JOURNAL AND PROCEEDINGS OF THE

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

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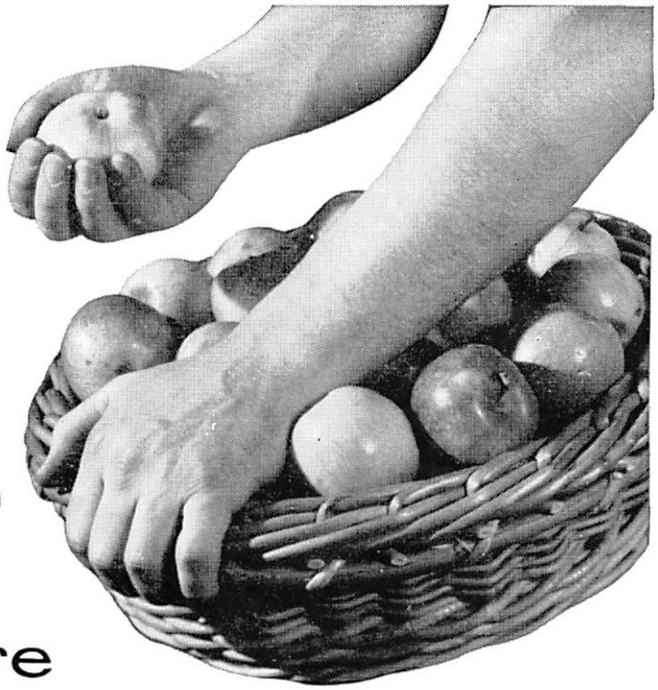

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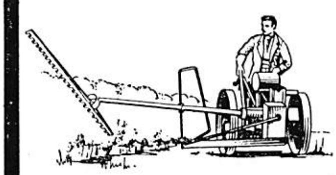

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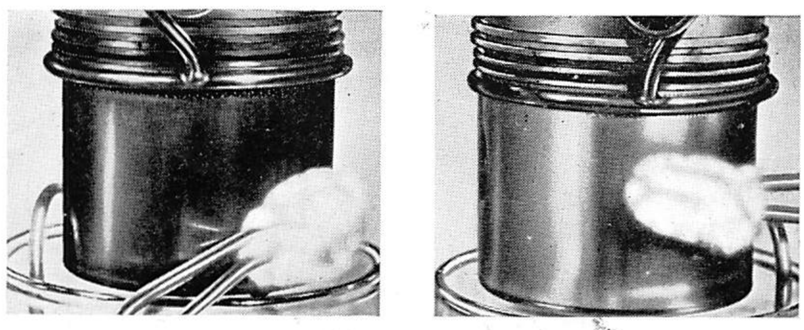

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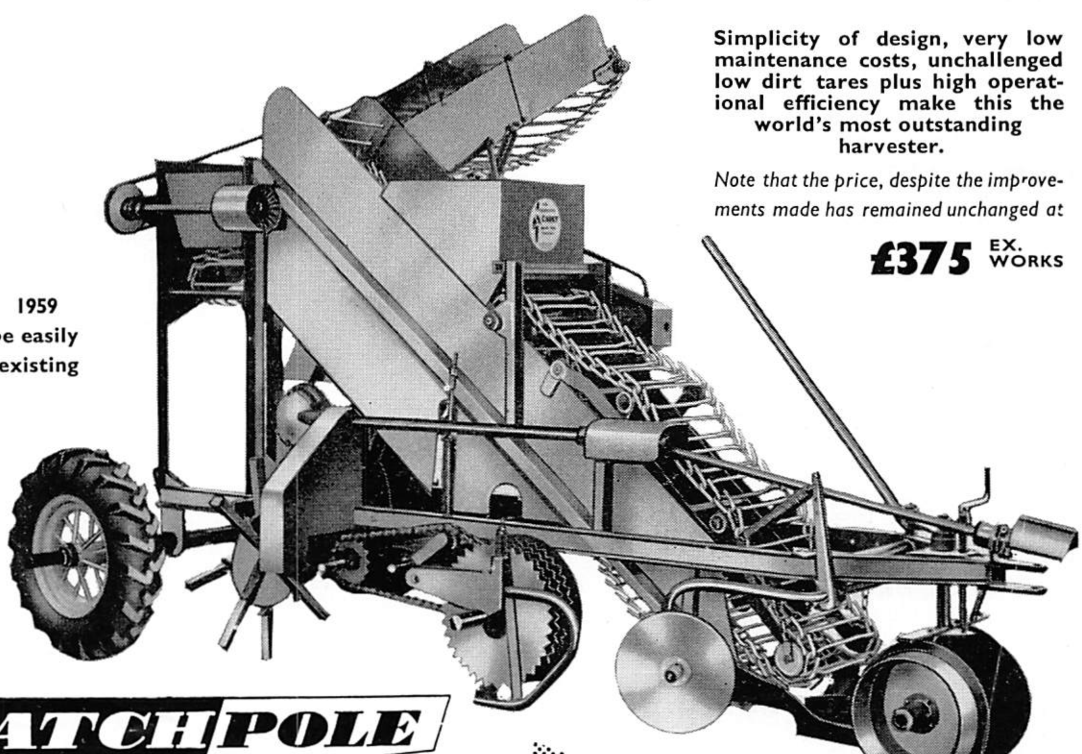

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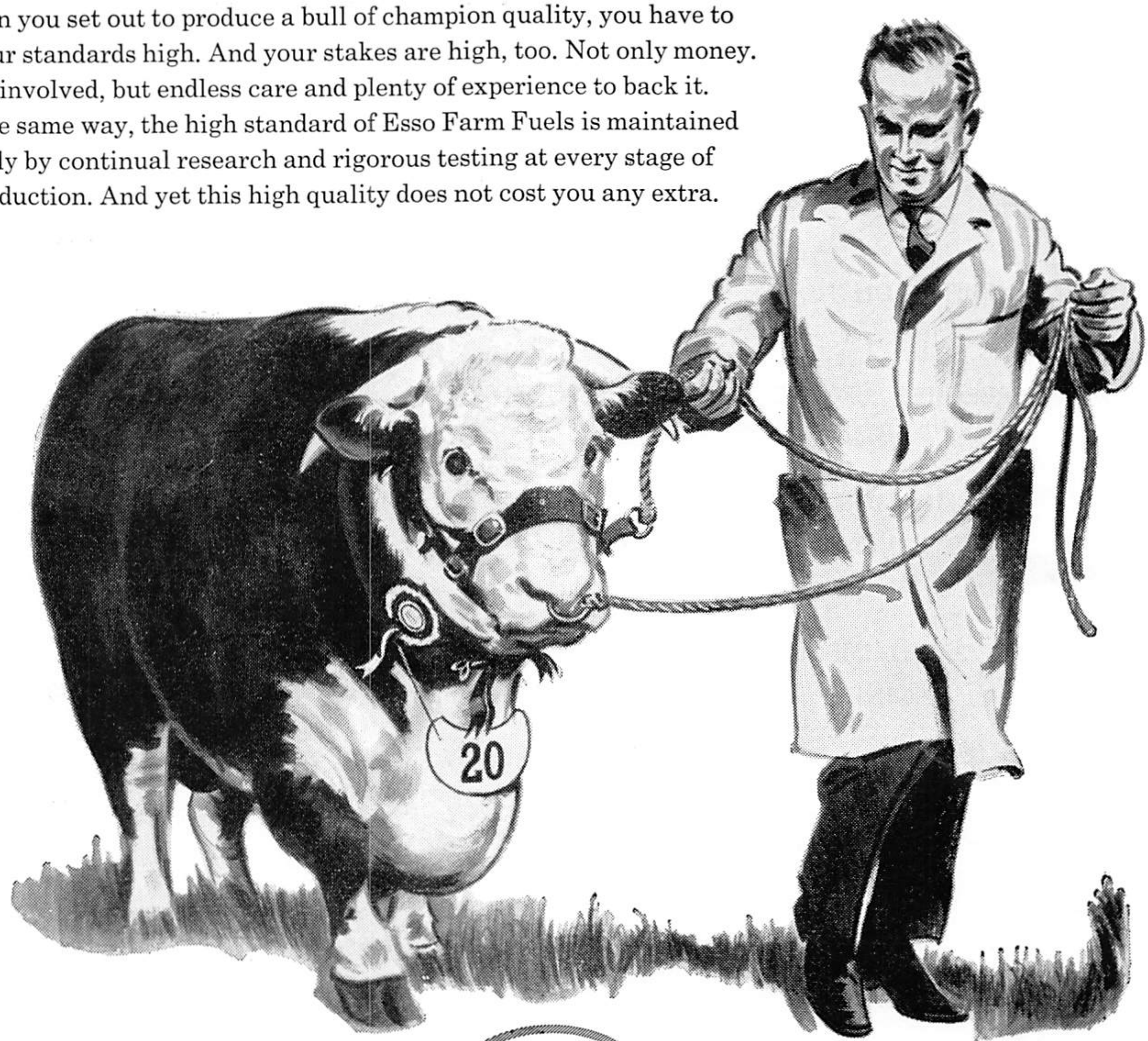

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INSTITUTION NOTES

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The Journal

Publication of this issue, which should have been received by members during the first week in August, has been delayed because of the dispute in the Printing Industry. Normal publication dates will be resumed with the October issue.

Annual General Meeting

At the Annual General Meeting on 1st May the Council's nominations for the Council for 1959–60 were confirmed. The new Council will take office on 13th October next, when its meeting will be followed by the Presidential Address of Mr. W. J. Nolan. It is hoped that as many members as possible will be present on the latter occasion.

Presenting the Annual Report of the Council, the President referred to the progress made in attaining more of the Institution's aims and objects. He mentioned in particular the stablishment of the National College of Agricultural Engineering, the Incorporation of the Institution, the continued growth in membership, Income Tax rebate on subscriptions and the larger attendances at Open Meetings, both in London and the Local Centres.

The Hon. Treasurer, Mr. W. J. Priest, in presenting the accounts in 1958, was able to report a small surplus on the Income and Expenditure Account, and added that a further investment had since been made—that of £500 in Corporation of Barking 5½ per cent. mortgage loan.

Mr. Priest said that advertising revenue from the Journal had increased substantially, but that more was needed if the annual deficit on the publication was to be reduced to a point at which it would be possible to think of providing more editorial matter and an increased service to members.

The President-elect, Mr. W. J. Nolan, said that although the President did not retire until October, he was sure that members present would wish to express their appreciation of the services renered by Mr. Chambers in his term of office, during which so much had been accomplished. Mr. Nolan's comments were endorsed with acclamation.

New Office Premises

THE removal from Buckingham Gate to No. 6, Queen Square took place at the end of June. The new offices provide additional staff accommodation, and a Council and Committee room. There is a lecture hall on the premises suitable for use for Open Meetings, and it is intended that most of these meetings will be held there during the coming session.

The offices are easily accessible from most of the railway termini, Holborn and Russell Square Underground Stations being within a few minutes' walking distance.

The Council are hopeful that this move will be the last for some considerable time, the additional space acquired providing room for planned expansion as the Institution grows.

A small room has been prepared for the use of members when in London. On prior application to the Secretary, this will be available for appointments.

Donations to Committee Room Furnishings

A number of donations have been received to date, and the total sum received will provide a substantial contribution towards the furnishing of the Committee room. The list of contributions has not yet been closed, so that those members wishing to do so may still be associated with the project, and with the provision of a Chairman's chair to commemorate the Institution's Founder President, Lt.-Col. Philip Johnson.

Election of Honorary Member

The Council has elected Sir Alexander Glen, K.B.E., C.B., M.C., an Honorary Member of the Institution. Sir Alexander, who recently retired from the position of Permanent Secretary to the Scottish Department of Agriculture, has for many years been actively interested in I.B.A.E. work in Scotland, and his invaluable help and advice have always been available to the Scottish Centre. A brief biography appears on page 76

SPEECHES AT THE ANNUAL LUNCHEON

Held in London on May 1st, 1959.

THE PRESIDENT : We are very fortunate this afternoon in having with us as our principal guest The Right Hon. Geoffrey Lloyd, Her Majesty's Minister of Education. I think we may take this as an indication of his interest in our educational activities, culminating in the announcement recently of the new National College of Agricultural Engineering.

THE RIGHT HON. GEOFFREY LLOYD, M.P. (Minister of Education), in proposing the toast "The Institution," said : As a layman—I mean by that somebody who is not either a farmer, an agricultural engineer or for the moment considering himself as a Minister but just as a member of the British public—I have long been an admirer of your industry. Therefore, it gives me very great pleasure to be here this afternoon and even greater pleasure to feel that as Minister of Education I am able to contribute something to the vitality of this remarkable industry.

