dung is removed regularly from the byres and stored in bulk in the steading. I wonder if there would be an application for any form of self-emptying store for dung in the farmyard. Some farmers, of course, put the byre dung directly into spreaders, which are emptied periodically in the field, but two objections to this are strawiness of the dung and wastage if the material is left to lie without being ploughed in.

With beef cattle regular bedding in the yards leads to an accumulation of rich dung, which is often turned over into a field midden before final application. If this system is to be continued, no great simplification of the work can be foreseen. One method used with success, however, is to winter the cattle in temporary shelters in the field, erected near a straw stack for bedding and adjacent also to a silage clamp or to hay. Feeding is simplified and the dung is left nearer to where it will be used.

I have touched then on most aspects of manuring as they affect the agricultural engineer, and if I have started one of them thinking on a line of improvement, then this paper will have served its purpose.

NATIONAL DIPLOMA IN AGRICULTURAL ENGINEERING

Diplomas awarded in 1958 were presented to a number of successful candidates at a meeting held at 6, Buckingham Gate on October 14th.

Mr. J. S. Robertson, winner of the " Johnson " Medal this year, was presented with the medal by Lt.-Col. Philip Johnson, C.B.E., D.S.O., M.I.Mech.E., Hon. M.I.B.A.E., the Founder President of the Institution.

Left to right—Mr. Robertson, Mr. W. J. Nolan (Vice-President) and Col. Johnson.

ASPECTS OF MODERN LUBRICATION FOR AGRICULTURAL EQUIPMENT

by W. J. Nolan, M.Inst.Pet., M.I.A.B.E.

A Paper read at a Meeting of the Western Centre of the Institution on the 17th November, 1958

DURING recent years many references have been made to the country's increase in mechanisation, and it is interesting to note that in 1957 consumption of all petroleum products by the agricultural industry exceeded one million tons.

The greater portion of that tonnage was consumed as fuel to produce mechanical horse-power, and it is against this background of production we can discuss some aspects of modern lubrication vital to the successful operation of farm machinery.

The oil industry with its resources, both in research and technical development, is adequately equipped to meet changes in the agricultural industry and the requirements of the manufacturers of farming equipment. At the same time, its specifications may be adjusted to meet the practical needs of the market.

The successful activities of British manufacturers in the export market and the increased use of farming equipment throughout the colder months of the year has not only influenced lubricating oil requirements, but has led to changes in specifications that offer the consumer a number of advantages.

The farmer/consumer has been attracted by the new premium quality oils that have been introduced during the last few years, for he knows the suppliers' research experiences are behind the products, as well as knowing that they have the official approval of the manufacturer or engine builder.

For example, the introduction of a multi-grade or multi-purpose engine oil, with its ability to give a superior performance over a much wider temperature range (30° to 90° F.) than is possible with a conventional oil, means that the farmer with a fully mechanised farm is given the choice of being able to use one grade throughout the year.

One of the reasons why so much importance is now attached to a manufacturer's approval is the fact that costs of new tractors, power-driven implements and dealers' servicing charges have risen, whilst in the export market it has proved to be a positive guide to the operator to use the right type of oil. The premium paid for high-quality oils, carrying a manufacturer's approval, is nothing more than a low cost investment that will prevent wear and maintenance costs from rising.

If we now consider the modern or "all-purpose" tractor, we find that it has been designed to meet the requirements of home and overseas markets and has become a most versatile unit for use throughout the year. At this point, it is convenient to mention some operational factors that have a bearing on modern lubrication :

1. Operators' marked preference for diesel power.
2. Low temperature operation, especially starting of engines at temperatures less than 32° F.
3. High temperature operations.
4. The introduction of high/low speed gearboxes and planetary gears.
5. Hydraulics.

These operational factors may now be discussed.

Diesel Power

The diesel engine offers many advantages, for its superiority in performance over the V.O. or petrol engine, expressed in terms of higher thermal efficiency and reliability, has been confirmed by the farmers' marked preference to use diesel-powered tractors, implements and stationary units.