After a second world war in almost a single generation, the economic power of our country received tremendous blows and, therefore, all the vigorous and patriotic people since the war have put a very high value upon restoring the economic strength and the financial power of our country. Anybody who thinks a little bit about these problems knows that it cannot be done by trying, so to speak, to restore the great industries which made the fortune of England in the nineteenth century.

I will not go into details on this subject, but you know perfectly well that, broadly speaking, the industries which were the great source of our progress in the nineteenth century have been the headaches of the twentieth century. Therefore, anybody who thinks about our national problem knows that it is by finding the new industries in which we can make a new fortune that our future lies. I therefore am delighted to meet you who are working in one of the most dynamic of the thriving industries that have helped to rebuild British fortunes in the years after the war.

When I am approaching this in the same way, from the national point of view, while I am tremendously pleased and, as an Englishman, proud of what you have achieved, I naturally ask myself the question of what more can you do in the future. As an outside observer, it seems to me that you have by no means reached the saturation point of the increasing fortunes of this industry. Indeed, it looks as if you still have a tremendous future ahead, both for yourselves and for the country.

I have been learning a great deal about agricultural engineering, as you can imagine, from you, Mr. President, to-day, and we have been, so to speak, analysing together the functions of this industry from a national point of view—you with a wealth of knowledge of the industry and me coming in as the layman from the national viewpoint.

It is very interesting that the upshot of our talk really is that the industry obviously, first of all, makes this tremendous contribution to increasing the productivity of home agriculture. This is a theme which you know very well and I shall not labour it, but it would seem that this contribution also has by no means reached its highest point and that more can still be done in this direction of getting a more intensive productivity from our own English land.

In so far as you assist in that, you reduce our need for imports and thus you reduce the tension on our need to export. But at the same time as you reduce our actual need to export you have made this very dynamic contribution to export itself. I believe the figures show that an export figure of something around £5 million before the war is coming up to the wonderful total of £100 million this year. You can understand that this is very impressive to the average Englishman who is not part of your industry and extremely pleasing.

But there is another aspect to it as well, which is that in so far as you are increasing the productivity and, therefore, improving the economic position of the primary producers in the various parts of the world to whom you sell your implements, and considering that it is these very people who are the largest part of the overseas customers of the British economy in general, you are also, from this broader point of view, improving our general export position by improving the economic position of our main customers.

One of the most interesting questions which, I have no doubt, many of you have thought about a good deal is not only the straightforward, down-to-earth question of how you can continue to make out in relation to foreign competition—and I know that you have established this decisive lead, which, nevertheless, you know better than I do, can only be maintained by continued vitality in the industry ; not only that, but the other question of the size of the market in the future is a fascinating one, not only from the viewpoint of your industry, but also from the point of view of our country and of the world.

After all, your market—at any rate, when you leave Europe—is geared to the agricultural primary producing countries of the world, which, roughly speaking, can be divided into the more progressive areas like Australia, New Zealand, perhaps South Africa, and so on, and the tremendous area of Asiatic cultivation where still the most primitive agricultural practices prevail. It is a very delicate and sensitive question and I do not consider to know—I doubt whether anybody does—what will be the pace of the turnover of the great Asiatic masses from primitive agriculture to the type of more intensive and more modern cultural practices which will give you your tremendous opportunity.

I know enough about it to know that this is mixed up with questions far beyond your own industry. It is mixed up with educational and with social and political questions, and even religious questions in some of the countries concerned. One hopes, however, that this process may turn out to go a good deal faster than sometimes appears at the present time, particularly when we remember that enormous political questions are involved in this, particularly with regard to the uncommitted countries in relation to the Western world and the countries of the Eastern bloc and the absolutely vital requirement of raising the standard of living of millions of people at present living on a low level, in which there is no doubt that agriculture, and, therefore, your industry, must be one of the most important elements concerned.

I have ventured to make these observations of a rather broader kind and I hope that they are not, in your view, too much out of tune with reality. I want to reiterate my admiration for your industry and my desire, as Minister of Education, to do everything possible to further its vitality in the future. That is the fundamental reason why we have come along to help the industry by doing what the industry wanted, which was to set up the National College of Agricultural Engineering to do what, I know, you want, which is to help in the provision of the high-grade experts in your industry for the future. (" Hear, hear.")

You know that I would be an admirer of private enterprise, which I am. Sometimes I feel that the Government do not do enough to help private enterprise, but I am very pleased that on this occasion, at any rate, my Department is co-operating with this industry and I wish you the very best of luck on this, your very vigorous twenty-first birthday. Therefore, I would like to propose the toast of " The Institution," coupled with the name of your President. (Applause.)

THE PRESIDENT, in responding, said : I feel that anything I have to say following the Minister's speech will be an anti-climax, but I have prepared something, and I hope you will excuse me if I go on with the job. The Minister has mentioned the National College ; that, and agricultural education in general, is really what I am going to talk about.

We all in the Institution, together with our friends in the other organisations who supported us in putting forward the proposal for the College, are very happy that it is now going ahead as fast as possible, but there is a great deal to do before it becomes a reality. The Chairman of the Board of Governors has been appointed, and shortly the names of the Board of Governors themselves will be announced. After that, the Board will meet to deal with the great amount of preliminary work involved. The College will become, I am sure, one of the landmarks in the educational history of the country. (" Hear, hear.")

But a building itself is only a building. It is what we put into the building and what we take out of it that will matter. We can only take out what we put in. We must have the best teaching staff vaailable, and we must see to it that the right type of student is admitted to the College.

By " the right type " I do not mean only those of the highest qualifications who will go there for advanced postgraduate studies. I hope that there will be courses —and this will doubtless be considered by the Board of Governors—at other levels. But at whatever grade they leave the College, successful students must be the best that this country can produce.

The need for better agricultural engineering education is becoming more obvious. It was foreseen some four or five years ago when at a luncheon of the Institution our Past President, Mr. David Ransome, whom we are very glad to see here to-day, first put forward the proposal for a National College. At a subsequent Luncheon, the then Minister of Education, Sir David Eccles, indicated that his Ministry were sympathetic to the idea. I am very glad that things have progressed so much since you first proposed it, Mr. Ransome.

The need is becoming greater every day, because we are getting more and more competition from abroad. Some of the other European countries are still far behind us, but they are striving hard to catch up. We have got to go into training to keep ahead, and we will with this new College.

The College will turn out men who will keep ahead —I am certain of that—but in my opinion it must give complete courses covering all aspects of agricultural engineering. We will not get by with being better in just one field, but by being better than other people in every aspect of agricultural engineering.

We are now leaders in the field ; we look upon our predecessors in agricultural engineering in this country as village blacksmiths—of different grades, of course ! But we are inclined to talk about them as being blacksmiths. I can see the day when the young men who go through the College, with all the increased knowledge that the College will give, will look upon you and me as blacksmiths ! (Laughter.) And I will not resent it. I will know that they are going ahead in the tremendous race for a higher and higher standard of living and higher and higher exports. (Applause.)

Membership Certificates

The delay in the issue of Membership Certificates to those members who have applied is regretted. It is due to re-consideration by the Council of the title of the Institution.

THE MEASUREMENT OF CROP DRIER PERFORMANCE

by P. H. Bailey,* B.Sc.(Eng.), A.M.I.B.A.E.

A Paper presented at an Open Meeting of the Institution on 14th April, 1959

INTRODUCTION

THE routine testing of commercial machines—agricultural or otherwise—is sometimes regarded as a pedestrian activity because it has neither the academic respectability of fundamental research nor the appeal of wider approaches such as operational research or work study. Nevertheless, routine testing, to be of any value, must be based on methods of measurement giving repeatable results of predictable accuracy, and the study of the methods of measurement suitable for any given type of agricultural equipment is, as McLaren[1] pointed out, as rigorous an exercise as any other form of scientific enquiry. This is particularly true in the case of crop drying equipment, where the performance is greatly influenced by the type of crop and its state, as well as by ambient conditions. An understanding of how these various factors affect the measurement of performance is absolutely essential to the design of satisfactory techniques to be followed in the course of routine testing.

The fact that routine testing has a useful part to play in this further development of crop drying seems to be fairly generally accepted. The point is underlined by a comment by Nix[2], reporting in 1956 the results of an economic survey which included 22 continuous driers, that " in practice, the drying rate was often below—sometimes well below—manufacturers' claims." It can be argued that it should be possible to calculate fairly accurately the performance of a drier, but, even in cases where this is so, there is everything to be said for an independent test under practical operating conditions to confirm the theoretical predictions.

PRINCIPLES OF MEASURING CROP DRIER PERFORMANCE

McLaren[1] classified under six headings the observations appropriate to the test of an agricultural machine, and a somewhat more detailed analysis for the special case of grass driers has been made by the present author[3]. It is proposed to consider here, for the types of evaporative farm drier of which the author has direct experience, problems arising under McLaren's first two headings—*Quality of Work* and *Rate of Work* (which is closely linked for crop driers with the third heading, *Power Requirement*).

Rate of Work

Evaporation

The rate of work of a drier is commonly specified in terms of its output of dried stock, but as the direct result of expenditure of energy is the evaporation of water, evaporation rate is a more fundamental characteristic. Thus, in driers for various types of green material the evaporation rate may remain almost constant, although variations of input moisture content have considerable affect on the output rate[4, 5] and similarly in most grain driers the evaporation rate is little affected by the output rate.

Specific Consumption; Coefficient of Performance

For a given machine working in stated conditions, the relationship between the amount of water evaporated and the fuel consumption is a parameter which may be regarded as a characteristic of the machine, and which may be expressed as specific evaporation—*i.e.*, as weight evaporated per unit consumption of fuel or heat—or inversely as specific consumption—the fuel or heat required to evaporate unit quantity of water. The relationship between the specific consumption and the amount of heat required to evaporate unit quantity of water under ideal conditions at a comparable temperature is an indication of the thermal economy of the drier. (For an adiabatic drier, the relationship approximates $\frac{T_2 - T_0}{T_1 - T_0}$, where T_0 is ambient temperature, T_1 is hot air temperature at entry to the stock, and T_2 is exhaust temperature at exit from the stock.) This ratio is sometimes called the efficiency of a drier, but the term is misleading because the purpose of a drier is strictly the drying of the stock and not evaporation of water. The term " coefficient of performance " suggested by M'Ewen and O'Callaghan[6] is preferable. They show for a hypothetical grain drier how the ratio may vary with air velocity, thickness of bed, temperature, and initial moisture content. Although for the conditions considered the parameter varies considerably, falling with increasing air velocity and increasing with bed thickness, these factors are not usually capable of wide variation in agricultural driers, and often are fixed by the design of the machine. For a practical drier in which radiation and other heat losses cannot be neglected, $\frac{T_2 - T_0}{T_1 - T_0}$ gives an over-estimate of the effective coefficient of performance, but specific consumption and evaporation continue to specify performance satisfactorily.

The statement of specific consumption involves measurement of evaporation, fuel consumption rate and the sampling of the fuel for measurement of its calorific value. Although there are problems of making the measurements relating to the fuel they are not specific to crop driers, and will not be further considered here.

Methods of Measuring Evaporation

Two approaches to the measurement of evaporation are possible—directly, by multiplication of the air

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quantity supplied for drying by the increase in its absolute humidity, and indirectly, by consideration of the change in the stock during drying. The direct approach is useful as a check where it can be applied, but it is often impossible either to make an accurate measurement of air velocity without modifications which might alter the characteristics of the drier, or to obtain a sufficiently accurate measurement of the mean exhaust temperature and relative humidity. Table I gives comparisons between estimations of evaporation by the two methods and shows that considerable divergence may be recorded even in favourable conditions.

TABLE I

Comparison of Estimation of Evaporation from Air Quantity and Humidity (C) and from Change of Weight of Stock (E)

Source.	*Range of E, lb.*	*Mean C/E.*	*Number of Runs.*	*σ of C/E.*
Hop Kiln A ..	3340–4280	1·20	5	} 0·11
Hop Kiln B ..	2070–2590	1·24	4	
Hop Kiln C ..	2110	1·05	1	—
Small batch grain drier ..	16·3–37·2	1·03	14	0·19

The sources of information in Table I are recent tests of hop kilns, in which the air velocity could not be measured directly, but was estimated from the fuel consumption and temperature rise using an assumed value for air heater efficiency ; tests of Belgium hop kilns by Jacobs & Maton[7] ; and experiments on a small grain drier. This drier (Fig. 1) was originally a commercial continuous throughput cross-flow machine, but

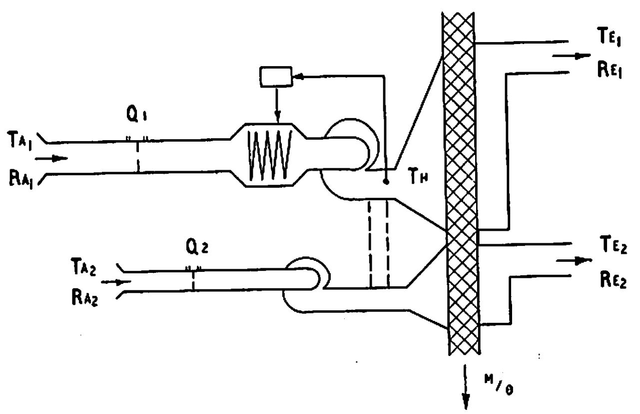


FIG. 1. Small Drier - Diagramatic

was modified for experiments on grain drier testing techniques by being fitted with air measuring ducts and with trunking to collect the exit air for final exhausting through ports in which instruments for measuring temperature and relative humidity could be fitted ; both these alterations tended to reduce the airflow and therefore the rated output, but made it easier to measure performance. A further modification was an arrangement by which the hot air and cooling plenum chambers could be interconnected, the cold air fan being disconnected so that batch driers working with a low fixed temperature rise could be simulated. Two series of batch drier tests were made, one with a fixed 3½ kW. nominal heater capcaity and the other with 5¼ kW. in place of the 21 kW. thermostatically-controlled heater bank normally available.

Apparent Loss of Dry Matter—Accuracy

The indirect method of measuring evaporation, which in its simplest form requires only the subtraction of the dried weight from the initial weight of stock, is intrinsically much more accurate than the direct method, as it depends on weighings. However, the loss of weight in drying may include a loss of dry matter, which can be determined only when the moisture contents as well as the weights both of wet and dried stock are known. The " apparent loss of dry matter " has been discussed in detail for grass driers[3]; briefly, it depends not only on any actual loss which may occur, but also on random and persistent errors of measurement and sampling. Typical values for apparent loss, together with an indication of the effect of random errors of measurement, are shown for grain, grass and hop driers in Table II. It follows that it is desirable to measure input weight and moisture content and output weight and moisture content ; however, in some types of drier one of these quantities may not be accessible and it is then necessary to assume zero loss of dry matter.

In the existing N.I.A.E. grain drier test scheme[8] the measurement of the dried weight only, together with the wet or dried moisture contents, is specified and an implicit assumption is made of negligible loss of dry matter. (This is necessary because the input may not be accessible for weighing or because there may be an internal circulation of the input overflow.) Table II suggests that this assumption is justified. From theoretical considerations, loss of dry matter due to metabolism of grain is unlikely to be important in the drying time of most drying machines ; nevertheless, physical losses could occur, and on two occasions in 14 years the grain in batch driers under test has been observed to part with an insect infestation (of unknown dry matter content) when the hot air was admitted to the drier.

It may be noted that although only very small dry matter losses occur in grain driers, the weight of water evaporated is itself fairly small in relation to the weight of stock and therefore neglect of such losses may lead to appreciable error in the estimation of evaporation from the difference of initial and final weights. Thus, supposing 1 ton of grain is dried from 20% to 17% moisture content, and additionally a loss of 0·1% dry matter occurs ; the total loss of weight in the drier would be 84 lb. compared with the evaporation of 82 lb., and use of the loss of weight as a measure of the evaporation would in this example produce an error of about 2½% of the actual evaporation. Similarly, an error of 0·1% in weighing either the wet or dry grain would produce a 2% error in evaporation, and an error of 0·1 in the moisture content percentage would produce an error of 3⅓% in evaporation. This is illustrated in Table III, where some of the data given for apparent loss of dry matter in Table II for the small batch grain drier is presented in an alternative form, evaporation being calculated for a few typical runs both from the loss in weight and from the final weight together with the moisture content data. In green crop driers the apparent loss of dry matter may have a larger value, but there the evaporation is much larger and is not so sensitive to minor errors of measurement, except of the initial moisture content.

TABLE II

	Mean a.l.d.m. %	*Number of Runs.*	*95% Confidence Limits of a.l.d.m. % ±*
Grain Drier A	+0·24	16	0·50
Grain Drier B	−0·25*	3	—
Grass Drier A	+2·2	12	3·8
Grass Drier B	+3·0	11	2·4
Grass Drier C	+5·4	12	4·3
Hop Drier B..	+3·8	4	—
Hop Drier D..	+3·3	15	1·2

* Negative loss signifies apparent gain.

TABLE III

Batch.	*Loss of Weight, lb.*	*Evaporation from Output Weight and m.c.s., lb.*	*a.l.d.m. %*
6/12/57	29·1	29·4	−0·07
16/1/58	33·5	28·2	+1·26
12/6/58	27·8	31·1	−0·71
19/6/58	32·2	38·4	−1·45
3/7/58	36·5	32·5	+0·87
17/7/58	37·3	37·3	0
14/8/58	35·2	33·9	+0·28

Accuracy of weighing, sampling and moisture content determination is highly desirable for all types of crop drier, but Table III may be taken to illustrate the difficulties that may arise even under reasonably good conditions for testing. In the experiments reported the drier was completely emptied after each run, and the damp grain was weighed in 50 lb. (net) lots on a steelyard-type sack balance. Subsequently the dried grain was weighed on the same machine in similar lots. This machine (which is regularly used for tests of all types of drier) was checked for random error by weighing 50 combinations of metric weights amounting to about 50 lb. and differing by a small amount between successive weighings; it was found to have a calibration error of 0·001 lb., and the standard deviation of an individual reading was 0·02 lb., the greatest individual error in the 50 weighings being 0·07 lb. Moisture content was measured by the Carter-Simon Rapid Oven method, in which a sample of ground wheat is heated for a total of 15 minutes in three successive positions in the special oven at a nominal temperature of 155° C. This method has been used for grain by the N.I.A.E. for many years, and although other oven and distillation methods are also in use, the Carter-Simon oven is found to be satisfactory for routine moisture determination in connection with grain drier testing because it gives consistent treatment to large or small numbers of samples. An examination of deviations between duplicate results from single samples in recent work suggests that the standard deviation of mean results for single samples is less than 0·2% m.c.; this includes the effect of lack of consistency of the grain within individual samples.

While the determination of moisture content can never be regarded as absolute, it is important that a basic method—oven or distillation—should be used in measuring drier performance, especially where only one weighing is made of the stock, and the relative values of the two moisture contents are of paramount importance. The use of electrical, chemical, or other meters giving a direct measurement, while quite satisfactory for normal farm purposes, may sometimes result in serious errors in the measurement of drier performance. In the example quoted where grain was dried from 20% to 17% m.c., an error of 1% moisture content (and most quick-reading meters do not claim a greater accuracy than "within ± 1%") could lead to an error of 30% in the estimate of evaporation.

Possibly the greatest opportunity for error in the measurement of crop drier performance is in the sampling of the stock. In a grain drier test using artificially dampened grain, skilful dampening can, by reducing the variability of the sample, contribute substantially to the accuracy with which the moisture content of the wet grain is known. Table IV shows the mean moisture content and its standard error for wet grain in typical batches entering the small grain drier. Incidentally, although mechanical mixing is satisfactory for batches of up to 1 ton, no alternative to hand turning has been found for dampening 20 to 30 tons of wheat on location for a typical grain drier test.

TABLE IV

Catch.	*"Natural" or Dampened.*	*Mean m.c. %*	*Number of Samples.*	*S.E. of Mean ±*	*95% Limits of Mean ±*
27/8/57	N.	20·5	10	0·082	0·19
28/8/57	N.	20·9	11	0·055	0·12
13/2/58	D.	21·8	11	0·070	0·16
20/2/58	D.	21·4	11	0·092	0·21
3/3/58	D.	21·2	11	0·073	0·16
8/8/58	D.	20·6	10	0·075	0·17
17/9/58	N.	20·7	10	0·058	0·13
26/9/58	N.	20·5	10	0·212	0·48

In driers where the temperature of the drying air is more than a few degrees above ambient, a moisture gradient exists in the grain at the conclusion of the drying cycle, grain nearer the air entry being dried to a lower moisture content than the mean and that near the exhaust being at a higher moisture content than the mean; the process has been discussed in detail by M'Ewen and O'Callaghan[7]. In continuous driers the output gear and conveyors have a mixing effect, and the sampling rate usually adopted of one sample every five minutes during the periods of detailed observations, backed up by intermediate sampling at a reduced rate, appears satisfactory from the internal evidence of consistency of numerous tests of conveyor driers. On the other hand, batch driers retain a moisture gradient at the conclusion of drying, and a very high sampling rate may be necessary to obtain a satisfactory estimate of the mean final moisture content.

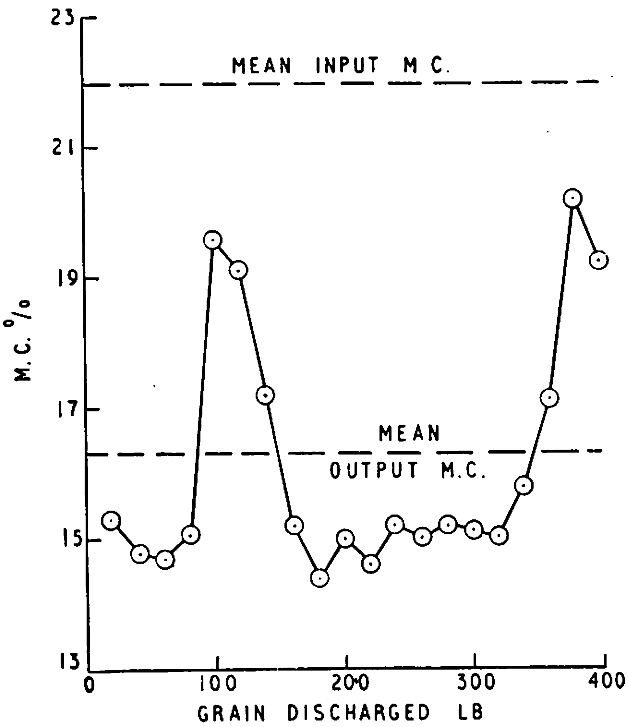


FIG. 2. Variation of moisture content in emptying small batch grain drier.

one has not so far been used on routine tests by the N.I.A.E., because of the difficulty of devising a type to fit the varied situations encountered in driers on test.

The problems of sampling grass and hops are more or less the same (though the petal/strig relationship in hops does not lead to quite the same difficulties as leaf/stem in grass), but differ from those of sampling grain. In general, the procedure for sampling wet hops follows that of sampling wet grass previously described[3,4], the principle being to take a fairly large number of samples directly from the material as it is loaded to the kiln. Dried hops are sampled directly as the hops are swept to the press. Table V shows the degree of consistency in sampling batches of hops in 1956 and 1957.

Quality of Work

Generally speaking, the quality of work of an agricultural drier is the extent to which it succeeds in carrying out the drying process without producing changes in the stock other than the intended change of moisture content, and measurement of quality of work consists of comparative analysis of samples of dried stock and control samples. It is obviously impracticable to carry out a comprehensive analysis of all properties which might be changed, and in practice the analysis adopted is of some feature of commercial importance or of a property of known sensitivity to heat treatment related to such a feature. Separate problems arise for different crops—for grain there are no particular problems of treatment for the control sample, but with green crops a drying or preservative treatment must be used for the controls. Although the feeding value of fresh fodder crops is highly relevant to that of the dried material, the properties of " green " hops have no accepted commercial relevance, as the hop market knows only the dried product.