On the question of maintenance, it has long been realised that it is an essential requirement to use only clean fuel and to have the fuel injectors serviced at regular intervals, but, more important still, is the fact that ignition and combustion of fuel are dependent solely on the temperature of the compressed air ; therefore, lubrication of pistons and rings will always remain a significant factor in the successful operation of a disel engine.

Accepting the fact that lubrication of a diesel engine is more exacting, nevertheless, home and overseas requirements have been met by extensive research and testing, with the result that carefully-balanced formulations contain the very latest developments in the use of additives that remain fully compatible under a wide range of operating conditions.

The performance of a crankcase oil, described as "heavy duty, detergent or additive type," must at least meet the minimum requirements acceptable to engine builders. The majority of manufacturers have tended to regard the following British and American specifications as "paper" standards, but they only ensure a minimum quality :

British—DEF. 2101B. or B.S. 1905.
American—(Military) MIL-L-2104A.

Fuel

In areas overseas, where the quality of fuel is less rigidly controlled and the sulphur content is higher—*e.g.*, 0·5 to 1·5 per cent.—oil suppliers in those areas market crankcase oils to a higher level of detergency, and these are known as "superior lubricants," or classified as Series II or III. Such oils are recommended by some of the principal American manufacturers to safeguard their engines against the deleterious effects that may be caused with fuels having a high sulphur content.

For the home or the domestic market, the ignition quality of diesel fuel is maintained to a high standard, but, in spite of this, the fact that combustion chambers differ in design makes it inevitable that, under some conditions of operation, crankcase oils will have to deal with higher proportions of undesirable products from incomplete combustion of the fuel.

A satisfactory diesel engine lubricant should be able to perform the following important functions satisfactorily :

1. It must form a satisfactory lubricating film between working parts and must prevent wear.
2. It must form an effective seal between the piston rings and the cylinder walls.
3. It must dissipate functional heat and heat of combustion from the engine.
4. It must be free-flowing and provide ease of starting at low temperatures.
5. It must prevent combustion soot and oxidation products from accumulating and it must flush away contaminants.
6. It must not cause corrosion of working parts.

To carry out all the above functions, a diesel engine lubricant must possess :

(*a*) Detergent/dispersant properties so that lacquer deposits are not allowed to form in piston ring grooves and combustion soot is prevented from settling into oil-ways, etc.

(*b*) Good resistance to oxidation so that the oil does not thicken in use and develop acidity.

(*c*) Good wetting properties so that adequate protection is given to all moving parts.

(*d*) Anti-wear properties and ability to prevent scuffing of valve gear, cam followers, etc.

(*e*) Good viscosity/temperature characteristics so that the oil flows freely at temperatures below 32° F. and yet is sufficiently viscous to provide good lubrication at the highest temperatures reached.

To meet the manufacturer's high production rate of engines, the metallurgist has successfully produced a range of hard materials with good wearing properties ; *e.g.*, chrome-plated " wet " or " dry " cylinder liners, chrome-faced piston rings, hardened crankshafts, etc. All these components have high finishes and their wetting characteristics can be quite critical, with the result that, unless covered adequately with oil, either scuffing or incipient seizures can occur, particularly during the early life of an engine.

The inclusion of suitable constituents in the lubricant has solved this problem ; in practice, however, the " mating " or " running-in " period of an engine, before maximum power can be produced, has been extended. The reason for this lies in the fact that these new oils provide a positive film between the surfaces of the piston rings and liners ; where chrome-plated rings are used, the hardness of the material delays the " mating " of the ring to the liner. In some instances, the initial consumption rate of oil may be higher than anticipated and will remain so until the rings have settled down.

The effective wetting and protection given to all the moving parts, plus the use of detergent and anti-corrosion additives, means that the rate of wear is reduced and internal cleanliness maintained. This enables farmers to run their diesel-engined tractors for thousands of hours without overhaul.

In the event of an oil supplier adjusting the formulation of an oil to meet a change in market requirements, the customer's interests are safe-guarded by the fact that manufacturers may require the oil to be re-tested ; this is most likely to occur where, for example, a manufacturer has introduced modifications of his own. This point can be illustrated by referring to a particular case of a manufacturer and an oil supplier who, between them, mutually agreed to test a modified engine with a newly-formulated oil to confirm that the changes introduced were capable of withstanding the severest conditions of operation likely to be experienced at home and overseas. A test of this kind is a lengthy procedure, for it involves running an engine in a laboratory for a period not less than 1,000 hours. The reason for this is that, to be able to make a fair assessment of the performance of one oil, a comparison must be made with another of known high performance—*i.e.*, a reference oil.

Before commencing an oil test with a new engine, first of all it must be " run in " and its maximum power output stabilised. This may take as long as 80–100 hours. The next stage is to clean the engine thoroughly and measure all working parts very accurately ; *i.e.*, cylinders, crankshafts, pistons, etc.

Meanwhile, the procedure for running the engine under cyclic load conditions will have been prepared ; this may be an 8-hour cycle, operated and controlled by an automatic unit, enabling the engine to be run continuously for a 5-day week. The automatic unit will vary the load on the engine from time to time and may include a period of idling—say, for 15 minutes. In other words, the test cycle is representative of conditions likely to be experienced when a tractor is at work in the fields. At 24-hour intervals, the engine may be stopped for purposes of checking the oil level and the cooling water.

Throughout the test, the consumption of oil and fuel will be recorded accurately and oil temperatures kept constant and the breathing of the crankcase measured. This last item is quite important ; it is usually carried out by coupling the crankcase breather to a meter, one similar to a domestic gas meter.

The rate of breathing expressed in cubic feet per hour will vary from engine to engine. In the event of a marked increase in breathing being maintained, this would indicate that the performance of the compression rings had been changed and further increases of gas blowing past the pistons would eventually lead to overheating and subsequent sticking of the piston rings.

At the end of the first run of 4–500 hours the engine will be stripped and with the utmost possible care each piston removed, for it is on the condition of the rings and piston skirts so much depends. The engine will then be rebuilt with new components and the test repeated and, on completion of the second run, both sets of pistons will then be compared and the individual assessment carried out by a standard procedure—thus each piston will be given a merit rating for both oils.

A final report will then be prepared recording the condition of the pistons, as well as other components, such as valve gear, timing gears, crankshaft, etc. When the manufacturer is satisfied with the performance of the oil, it may then be approved officially.

From all this it will be appreciated that in cases where the performance of an oil is to be assessed accurately it is a costly procedure for which there is no substitute.

Low Temperature Operation

In Scandinavia, as well as in this country, starting problems have been increased with the swing over to diesel power. No doubt, the reason for this is that their tractors are being used more during the colder months of the year. The amount of electrical energy required to start, say, a 40–50-b.h.p. engine can be measurably increased when the air temperature falls to 32° F. or below. Ease of starting is determined by the cranking speed required to raise the temperature of the compressed air high enough to ignite the fuel.

As soon as cranking commences, much of the heat during the first few revolutions of the engine is dissipated to the chilled combustion chamber. Unless sufficient electrical energy is available, any reduction in cranking speed may delay starting and cause batteries to become exhausted.

To remove this possibility, the majority of engines are fitted with a starting aid either in the form of de-compressors, capsules, or glow plugs in direct contact with combustion chamber, or, alternatively, a fuel injection and heating device may be fitted to the air induction manifold. Even so, starting at low temperatures can still be difficult if consideration is not given to the increase in viscosity of the oil.

The increase in fluid friction can best be illustrated by comparing the typical oil visocisities at 70° F., 32° F. and 0° F.

*Viscosities.**	*S.A.E.20W.*	*S.A.E.10W.*	*S.A.E.5W.*
70° F. Redwood No. 1 secs. ..	850	325	220
32° F. Redwood No. 1 secs. ..	4,500	1,320	750
0° F. Redwood No. 1 secs. ..	30,000	6,500	3,500

* By extrapolation.

The courses open to a manufacturer who may be in difficulty with starting at low temperatures are :

1. To fit more powerful batteries and a larger generator.
2. To use a lower viscosity oil that will reduce fluid friction.

The latter course is the most acceptable and has been adopted by the majority of manufacturers and engine builders. By extensive testing of engines in a cold chamber at temperatures ranging from 20° F. to 0° F., ease of starting has been proved possible with an S.A.E.10W. oil ; below 0° F., an S.A.E.5W. is required.