TABLE V

95% confidence limits of mean moisture content for individual runs ..	0 to ± 0·4	± 0·5 to ± 0·9	± 1·0 to ± 1·4	± 1·5 to ± 1·9	± 2·0 to ± 2·4
Wet hops ; number of runs in each group	12	5	1	1	1
Dry hops ; number of runs in each group	1	13	4	2	0

Fig. 2 shows the moisture content of output samples from a typical run with the small batch grain drier. Although the variation of moisture content with the progress of emptying the drier is greater than any so far met in a commercial batch drier, as there is a small blanked-off area between the hot air and cooling sections of the original continuous drier, this record illustrates the risk of obtaining a mean biassed by the inclusion of incorrect proportions of samples at the different moisture content levels existing in a drier. Besides the variation with time, the stream of grain emerging at any instant may be of varying moisture content, and this may lead to biassed sampling if the samples are taken by holding a container in the grain issuing from the drier. A continuous sample divider is an obvious requirement, but

Damage to Grain

Heat treatment (and mechanical damage) in a grain drier may affect germination and baking quality. In the N.I.A.E. grain drier test scheme germination tests are used when rating a drier with the air temperature recommended for drying milling wheat, which is considerably higher than that recommended for drying malting barley or seed grain[9]. The reason for this apparent anomaly is that the recommended air temperatures incorporate a small safety factor, the magnitude of which depends on the design of the drier and decreases with increasing moisture content of incoming grain, so that baking or extensometer tests (apart from being somewhat cumbersome for routine drier testing) might not be sufficiently sensitive. The results given by

Hutchinson[10] show that a critical combination of temperature and time at the standard specified input moisture content of 21% is one hour's heating at about 132° F. Measurements on a cross-flow grain drier tested in 1946 suggested that 135° F. is about the maximum grain temperature reached with a hot air temperature of 150° F. in a grain drier of conventional design, but that germination in these conditions with wet grain at 21% m.c. is practically unimpaired. A germination test therefore seemed suitable as a check on abnormally deleterious combinations of time and temperature in a grain drier. The check appears to have worked in practice, and although negative results are invariably obtained with well-designed driers, flaws in design have been shown up by it.

Whenever a grain drier test is made, samples of the wheat used for the test at the input moisture content of 21 ± 1% are heated for one hour without drying at temperatures of 125°, 130°, 135°, 140° and 145° F. to check for normality of response to heat treatment. The results obtained with the grain used in several tests in the last few years are shown in Fig. 3, which confirms the original value taken for critical temperature. A laboratory investigation of the effects of different times of heating, and different grain moisture contents, is being made to confirm and extend the information on critical moisture contents given by Hutchinson, with special reference to the conditions of grain drier tests, and using different varieties from the Squareheads Master used by Hutchinson. It may be noted that the arbitrary tolerance of ± 1% for the moisture content of the damp grain may be expected to influence the critical temperature by less than ± 2° F.

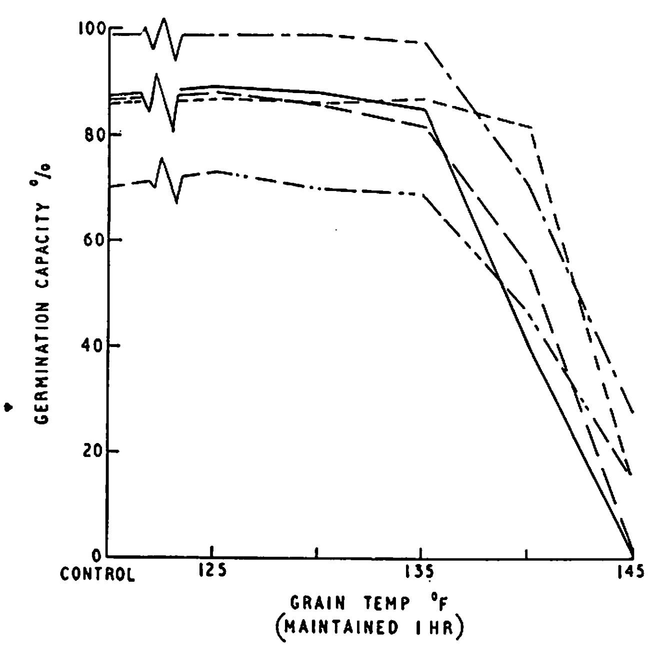


FIG. 3. Normality of response to heat treatment of wheat at 21% M.C.

Damage to Grass

The analysis of green fodder crops for β–carotene and crude protein in drier tests, and the problems of preserving and drying the control samples, have previously been discussed at length[4]. A disconcerting feature of many tests was a tendency for the crude protein of the dried product to exceed that of the frozen and freeze-dried control. After experiments carried out intermittently for several years, the discrepancy was traced to a differential loss of dry matter in laboratory hammer milling of grass samples[11]. The finest particles (having the highest nutrient content) were lost through the mill filter bag in the cooling air, and the loss was exaggerated with the freeze-dried material, in which the protoplasm did not coagulate and adhere to the vascular bundles as with hot-air-dried materials. Freeze-drying, followed by a modified milling procedure, is now carried out successfully as a control procedure io the research on baled hay drying reported by Shepperson[12].

Damage to Hops

The first problem in recognising drying damage to hops is the subjective nature of the criterion generally applied in the trade for the commercial value of the hops —merchants' examination for rub, aroma, and appearance. The merchants are undoubtedly highly expert at this method of valuation, and information from examination of replicated samples from hop drying experiments appears consistent[14], but a more objective measurement is desirable for a routine method of measuring hop kiln performance. Progressive brewers control hopping rate according to the total soft resin content, or sometimes the α–resin content of the hops. Total soft resin content, which may be determined fairly simply, was used as a criterion of drying treatment in hop kiln tests in 1956 and 1957[5, 13] but, unfortunately, it is relatively insensitive to heat treatment. In the U.S.A. hop oil or lupulin content has been quoted as an indicator of drying damage[15]. An experiment at present in progress on the relative merits of α–resin, total oils, and oil composition as indicators of damage is in its early stages, but first indications are that α–resin content is fairly sensitive to heat treatment and correlates well with market valuation.

TABLE VI

	Ratio of Total Soft Resin Values, Control Method/Kiln Dried.	
Control Method.	*Freeze Drying.*	*Oven Drying.*
Kiln A	—	0·92
Kiln D (runs 1–4)	1·17	—
Kiln D (runs 5–14)	1·03	0·96

Treatment of control samples of wet hops presents problems at least equal to those of treating wet grass. In 1956 and 1957 a " Unitherm " laboratory oven was used to dry the control samples, but it seems probable that this treatment is inferior to that given in a carefully controlled hop kiln (see Table VI). The freezing and freeze-drying process used for control samples of grass is obviously attractive, but it is by no means certain that the freeze dried hops will be acceptable as a control. Table VII shows comparative results from freeze dried and kiln dried hops in 1957 when analysed for resin content and when used in a trial brew ; it is apparent that comparison of the resin contents of freeze dried and kiln dried hops would have led to a reflection on the kiln treatment which is not confirmed by stability as shown in the brewing trial. Merchants' opinions of freeze dried hops from the 1957 harvest were favourable, but in 1958 were mixed.

TABLE VII*

Drying Treatment.	*α Acid %*	*Isohumulones in Beer, p.p.m.*	*Stability.*†
Kiln D.. ..	7·0	48	40·2
Kiln B	7·3	44	36·6
Freeze Dried ..	7·6	57	36·1

† Days after inoculation with Lactobacillus Pasteurianus to reach 0·12% expressed as acetic acid.

* The trial brew and analysis were made by Mr. L. E. Hudson, of Arthur Guinness, Son & Co. (Dublin), Ltd., on kiln-dried hops and hops dried in the N.I.A.E. freeze-drier.

CORRECTION OF RESULTS TO STANDARD CONDITIONS

When all practicable precautions have been taken so that the measurement procedure yields a satisfactorily accurate statement of drier performance under the conditions of crop and of air temperature, humidity and pressure prevailing at the time of test, the question arises of how much the performance will be affected by departure from these conditions. It is obviously desirable to be able to state with conviction the expected performance of a drier under standard conditions, so that direct comparison may be made between driers tested on different occasions. Where it is possible to make an estimate of drier performance entirely from theoretical considerations, it should be possible to use drying theory to correct an observed performance to standard conditions without serious error.

Effect of Drier Design

All driers do not react in the same way to changes in atmospheric or crop conditions, and the extent to which they are insensitive to external conditions may be regarded as a measure of the sophistication of the thermodynamic design. Counterflow driers, for instance, can usually operate with a nearly saturated exhaust over a wide range of crop conditions ; other arrangements that tend to give high performance coefficients with minimum dependence on external conditions include high temperature co-flow driers with controlled exhaust, and recirculating driers.

For simple driers without recirculation, the performance will depend for a given crop roughly on the ratio of air mass-flow to the quantity of stock dried ; M'Ewen and O'Callaghan[6] showed that for cross-flow batch grain driers performance coefficient increases with bed thickness and decreases with increasing airflow. Simmonds, Ward and M'Ewen[16], in discussing prediction of approximate performance of grain driers in which drying falls partly in the maximum rate regime and partly in the falling rate regime, arrive at the following expression for moisture content at the end of the maximum rate period :

$$W_x - W_e = \frac{Q}{M} \times \frac{(H_s - H_l)}{2{\cdot}303 \times 7{,}000 \times m}$$

where W_s is moisture content of grain at the end of the maximum rate period, lb. water/lb. dry grain.

W_e is moisture content of grain in equilibrium with the drying air at entry, lb. water/lb. dry grain.

Q is air quantity supplied, lb./hr.

M is weight of dry grain in the bed, lb.

m is a drying rate parameter, hr.$^{-1}$.

H_s is moisture content of air entering the drier, gr./lb. dry air.

H_1 is moisture content of the drying air at adiabatic saturation, gr./lb. dry air.

It follows that, for given atmospheric conditions and hot air temperature, when drying grain over a given moisture content range, there will be limiting values of the ratio Q/M beyond which drying will fall entirely into one regime or the other, and between which it will be partly in each. The empirical expression given by Burgess[17, 5] for the time taken to dry a load of hops contains a term for drying in the maximum rate regime which is a function of the ratio of initial load to mass-flow of air.

When the bed is sufficiently thin for drying to be mostly, or completely, in the falling rate regime, the performance becomes dependent on the way in which the stock parts with its moisture, and not on the water-removing capacity of the drying air. This is strongly influenced by temperature, but nearly independent of air velocity (as for grain[16 18]) or dependent on a low power of air velocity (as for hops[17]). Thus, for instance, a column-type grain drier with thin columns is liable to depend strongly on crop conditions.

Effect of Crop Conditions

With green crops, which cannot be stored in their fresh state and cannot be effectively reconstituted to the fresh state when dried, it is necessary to make drier performance measurements using whatever material may be available. The effect on the leaf/stem proportion in grass, clover, and lucerne, or petal/strig in hops, is important if drying is all in the falling rate phase ; Watson[19] has shown that drying times for separated strig are considerably longer than for petal, for instance. Fortunately, most green crop driers are designed to be as independent as possible of crop conditions.

For grain drier tests, however, it is possible to dampen grain that has been harvested or carefully dried to a safe storage moisture content. In the N.I.A.E. grain drier test scheme the effect of variations in the crop is circumvented by specifying that the grain used shall be potentially millable wheat artificially dampened to 21 ± 1% moisture content, by adding the requisite amount of water and turning, over a period of 72 hours immediately prior to the test.

The use of artificially dampened grain has the advantage that performance measurements can be made on grain driers out of season, and it is not difficult to arrange a number of tests in one year. It has been found somewhat impractical to carry out detailed performance measurement on a farm during harvest because of the conflicting requirements of the farmer wishing to save his crop and the test team wishing to investigate the drier ; out of season it is possible to run the drier to order and still possible to see how the drier fits into the farm pattern.

Artificial dampening has sometimes been criticised on the ground that the grain is not typical of harvest conditions ; however, grain as received at the drier from the combine may be extremely varied in condition ; grain dampened by the standard procedure is at least consistent. In the experiments with the small grain drier, a comparison has been made between results obtained in harvest and out of harvest. The results shown in Fig. 4, for the drier working continuously with the temperature thermostatically controlled at 150° F. and the wet grain at 20–22% m.c., and Fig. 5, with the drier operating as a batch drier at various temperatures, may be considered to justify the use of dampened grain.

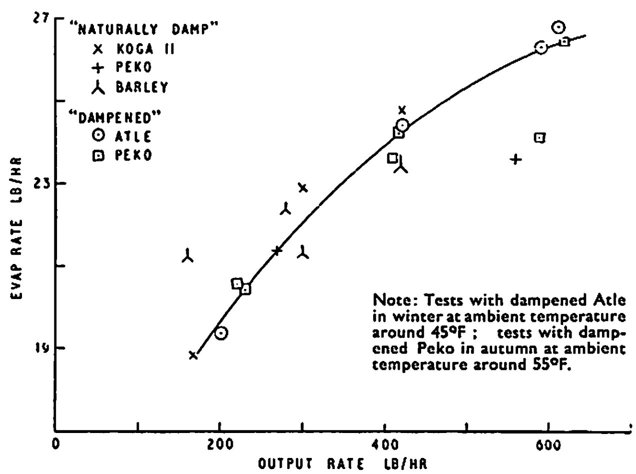


FIG. 4. Variation of evaporation rate of small continuous drier with output rate.