The importance of using an S.A.E.W. (Winter) classification is that limits are imposed to control minimum and maximum viscosities at 0° F., as well as a minimum at 210° F.

Whilst an S.A.E.5W. oil will enable an engine to be started under extreme cold conditions, thereafter it must be capable of meeting all the requirements at working temperature. With an S.A.E.5W. oil, cases of piston scuffing have occurred and some manufacturers therefore prefer not to use this grade, but to recommend an S.A.E.10W. oil and dilute it with 10 per cent. kerosene where starting conditions are known to be extremely difficult.

The objections that have been raised against 5W. oils and the principle of diluting S.A.E.10 oils have now been overcome successfully. Manufacturers have recently approved a new multigrade diesel lubricant classified as 5W./20, which is now available overseas. This grade will help materially to overcome the difficult conditions of the past and enable tractors in Scandinavian countries to be used for transport and to keep trunk roads open.

High Temperature Operations

Turning from low to high temperature operations in tropical or semi-tropical areas—*e.g.*, the Sudan, Pakistan and India—tractors may be required to work in a dusty atmosphere at temperatures between 90° F. and 130° F. Under such conditions, it can be envisaged that lubrication of tractor engines is not an easy problem, since, apart from the effects of high ambient temperatures, the ingress of dust, in minute particles, will quickly contaminate oil and cause excessive wear. Also, the cooling of an engine may not be sufficient to prevent the temperature of the crankcase oil from reaching a point where excessive thinning out takes place and where the viscosity of an oil is too low reduced ability to form an oil film may cause bearing failures.

In the past, extreme high temperature conditions have been met by operators using an oil of higher S.A.E. classification—*e.g.*, S.A.E.40 replacing S.A.E.30. To-day, the latest developments have made it possible for such areas to operate tractors on a multigrade crankcase oil classified as S.A.E.20W./40. This new grade of oil possesses unique advantages ; through the medium of special additives, its resistance against the effect of increases in engine temperature is most effective and oil pressure remains more constant.

Some of the additives which are used in modern lubricants are expendable ; therefore, it is erroneous to assume that a premium quality oil can remain in the crankcase for a longer period than that recommended by the engine manufacturer. Allowing an oil to remain in service too long may lead to partial sticking of piston rings and any increase in temperature resulting from " blow-by " will cause carbonaceous deposits to form and to bring about a serious loss of power ; in extreme cases it may even cause a seizure.

Transmission and Hydraulics

Having dealt with engine lubrication, we should now consider the requirements of transmission and hydraulic systems. Modern tractors may be fitted with a high/low six-forward speed gearbox ; a more recent model incorporates a planetary reduction gear at the output end of the main shaft. In all cases, the hydraulic pump and circuit are an integral part of the transmission and can be satisfactorily lubricated with one grade; *e.g.*, S.A.E.90 transmission oil or S.A.E.40 engine oil. The volume required may vary according to type and make of tractor from 7 to 14 gallons.

In cold weather (less than 40° F.) the temperature increases the viscosity of the oil. This increases fluid friction, with the result that oil drag makes gear engagement sluggish; furthermore, unless the clutch is disengaged, the starting load of an engine is increased.

A practical example of temperature/viscosity changes can be illustrated in the following manner:

In March, 1958, air temperature readings taken at Ross-on-Wye showed the monthly average between 6 a.m. and 12 noon to be 35/43° F. At those temperatures the viscosity readings of a typical S.A.E.90 transmission oil would read:

*Viscosities.**			*S.A.E.90 Gear Oil.*
(Redwood I.)	At 43° F.	..	17,000 secs.
	At 35° F.	..	26,500 secs.
	At 32° F.	..	32,500 secs.

* By extrapolation.

At similar temperatures, the efficiency of the hydraulic pump is equally affected.

As oil visocisty increases, lifting of a fork or the tipping of a loaded trailer may be prevented by the "blow off" valve coming into action. Likewise, the rate at which oil returns from the lifting rams or jacks is noticeably slower; thus the working rate is only improved when sufficient heat, caused by the action of the gears churning the oil, has been generated to raise the working temperature of the oil.