Effect of Air Conditions

Thin Bed Driers

The effect of air conditions on the performance of driers with high values of Q/M has already been considered. Fig. 5 shows the considerable variation in performance of such a drier working from winter to summer with fixed temperature rises and therefore varied hot air temperatures ; superimposed on the diagram (on an arbitrary scale chosen to make the line pass through the experimental points) is a line for the drying rate constant m proposed for grain by Simmonds, Ward and M'Ewen and defined by M'Ewen and

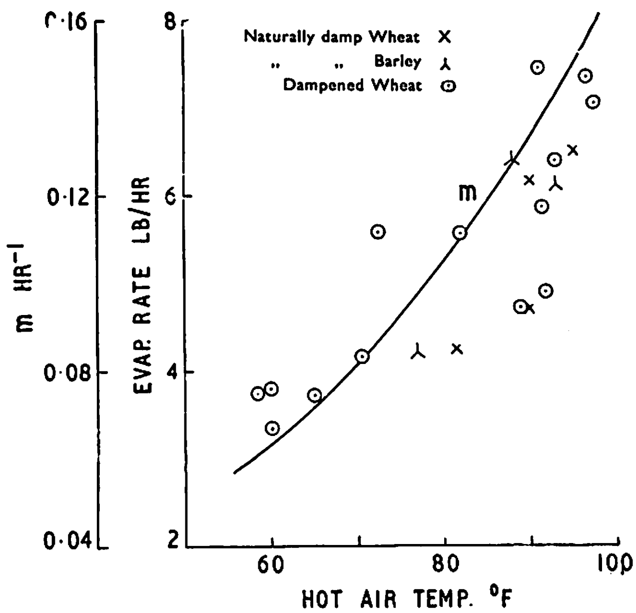
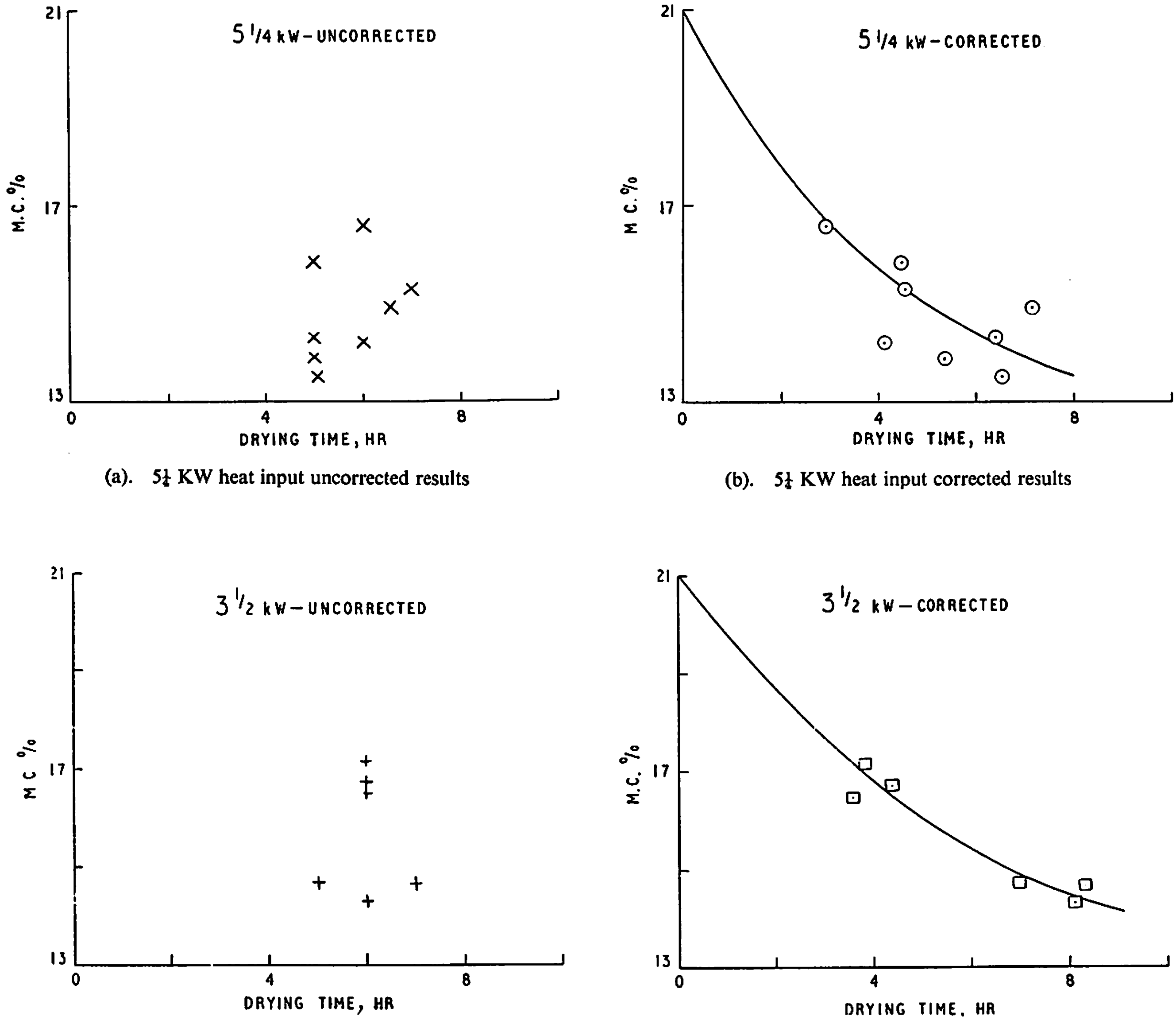


FIG. 5. Variation of evaporation rate of small batch drier with hot air temperature.

O'Callaghan in the revised form $\log_{10} m = \dfrac{T - 159}{87}$,

where T is the effective drying temperature, °F., taken in this case as the logarithmic mean of hot air temperature and exhaust temperatures. A tentative correction procedure, in which a value of m for standard conditions is estimated from the logarithmic mean of hot air temperature at standard ambient conditions and estimated exhaust temperature, and compared with the value of m for the actual test conditions, yields the results shown in Fig. 6. By plotting the results against final moisture content the difficulty of working with equilibrium moisture content required by the prediction methods of Simmonds *et al.*[21] and M'Ewen and O'Callaghan[8] is evaded. As pointed out by Oxley[20], the published data on grain moisture content/air humidity equilibria is not consistent, and subsequent publications have not reduced the confusion. Simmonds *et al.* and M'Ewen and O'Callaghan both use the concept of dynamic equilibria, M'Ewen and O'Callaghan repairing the omission of the earlier work to take proper account of humidity ; this concept is attractive for calculating drier performance, but it is self-evident that the dynamic equilbrium moisture content for given air conditions is not a constant but a parameter, depending on the rate of travel of moisture in the stock and the ultimate equilibrium.

A thin bed drier working with a thermostatically-controlled hot air temperature, in contradistinction to one working with a fixed temperature rise, is little affected by ambient conditions. Neither type is sensitive to ambient humidity or to barometric pressure and, with the hot air temperature fixed, the only performance correction needed is for the variation in the fuel consumption required to reach the hot air temperature, which is quite straightforward.



(a). 5¼ KW heat input uncorrected results

(b). 5¼ KW heat input corrected results

(c). 3½ KW heat input uncorrected results

(d). 3½ KW heat input corrected results

FIG. 6. Small batch grain drier results corrected to standard conditions (high Q/M).

Thick Bed Driers

When the ratio Q/M is low, and the drier performance is governed largely by the drying capacity of the air, the effect of ambient variations may be easily determined from hygrometric data or the psychrometric chart, and are found to be as follows :

For thermostatically-controlled driers, evaporation is unaffected by ambient temperature, but slightly decreased by increased relative humidity ; fuel consumption is independent of ambient relative humidity, but dependent on ambient temperature. For driers working with constant heater loading fuel consumption is, of course, constant, and evaporation increases with ambient temperature, but decreases with relative humidity. The smaller the temperature rise above ambient the greater are the effects of ambient conditions—in the extremes, a drier working with a hot air temperature of 1,500° F., for example, will be hardly influenced by ambient temperature and humidity, but one drying with unheated air will be completely dependent on them. The effect of increased barometric pressure is to increase the quantity of air handled by the fan, but to decrease the drying capacity of the air.

A method of correction base on these principles has been used to correct the performance of batch driers working with low temperature rise and low Q/M ; Fig. 7 is an example from a published report[22].

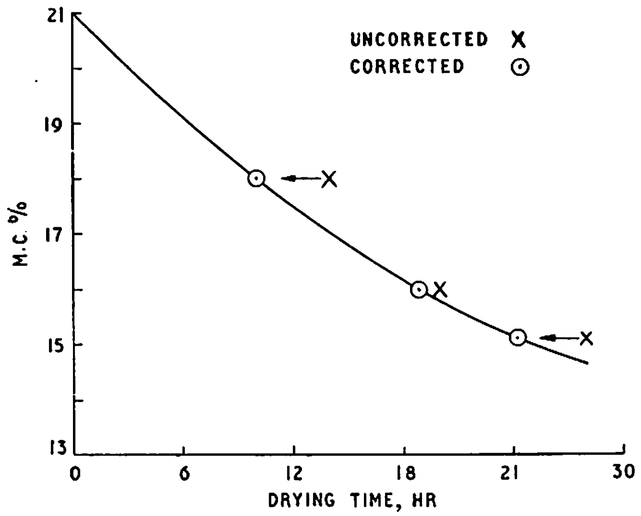


FIG. 7. Commercial batch grain drier results connected to standard conditions (low Q/M)

Accurate measurement of temperature is essential when working with small temperature rises. For example, with a 20° F. rise above the standard condition of 60° F., 80% r.h., an error of ½° in measurement of exhaust wet bulb temperature if the exhaust dry bulb temperature were 68° F. would amount to 10% of the evaporation. N.I.A.E. practice is to record all relevant temperatures, using resistance thermometers connected to recording instruments fitted in the mobile testing drier laboratory Considerable practical difficulties may arise in making satisfactory measurements of exhaust conditions, however, and further experimental work on driers of known performance is certainly required before the correction procedures can be applied with complete confidence.

Applicability of Performance Corrections

It is seen that for driers with a moderate temperature rise corrections for air conditions are apparently effective and at least result in a better estimate of performance under standard conditions than if no correction were applied. Apart from the usual correction for heat to warm the drying air from the actual to the standard ambient condition, corrections have not in the past been applied to N.I.A.E. tests for driers working with hot air temperatures of 140° F. and above, on the grounds that the corrections would probably introduce approximations commensurate with those existing in the uncorrected results. However, it now seems likely that some degree of correction would improve the degree of accuracy of the results ; for instance, correction of air quantity for barometric pressure seems to be justifiable in all types of drier working in the saturated exhaust regime, but care is necessary to determine in which regime a drier does operate.

Out-of-season tests of driers operating with a very low temperature rise might well involve a correction procedure in which the difference between the actual and standard performances would be greater than the actual performance—an obviously unsatisfactory condition. Where a new design of drier operating with a very low temperature rise must be tested, there seems no alternative to measuring its performance in typical seasonal weather[23]. However, where the performance of a low-temperature system has been thoroughly established by published research, as with floor-ventilated bin drying of grain, or barn hay drying, the testing of a complete installation would be superfluous. It may, nevertheless, be relevant to measure the performance of proprietary components for use in an accepted system ; for instance, the air delivery characteristics and efficiency of an air heater for crop drying[24], or the resistance of a proprietary bin floor material.

PRESENTATION OF RESULTS

The presentation of the experimental results in full or slightly condensed form is an essential part of a report on crop drier performance. The additional presentation of the results in a nutshell is convenient for the technician and essential for the user, who may not be able to extract the salient points from the full data. For types of drier in which the evaporation rate and specific evaporation are reasonably constant, these measurements with the relevant conditions give the best summary of technical performance (coupled with a statement of the amount of drying damage, if any). For the user, it is convenient to have a rating in terms of output of dried stock, and this must, of course, be related to the initial and final moisture contents.

The N.I.A.E. rating of grain driers is the output of millable wheat at 15% moisture content dried from 21% using the temperatures recommended for drying milling wheat. There has, however, been some demand in recent years for a statement of the output when the moisture content is reduced from 21% to 17% and to 16%, and current practice is to quote all three outputs, with the 21–15 figures starred. It will be noted that both input and output moisture contents are stated. The common practice of giving the *difference* between wet base moisture contents and calling it " percentage extraction " is to be deprecated except for purposes of gross approximation. The same *difference* does not, in fact, represent the same amount of water, with different initial moisture contents. The water is easier to extract with higher initial and final moisture contents, and the simpler types of drier will then give a better performance. Above all, there is a risk of confusing the user with the percentages ; for example, the reduction of weight when drying 1 ton of wet grain from 21% to 15% is, of course 6/85 ton and not 6/100 ton.

Similarly, for green crop driers, results are quoted when drying from two different initial moisture contents to a typical final moisture content. The standard values used for grass driers are 80% and 70% representing fresh and wilted grass, and 5% for the dried grass. Fresh hops rarely if ever arrive at the kiln at a moisture content of less than 72%, and in the author's experience are not dried much below 7% m.c. ; therefore, in stating the conclusions of hop drier tests these values have been adopted in place of 70% and 5%.

Apart from the actual output rate (or for a batch drier the time to dry a batch of normal weight), the consumption of fuel per unit of output is of interest to the user, although it is of more importance in drying green crops than grain. The burner and motor fuel consumptions can be tabulated with the outputs, and a standard form of table is thus produced, which (with slight modification for different crops) conveniently shows the formal performance for any type of agricultural drier. The example (Table VIII) is taken from a published grain drier report[25]. The column showing the heat equivalent of the total fuel consumption calls for comment ; in a drier where the same fuel is used for motor and heaters it appears completely logical to add the two consumptions, as most of the fan power is ultimately converted to heat and available for drying in the majority of driers. Where different fuels are used, the sum of their heat equivalents is of more academic interest, unless a drier tested with, for instance, an oil burner and electric motor is also available with electric heaters.

TABLE VIII

		Fuel required per Ton of Dried Grain.		
Final m.c. %	*Output Rate, cwt./hr.*	*Gas Oil*, gal.*	*Electricity, kW.h.*	*Heat Equivalent of Total, B.Th.U.*
17	29·5	1·2	11	230,000
16	21·8	1·6	14	300,000
15	17·4*	2·0	18	380,000

* N.I.A.E. rating. (The manufacturers inserted a comment in the published report emphasising that the production machine had modifications which ensured a higher output than this rating of the prototype.)

† Gas oil used is correct for an ambient temperature of 60° F.

Finally, a statement of labour requirement during the test is made. This may be detailed where a batch drier needs a large labour force (a conventional hop kiln, for instance—Table IX), but continuous machines integrated into a storage installation need only intermittent attention, and it is impossible to make an accurate assessment of the labour requirement without a detailed work study, which would hardly fall within the scope of measurement of crop drier performance.

ACKNOWLEDGMENTS

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TABLE IX[5]

	Loading.			
	100 — 50 *lb. Pokes.*		60 — 60 *lb. Pokes.*	
M.C. of wet hops, %	72	80	72	80
Time to dry, hr.	9·6	10·4	7·9	8·5
Utilisation factor, %	80	87	66	71
Specific evaporation, lb./gal.	49	51	43	46
Output of dried hops per day (7% m.c.), cwt.	27	19	19	14
Per cwt. of Dried Hops				
Gas oil used, gal.	5·3	7·9	6·0	9·0
Electricity used, kW.h.	5·0	7·6	5·7	8·6
Heat equivalent of total fuel, B.Th.U.	836,000	1,321,000	1,004,000	1,505,000
Approx. direct labour, man-minutes	50	60	50	60

DISCUSSION

MR. J. F. BROWN, of Guinness Hop Farms, Ltd., said that from two to five million acres of grain are grown in this country, and this is dried from about 21% to 14% moisture content at a fuel consumption of round about 2 gallons per ton of grain.

Hops covered only 20,000 acres, but the drying problem was much more difficult, as the moisture had to be reduced from 75% or more down to 7%, his fuel consumption being about 140 gallons per ton of dried hops—a cost of about £8 per ton—although some growers used up to double this amount of fuel.

Sampling of hops was also difficult, as a mass will not flow like grain and the hops must not be bruised. The criterion of value is the resin content, which must be retained.

With regard to the apparent loss of dry matter, he wondered whether this might be due to a real loss of carbon dioxide through respiration.

Concerning the statement of drier performance in terms of evaporation, Mr. Brown emphasised that drier users wanted to know how much finished product they were going to get rather than how much water they were going to lose.

MR. P. PINN-KELCEY, of the Electrical Research Association, congratulated the author on dealing with the misuse of the word efficiency in connection with drier performance. The E.R.A., like the author, found it difficult to obtain agreement between loss of moisture from the material being dried and increase of water in the drying air. He questioned the validity of measurements of mean temperature and relative humidity of the exhaust air from a tower drier.

He was surprised to see that the author still used the Carter-Simon oven.

He asked the author whether he felt crude protein was of any value as a measurement of the quality of grass.

MR. F. GREEN, Shell-Mex & B.P., Ltd., said that he would like to endorse the view that performance of a drier should be specified on evaporation rather than on output of dried material. He asked the author to comment on his experience of radiation and leakage losses.

Good combustion was an essential part of drier performance, and tests should include a check on performance of the combustion unit.

MR. J. R. O'CALLAGHAN, University College, Dublin, remarked that in a problem of heat and mass-transfer the classical approach would be to carry out a heat and mass-balance on the system.

Applied to a grain drier, the heat supplied was easily obtained from the quantity of fuel, but the distribution of that heat between evaporation, grain, and heat losses from the drier was very difficult to measure accurately.

To use the adiabatic relationship as a measure of efficiency was a serious error because it neglected heat losses, as Mr. Bailey said, and also the exit temperature of the air varies from point to point in many driers.

The mass-balance could not be applied with accuracy either. In wheat, it was difficult to detect the small differences in the total weight involved and apparent loss of dry matter is a cumulative error. In the air, measurement of air humidity was difficult because in many driers it was hard to get a representative sample and many of the instruments give no more than indications. This method of approach, in fact, meant measuring the quantity of air, and if collecting ducts had to be used they might alter the conditions of air flow in the drier.

The method that was left was to measure the moisture content of the grain entering and leaving the drier. The difficulty was to get a representative sample and a reliable method of measuring moisture content.

A sample divider seemed the best way of getting a representative sample. In a batch drier correct sampling was not only made difficult by the gradients in moisture content in the drier, but also by the highly individual way in which different hoppers emptied themselves—at first the centre fell out and then it emptied from the top and sides.

Mr. O'Callaghan then said he thought that both the weight of material entering and leaving the drier should be measured, rather than one of these quantities as in the N.I.A.E. test, since the balance served as a very rough check on the moisture content determination.

As regards the use of dampened grain, Mr. O'Callaghan said he had compared the use of artifically dampened grain in drying with naturally damp grain. He had steeped the grain for 24 hours and then centrifuged it to remove the excess. When placed in the drier there was some surface evaporation for about 5 minutes, and then drying for the remainder of the drying period. Water diffused from the inside of the grain to the surface in the same way as in the natural grain. The moisture contents he used were up to 60%. In the N.I.A.E. test the moisture contents were of the order of 20%; there was no immersion in water, and he wondered if the manner of drying was the same as with natural grain. If water from such wetted grain was removed more easily, it could mean that a drier in which the drying time would ordinarily be too short for diffusion would perform well in a test.

On presentation of results, Mr. O'Callaghan said the drying process was influenced by the temperature, relative humidity of the drying air and by the moisture content of the grain. It was desirable to reduce performance to a common denominator to allow different driers to be compared. Now we seemed to have two partial yardsticks—specific heat consumption and the throughput of the drier when reducing the moisture content from 21% to 16%.

To make the comparison possible, the condition of the air entering the drier must be the same in all cases; two cases seem to be of interest—air at 60° F. and 80% r.h. heated to 150° F. and heated to 120° F. The average specific heat consumption in drying at these temperatures from 21% to 16% would be a suitable measure of heat utilisation.

Since all grain drier tests could not be carried out at such standard conditions, a method was required of correcting actual results to these conditions. The method published by himselft was suitable for calculating the drying of fixed bed and contra-flow grain driers. However, it did not take account of heat losses, which could not be neglected in actual grain driers. It could be adopted to take approximate account of such losses, provided they were known, and a heat line could be assumed on the psychromatic chart. The heat losses from a drier might be estimated by placing dry grain that was in equilibrium with the air, in the dryer and carrying out a heat balance.

The cross-flow continuous drier was more difficult because the distribution of moisture content was unknown.

Besides the thermal efficiency, the quality of work was important. The germination test seems a satisfactory indicator. The grain should be cooled well before it left the drier.

MR. STENNING, Electrical Research Association, said he had experimented in drying small batches of wheat in deep beds. In order to obtain consistent results, they had endeavoured to work with air conditions near the Kew September mean, 57·5° F. – 79·5% r.h. They had obtained a very marked moisture content gradient from top to bottom of the batches.

MR. K. J. BENFIELD said he had some years' experience in the use of continuous driers and ventilated bins, and felt that the performance of these driers was often disappointing. He felt that dampened grain was very different to that obtained under field conditions. For instance, pre-cleaners work well at 18 or 19%, but at 21% or above effectiveness was reduced, so that the condition of grain entering the drier was affected. In in-bin drying the manner of delivery affected the packing of the grain and subsequent drying.

MR. J. WALD, Templewood Hawksley, Ltd., pointed out that heat losses are not accounted for in the N.I.A.E. tests, and said that if the building was suitable, parts of the drier could be enclosed by the building. Ingoing air would then be preheated, and the insulation of the drier became less important. He endorsed the necessity for care in sampling, and said that whole samples should be ground and tested.

MR. BROWN endorsed the views expressed on the differences between naturally and artificially dampened grain. Finally, he wondered whether the N.I.A.E. had been in touch with users of the dried products about possible damage to materials being dried.

MR. BAILEY replied that, taking Mr. Brown's last point first, the N.I.A.E. had been in touch with the users of the products. Joint experiments were in progress with the Cereals Research Station on damage to baking quality of wheat and with hop merchants and brewers on damage to hops. First indications were that the existing recommendations for grain drier hot air temperatures were satisfactory, and that the α–resin content of hops correlated fairly well with merchants' valuations. On the question of sampling, the N.I.A.E. tried to take sufficient samples by an appropriate method to obtain a measurement of statistical dispersion which would allow the accuracy of mean analytical results to be described.

Mr. Brown and Mr. Green had given apparently different points of view about expressing the results of drier tests ; but, in fact, evaporation rate was more useful to the drier technician, but was normally translated into terms of output for standard moisture contents in the conclusions to a test report. Mr. Green's point about the importance of furnace performance was agreed, but as many agricultural driers incorporated the furnace, the overall performance from fuel used to drying achieved was what user and manufacturer wanted to know. When necessary in the past, Mr. Green's associates had kindly co-operated with the N.I.A.E. to measure furnace performance. The N.I.A.E. experience on radiation losses was that they were often surprisingly small and the departure from adiabatic conditions was not serious. The measures suggested by Mr. Wald to reduce the practical effects of radiation losses could be endorsed.

Mr. Finn-Kelcey had questioned the use of the Carter-Simon oven. Experiments at the N.I.A.E. had shown that standard laboratory ovens could give rise to some variability—for instance, between shelf positions—and it was felt that for drier testing purposes the advantage of a well-maintained and correctly-used Carter-Simon oven outweighed its disadvantages. The author agreed that crude protein was a poor criterion of value of grass, as analysis could be affected by inorganic nitrogen ; ıt had been used because it was the commercial criterion. Recent work on determination of digestibility at the Grassland Research Institute might make it practical to use digestible protein as the criterion.

The author agreed with Mr. Brown that losses of dry matter were partly real and that in grass and hops particularly respiration was an important factor, which also affected quality.

Mr. Stenning's results were not surprising and agreed with the author's own experience. Incidentally, for a simple batch drier as described the steep moisture gradient could have been predicted by the method of M'Ewen and O'Callaghan[6].

The author agreed with most of Mr. O'Callaghan's points and thanked him for his stimulating contribution. His observations on the emptying of hoppers confirmed N.I.A.E. experience. The author agıeed that a sample divider was desirable ; one was already in use by the N.I.A.E. Grain Department for dealing with grain from a batch drier, and it was hoped to develop a portable one for use in routine testing.