In contrast, American and Continental designed tractors are equipped with "live" engine-driven hydraulic pumps that are supplied with oil from separate reservoirs and, according to temperature, may be filled with either an S.A.E.5W. or 10W. hydraulic oil. From this, it will be seen that the efficiency of their hydraulically-operated equipment is virtually unaffected by changes of temperature. These comments can be applied equally to tractors that are fitted with powered steering.

The disadvantages affecting the working rate of hydraulically-operated equipment could be resolved by replacing conventional transmission oils with a multi-purpose engine oil. Further developments may confirm this, for an oil of this type possesses adequate strength to carry the loads imposed on the gears, as well as being able to give better resistance against corrosion, and in cold weather viscosity changes would not affect the working rate to the same extent. This latter point can best be illustrated, firstly, by making a comparison of the viscosities between a conventional S.A.E.90 transmission oil and a multi-purpose engine oil at the temperatures previously mentioned, and, secondly, referring to unpublished work carried out by the National Institute of Agricultural Engineering.

*Viscosities.**			*S.A.E.90.*	*M–P Oil.*
(Redwood I.)	At 43° F.	..	17,000 secs.	2,700 secs.
	At 35° F.	..	26,500 secs.	4,000 secs.
	At 32° F.	..	32,500 secs.	4,500 secs.

* By extrapolation.

From an unpublished report on the low temperature performance of a typical hydraulic system, the results have shown that with a lighter oil in the transmission the output of work expressed as a "percentage increase" is higher. The working cycle consisted of loading a 3-ton trailer with a front fork loader, hauling 500 yards, tipping, and the trailer body being allowed to drop on the empty return journey; 5 minutes were also allowed for hitching and unhitching.

Under ambient temperature conditions almost the same for each tractor, the test procedure was to complete three load cycles with tractor B and trailer and then allow this tractor to stand while three loads were delivered with the tractor A. In each case, this took approximately one hour.

After a 2-hour break the procedure was repeated, and during the next period four loads were delivered with the first tractor and four loads with the second tractor. Following a 1-hour break, each tractor delivered two more loads.

TABLE I
Minimum Temperature during Previous Night, 24° F.
Overall Rates of Work (Test 4 Ambient Temperature during Work, 31–36° F.)

Loads from Start.	*Loads/Hour.*		*% Increase with Multi-Purpose Oil.*
	Gear Oil 90.	*Multi-Purpose Oil.*	
	Tractor B.	*Tractor A.*	
1	2·74	4·29	56·5
2	3·33	4·46	33·9
3	3·71	4·46	20·2
	Two-Hour Break		
4	3·45	4·19	21·4
5	3·82	4·40	15·2
6	4·10	4·40	7·3
7	4·31	4·40	6·5
	One-Hour Break		
8	3·61	4·40	21·9
9	4·04	4·40	8·9

From this table it will be seen that as the viscosity is reduced, caused by an increase in temperature of the transmission oils, the percentage increase in output of work falls but still remains in favour of a lighter oil.

Thus, under low temperature conditions the efficiency of British tractor transmission/hydraulic systems could be materially improved without incurring any disadvantages at elevated temperatures.

In this talk on some aspects of modern lubrication, the aim has been to illustrate the important role undertaken by the oil industry in meeting the needs of a highly mechanised industry and to make it known that the technical services of an oil supplier are always available to the consumer. It is through this medium that every effort is made to assist the consumer to get the best possible performance from his engine and the lubricants he buys.

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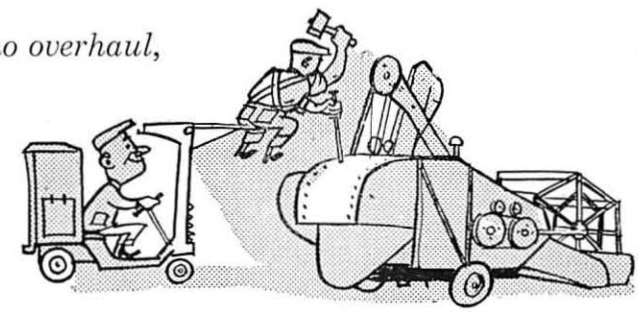

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