The dampening method used by Mr. O'Callaghan was suitable for relatively small quantities and high moisture contents, but the N.I.A.E.'s three-day dampening to 21% by spraying and turning was thought to produce satisfactory results analagous to grain dampened by a summer shower. In reply to various speakers who had questioned the use of dampened grain, the author could only say that he thought the results shown as Figs. 4 and 5 of the Paper endorsed the use of dampened grain. However, while he agreed with Mr. Benfield that the presence of chaff and other contaminants in the grain could severely affect drier performance, particularly that of ventilated bins, the N.I.A.E. test assumed the use of satisfactory pre-cleaned grain. The author also agreed with Mr. Benfield that some driers gave disappointing results in practice, and this had been noted by Mr. Nix[2]; however, he felt that results obtained by the procedures discussed in the Paper should reasonably represent drier performance.

The limits of accuracy claimed for grass drier tests in 1951 on internal evidence of random error were about $\pm 5\%$. At present, it was felt that accuracy which could be claimed for the test of a fairly small grain drier, taking into account the correction procedure, was within $\pm 10\%$. In most cases the accuracy would be higher. The accuracy of the correction procedure would undoubtedly become better as knowledge of grain/air moisture equilibrium conditions improved.

NATIONAL DIPLOMA IN AGRICULTURAL ENGINEERING

Results of the Ninth Examination, held on 21st/28th July, 1959

The total number of accepted candidates for the Examination was 39, but one withdrawal brought the number to 38, of whom three were re-sitting a subject in which they had previously failed, and one candidate was re-sitting the whole examination.

Twenty-seven candidates were successful in obtaining the Diploma, while four were referred in one subject, for which they may appear again in 1960.

Seven candidates failed the Examination.

Eight candidates were awarded Second Class Honours, but no candidate was of sufficient merit for the Johnson Medal to be awarded.

SUCCESSFUL CANDIDATES, 1959

ALFHA, M. B., B.Sc.(Agric.), 14, Fort Street, Freetown, Sierra Leone, West Africa.
ASKINS, J. A. C., Chequers Inn, Bablockhythe, Northmoor, Oxford.
BURLTON, A. P., N.D.A., " The Netherlands," Hempstead Road, Redbourn, St. Albans, Herts.
COFFEY, D. M. G., Glendarragh, Newtownmountkennedy, Co. Wicklow, Eire.
‡ CROMARTY, A. S., A.I.B.A.E., 4, Newlands, London Road, East Grinstead, Sussex.
‡ CROSTHWAITE, R. P., 16, The Woodlands, Chesham Bois, Bucks.
‡ DAVIES, A. W. B., Pen-y-Bryn, Bishopstow, Swansea, Glam.
* FARNES, D. C., B.Sc.(Agric.), " The Loke," Rake, nr. Liss, Hants.
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‡ HOBBS, G. R., " Maybury," Deepdene Drive, Dorking, Surrey.
HUTTON, M. E., 37, Highbury, Newcastle-upon-Tyne, 2.
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WOOD, E., N.D.A., Tanfield House, Hillfield Road, Horbury, Wakefield, Yorks.

* Winner of " Dunlop " Scholarship, 1958.
† Winners of " Shell-Mex " Bursaries, 1958.
‡ Second Class Honours.

SCHOLARSHIPS AND BURSARIES

The following have been successful in obtaining Scholarships and Bursaries in the gift of the Institution for the final year's course of study for the Diploma commencing in the Autumn of 1959 :

Dunlop Scholarship—R. W. Jessup, B.Sc. (Agric.).
" *Shell-Mex* " *Bursaries*—F. J. M. Clarke, B.Sc. (Agric.). M. R. Williams, B.Sc. (Agric.).

ACCIDENTS ON FARMS AND METHODS OF PREVENTION

by J. R. Whitaker, N.D.Ag.E., A.M.I.B.A.E.

A Paper originally presented to the Northern Centre of the Institution on 10th February, 1958

Introduction

I AM extremely pleased to have this opportunity to address you tonight on the subject of Accident and Accident Prevention. I propose to sketch in very briefly the background to the present safety regulations, outline the Act and the Regulations, and then to deal with accidents and how they appear to be caused and could, perhaps, be prevented.

There is complete agreement that there are too many accidents on farms and that something must be done to reduce them. Each and every one of you has a part to play in prevention, and it is only by the concerted action of all concerned that a reduction in the number of accidents will be achieved.

The background, then, really starts with the 1937 Factories Acts, when the agricultural workers' representatives pressed for agriculture to be included in that Act.

Tractors and other field machinery existed only in penny numbers then and it was generally felt that agricultural conditions were not comparable with those in factories, so agriculture was excepted, with the provision that its problems would be discussed and the necessary legislation provided separately.

In 1939 the T.U.C. again raised with the Government the need for safeguards on agricultural machines, protection for workers against corrosive sprays and fertilisers with the provision of first-aid kits, washing and sanitary facilities. In brief, " Safety—Health and Welfare " ! The Government agreed to these points being investigated by the departments concerned in conjunction with the industry, but, unfortunately, the outbreak of war put a stop to discussions.

In 1946 the T.U.C. and N.U.A.W. passed resolutions in favour of including agriculture in the Factories Act, and the " Gowers " Committee was set up to enquire into—among many other things—Safety, Health and Welfare provisions for people employed at places other than those regulated under the Mines and Factories Acts.

In the Gowers Report which was published in 1949, four pages out of 50 related specifically to Agriculture. This was the first step towards providing safety legislation, though the Committee was a little sceptical about the possibility of adequate guards being designed for the machines in use.

The use of poisonous spraying compounds was rapidly increasing just at this time, and immediate action was taken to draft and bring into force the Poisonous Substances Act, 1952.

It is worth noting that a Voluntary Precautions Scheme was introduced before the Act was passed, and it worked whilst the Act was being prepared. It is still used for substances not controlled by the Act.

Official attention was then turned tosafety and the Safety, Health and Welfare Provisions Act was passed in 1956. The Act itself prohibits the lifting of heavy weights by young persons and requires the provision of sanitary and washing facilities. Apart from this, it provides for the making of regulations to deal with virtually all circumstances. Section I is the all-embracing section, which opens by saying : " Provision may be made by regulations under this section for protecting workers employed in agriculture against risks of bodily injury or injury to health arising out of the use of any machinery, plant, equipment, appliance, the carrying on of any operation, the use of any process, or the management of animals. For securing to such workers safe places to work in and safe means of access thereto and from protecting them against risk of bodily injury arising out of their falling through apertures in floors, walls or from their work places or while ascending or descending staircases or ladders."

Other sections mention various specific points.

When it is considered that a regulation is needed to deal with a particular point the Ministry prepare an outline. Consultation—as required by Section 17 (2) of the Act—then takes place with such organisations as appear to represent the interests concerned (and this is interpreted fairly widely).

Following this the new Regulation is laid before Parliament, when it can be passed or rejected.

It was extremely unfortunate that circumstances prevented action being taken in 1939. As you are all well aware, agriculture underwent a mechanical revolution between 1939–1949, and the spate of mechanisation is only now starting to tail off in this country. The result has been that virtually all machines have been designed without any thought at all for " safety," and in many cases quite simple modifications or guards would make a world of difference.

Had the Safety Act been law before mechanisation took place most of the machines at present on farms would be adequately guarded. This would have meant that right from the start new machines would have been introduced to workers and employers who were already beginning to be safety-conscious. An " awareness " that danger exists is the first and most important step in accident prevention.

If people could be persuaded to pause and think many many of the accidents against which we cannot legislate or guard could be prevented. The two points, greater care and better guarding, are the first lines of attack in the war on accidents.

Safety Regulations

The inherent danger of moving machinery and the potential danger of workplaces is being dealt with. Seven safety regulations have been published, although not all are in force yet, as time is being allowed to bring existing machinery into line and to alter production plans in respect of new equipment.

The following regulations are now in force :

(*a*) *First-Aid Equipment*, the amount varying according to the number of workers, must be provided by employers. The type and number of bandages, etc., is specified in the regulations.

(*b*) *Ladders* must be soundly constructed, in good condition and properly used. Missing rungs or damaged rungs or stiles are an offence, and certain details of constructions are required with wooden ladders.

(*c*) *Children* under 13 years of gae are prohibited from driving or riding on tractors and almost all agricultural vehicles, implements and machines.

(*d*) *Power Take-Off.* This regulation is not always fully understood. The tractor power take-off—just the short splined shaft—must either be covered up or guarded from the top and both sides at all times when the engine is in motion. The shaft to the machine must, apart from certain special exceptions, be totally enclosed right up to the first fixed bearing on the machine. The main exception is for machines in use on 1st February, 1959, but then only for shafts which throughout their whole length are entirely less than 2 ft. from the ground. In such circumstances these shafts must be guarded from the top and both sides by a guard which extends 2 ins. below the lowest point of the shaft. There are very few of these inverted U-type guards which are deep enough.

The following regulations come into force on the date shown :

(*e*) *Circular Saws.* Top and bottom guards and rising knives of specific design and position will be required. Limits are placed on the age at which a worker can first use a saw, and training and supervision are required.

In operation from September 12th, 1959 - March, 1960.

(*f*) *Safe Workplaces.* In general, these require safe floors, etc., hand-rails for staircases and guard-rails for openings in floors, edges of floors and pits in the ground. Covers or doors can replace the guard-rail in certain circumstances.

In force April, 1961.

(*g*) *Stationary Machinery.* Again, apart from special exceptions, guards will be required for the belts, pulleys, chains, cogs, gears, cranks, etc., of all machines designed for stationary operation.

In force July, 1961.

Causes and Prevention

The most important problem which we must tackle first is to obtain a reduction in the number of fatal accidents. It is probable that any measures, publicity campaigns or regulations which reduce fatal accidents will also reduce non-fatal ones. Very similar accidents can be anything from humorous to the onlooker to fatal to the participant. P.T.O. shafts have been known to tear a man's trousers off without injuring him, whilst a similar accident has killed another man.

Tractors are responsible for the biggest individual number of accidents. This could be partly a reflection of the fact that there are more tractors than any other machines, and that tractors are used for longer periods throughout the year. This can lead to misleading assumptions.

In their Report on Accidents, the I.B.A.E., from a sample in the Eastern Counties, showed that roughly there were :

	Accidents Rate.
15 Tractor accidents from 26,000 machines	1 per 1,800
and 5 Baler accidents from 1,350 machines	1 per 300

The baler, therefore, is a greater hazard—six times as great—and because it has a short season of use it is even more dangerous, or so the I.B.A.E. Report appeared to evaluate the figures.

But we are not concerned with hazards related to accident rates. Farms are equipped with a given range of machinery in numbers that will not change very greatly, and if tractors are involved in 15 accidents and balers in 5, then tractors are three times as dangerous as balers, and tractors must be our first consideration.

Then having blamed the baler as a machine, the Report later states that in each case that had been considered the accident was due to the failure of the operator to stop the machine before making adjustments—so surely there is some contributory negligence. It goes on to state that the fitting of additional guards would serve no useful purpose, as these would have to be removed before adjustment could be made.

I do not agree with this. On many balers there are several points which could be better guarded—belt drive, main crank, P.T.O. flywheel and needles ; and if the guard has to be removed for adjustment it must only be when the machine is stationary. In any case, the presence of and need to remove a guard will be a reminder of the danger.

Negligence is, perhaps, too condemnatory a word. It implies knowledge of the precaution which should or could be taken, and in many cases lack of instruction or training is the root of the trouble.

Speed, plus sharp turns, uneven brakes with a heavy trailer load, or bumpy ground are the causes of overturning. Any one of these on its own may not cause an accident, but two of them taken together add up to an overturned tractor and an injured or killed driver. It is not often the man who is taking a risk and looking for danger points who has the accident ; it is more often than not the routine job—apparently safe—done with a little less care or under slightly changed conditions which results in the accident.

The manufacturers do what they can, though I don't think it is enough. Instruction books warn against high speeds, sharp turns, etc., and I am sure, too, that dealers and salesmen when supplying tractors warn users of the dangers, but it does seem unfortunately true that memories are short and that a continuous campaign is necessary to make any appreciable impression. It is better to have an idea knocked into a man's skull than his skull knocked in by an overturned tractor.

The first of the new series of farm safety leaflets deals with tractors overturning ; we hope that the rather unpleasant picture on the front will have a deeper and more lasting effect than written exhortation.

Falls from tractors account for nearly as many deaths as all implement and field machinery accidents, and a large proportion of those who fall are passengers, including children who should not be there. If the Children's Regulation is complied with, it should reduce the deaths of children, due to accidents in agriculture, by at least a third.

So far as other passengers are concerned, opinion is divided. There is some suggestion that if a proper seat were provided it would be the best solution, and whilst I sympathise with the people who would like this, I cannot support it—mainly, I admit, because one tractor which provided a seat which could accommodate two people had its controls so positioned that with twopeople on the seat neither could properly control the tractor.

Many people carry loose on tractors a miscellany of tools, oil-can, coats and gadgets which can and often do interfere with the controls, and so contribute to an accident. I would plead for a large toolbox, with a separate compartment for drawbar pin, D. links, etc., and perhaps even a separate box for lunch kit and flask.

The circumstances which cause many accidents are generally simple—identical with what many of us here have done in the past and may do again in the future, although we hope without serious result.

In one case of a tractor overturning when turning from a steep farm lane into a field, to which there were no witnesses, clear tyre tracks showed the course that had been attempted, and my own opinion was that the tractor should have got round quite safely. I would willingly have tried to drive a tractor round—but the accident happened. Possibly, just at the wrong moment the driver wasn't concentrating.

A non-fatal accident, involving a ram-type pick-up baler, occurred when the operator fed several bales which had only been tied with one band back on to the pick-up. One of the tied strings caught round his ankle and his leg was severely injured by the pick-up which had picked up the tied string.

Simple in their occurrence, impossible to legislate against, yet they would have been prevented by taking greater care, and the latter certainly reduced in severity if the baler had had a guard rail in front of the pick-up which the operator could have grasped.

There are many similar examples which could be quoted. In the main, these accidents can be prevented by greater care and thought by the people concerned, but they will only take heed if everyone concerned, in season and out, keeps reminding them.

The other type of accident where the machine, etc., is the main cause will be prevented by adequate guarding. In view of the regulations already mentioned, we can look forward to the fitting of more guards in the very near future.

In so far as these guards will act as a reminder of danger, they may help general accident prevention by keeping people aware of the need to take a little more care at all times.

Many of the accidents happen because operators carry out servicing and maintenance whilst the machinery is in motion. It may not be possible or necessary to prevent this, but in every case revolving shafts and belts, etc., should be so protected that the worker is not endangered.

Normal servicing and maintenance should be done with machinery stationary, particularly if guards have been removed. Instructions to that effect could be given by every employer. If servicing has to be done to moving machiner with a guard removed, then a responsible person should be detailed to do it after having been given full instruction. This, however, should be exceptional.

Ideally, guards should be arranged so that the machine must be stopped and cannot be re-started until the guard is replaced (as is the case with many machines in factories). This would mean complicated guards and involved inter-locking arrangements for much equipment, and it is obviously too onerous a requirement for every situation.

On the other hand, if machinery can be run without its proper guards, greater emphasis must be placed on requiring guards to be fitted and kept in place by both employer and worker.

It should be accepted that an employer is responsible for giving or having given training and instructions to every employee, not just on the requirements of the Act or Regulation, but on the reason why a guard is there and the danger of its removal.

It is possible that those accidents associated with the maintenance of machinery, particularly when it is in motion, will be reduced by the introduction of self-lubricating bearings. A small reduction, perhaps, but important in that it allows greater emphasis to be laid on the remaining causes.

Similarly, other trends of modernisation can lead to safer working conditions. The overhead shaft driving a multiplicity of machines with flat, unguarded belts is being replaced by individual electric motors with short drives which can easily be guarded. The big danger here is faulty electrical installation.

Electricity can be the most dangerous power unit on the farm ; I say can be—it *need not*. Provided it is installed according to the regulations of the Electricity Board and the standard Code of Practice of the Institute of Electrical Engineers, it will be safe, but deterioration can and will occur. Regular inspections and tests by a suitably qualified electrician will show up faults before they can result in danger.

It is on the probable need for guards on existing machinery that the trade generally will have an opportunity to introduce the question of accident prevention and, it is to be hoped that they will use the opportunity not merely to sell the required guard, but to sell the idea of being accident conscious.

As you can see from the figures, it is not sufficient to guard machinery—or even to guard against bulls ; people must be protected from themselves by the only method we have—propaganda.

I am certain that most farmers and farm workers know of most of the dangers which are met with around the farm, but, like us all, they are not often consciously aware of the danger. If they are, they probably think —" well, it won't happen to me." This in spite of the fact that one worker in twenty has an accident every year—some not very serious, but others leading to incapacity and perhaps death.

A comparison with the situation in industry may be both useful and interesting.

Factories have a lead of many years on agriculture in the field of safety and accident prevention activity, and we should not hesitate to use any of their ideas which could speed the reduction of agricultural accidents.

I would like to quote figures, opinions and suggestions from a Report of the Industrial Safety sub-Committee on Industrial Accident Prevention. Their conclusion applies to farming equally as much as to industry.

In Industry, accidents have been reduced from 30 per 1,000 workers in 1937 to 22 per 1,000 in 1954. One very disturbing factor when these figures are broken down into age and sex groups is that the accidents rate for men and boyr is similar, 28·9 per 1,000 and 29·6 per 1,000, although it is reasonable to suppose that boys under 18 are generally employed on less hazardous work, and that women and girls also have similar rates, 10·0 per 1,000 and 11·5 per 1,000, which are very much less.

A breakdown of the figures into causes shows that only 1 in 6 accidents can be attributed to power-driven machinery, in spite of the popular belief that machinery is dangerous. (By comparison, 50% of the fatal accidents in agriculture are due to machinery.)

Industry itself realises that this popular misconception must be uprooted if any appreciable reduction is to be made in accident rates. Unless everyone can be made to accept, and fully realise, the fact that it is some failure of the human element—the momentary abstraction which causes most accidents—there will be no progress. The drive and enthusiasm must come from the top, and must be continually renewed *from that* course. The employer or manager must feel it is his job to keep the works free from accidents.

The report suggests six principles of accident prevention :

1. Accident prevention is an essential part of *good* management and *good* workmanship.
2. Management and workers must co-operate wholeheartedly in securing freedom from accidents.
3. Top management must take the lead in organising safety in the works.
4. There must be a definite and known safety policy in each workplace.
5. The organisation and resources necessary to carry out the policy must exist.
6. The best available knowledge and methods must be applied.

I am certain that these can also apply in principle to farms.

To Sum Up

The problem is a high accident rate, approximately double that for industry ; the need is to reduce it.

Those concerned are employers and employees, manufacturers and dealers, and the safety inspectorate.

Each has a specific job, but all must co-operate on some jobs. The manufacturer can design new machines with greater safeguards ; the dealer can supply and fit guards to existing hazards, which have, we hope, been pointed out by both employer and employee ; but unless there exists constant reminder by all concerned to " think Safety " *all the time*, we will only progress slowly.

The Safety Inspector, in co-operation with all the other people concerned, has to ensure that the proper guards are fitted, and to endeavour to see that everyone knows the need and reason for both guards and greater care.

GRADUATE MEMBERSHIP EXAMINATIONS

At the recent Examination held from 24th/26th July at the Essex Institute of Agriculture and Rycotewood College of Rural Crafts, twenty-seven candidates sat for all, or part, of the Examination. Of these, seventeen passed and are eligible to apply for Graduate Membership, including five candidates who were re-sitting subjects in which they failed last year. Sis candidates failed the Examination, and four were referred in one subject which they may re-sit in 1960.

The following are the names of the seventeen successful candidates :

AMBLER, L. D., Lackham School of Agriculture, Wiltshire.
ARNOLD, F. W., Lackham School of Agriculture, Wiltshire.
BETTS, R. J. S., White Lodge, 215, Worsley Bridge Road, Beckenham, Kent.
BLAKE, T. J., 7, Council House, Mill Lane, Clanfield, Oxford.
CRAWFORD SCOTT, C., Bachilton House, Methven, Perth.
GEESON, A., The Post Office, Denton, Grantham, Lincolnshire.
MACINNES, A. J. M., Little Corby Hall, Warwick Bridge, Carlisle, Cumberland.
PATERSON, I. G., 97, Countess Road, Amesbury, Wiltshire.
PARTRIDGE, R. T., 21, Hyland Grove, Westbury-on-Trym, Bristol.
POMEROY, E. G., 7, Victoria Road, Salisbury, Wiltshire.
ROBERTS, R. J., 2, Priory Road, Arundel, Sussex.
ROBINETT, L. R., 141, Main Street, Yaxley, Nr. Peterborough, Northamptonshire.
SMITH, P. H. S., 20, Castle Street, Farnham, Surrey.
SYMONS, M. W. (emigrated to Canada).
TOWNSHEND, D. C. R., Flat 4, " The Firs," 149, Brighton Road, Redhill, Surrey.
WEBB, D. G., " Two-Ways," Churchill, Oxfordshire.
YOUNG, G. M., 1, Ararat Road, Richmond, Surrey.

The following elections were effected by the Council in June, 1959 :

MEMBERS

Clayton, C. L. .. .. Yorks.
Miers, R. H. .. .. Lincs.

Overseas

Vasey, C. H. .. Australia

ASSOCIATE MEMBERS

Coutts, D. .. .. Warwicks.
Goodwin, A. C. .. .. .. Suffolk
Hughes, W. .. .. Brecon
Robinson, W. W. .. .. .. Pembroke
Street, J. .. .. Warwicks.
Wald, J. .. .. Bucks.
White, G. W. .. .. .. Essex
Williams, G. H. .. .. .. Hants.

ASSOCIATES

Abraham, H. H. C. .. Hants.
Anderson, F. R. .. Scotland
Atkins, F. C. .. .. Scotland
Belding, E. T. .. .. Glos.
Bentley, H. .. .. Derbyshire
Bradley, G. .. .. Glos.
Chaplin, S. H. .. .. Cambs.
Croghan, M. F. .. Somerset
Davies, G. G. R. .. Suffolk
Davis, R. S. E... .. Brecon
Farnworth, J. R. .. Lancs.
Garratt, E. A. .. .. Yorks.
Gibbs, A. J. .. .. Warwicks.
Hannah, J. R. .. .. Glos.
Hutchings, S. P. .. Worcs.
Jones, R. E. .. .. Denbighshire
Knight, Mrs. B. J. .. Somerset
Knight, D. W. .. .. Warwicks.
Mason, G. G. .. .. Worcs.
Muir, A. H. J. .. .. Herts.
Palmer, S. .. .. Herts.
Robertson, S. .. .. Scotland
Rose, S. W. C. .. .. Essex
Salmon, N. E. .. .. Norfolk
Spear, T... .. .. Durham
Spittle, D. J. .. .. Glos.
Sutton, R. H. .. .. Lancs.
Tingle, A. E. .. .. Norfolk
Tristram, R. J. .. .. Warwicks.
Twocock, J. G. .. .. Cambs.
Wardale, H. .. .. Durham
Warnock, J. .. .. Scotland
Wright, W. J. .. .. Scotland

Overseas

Cringle, P. M. .. .. Kenya
Davis, P. A. .. .. S. Rhodesia
Eliyathamby, H. W. .. Ceylon
Girgis, S. R. .. .. Egypt
Jenkinson, R. A. C. .. Kenya
McMillan, M. A. .. British Guiana
Mott, J. B. .. .. Uganda
Tile, J. R. .. .. Tanganyika

GRADUATES

Harrison, T. H. E. .. .. Yorks.

Overseas

Beaven, J. S... .. .. New Zealand

STUDENTS

Carnochan, I. M. .. Sussex
Hatley, M. A. .. .. Cambs.
Jessup, R. W. .. .. Suffolk
Roberts, J. W. .. .. Yorks.
Watson, D. J. .. .. Suffolk

TRANSFERS

FROM ASSOCIATE MEMBER TO MEMBER

Constantinesco, I.	London	Rundle, W. T. A.	Hants.
Ladbrooke, R. W.	Middlesex	Whitsed, W. J.	Northants.

FROM GRADUATE TO ASSOCIATE MEMBER

Edge, L. T.	Worcs.	Shipway, G. P.	Beds.
Robinson, P. J.	Northumberland		

Overseas

Clough, M. G. .. .. Nigeria

FROM STUDENT TO GRADUATE

May, B. A.	Kent	Whitehouse, A. E.	Surrey
Ward, J. R.	Lancs.		

FROM STUDENT TO ASSOCIATE

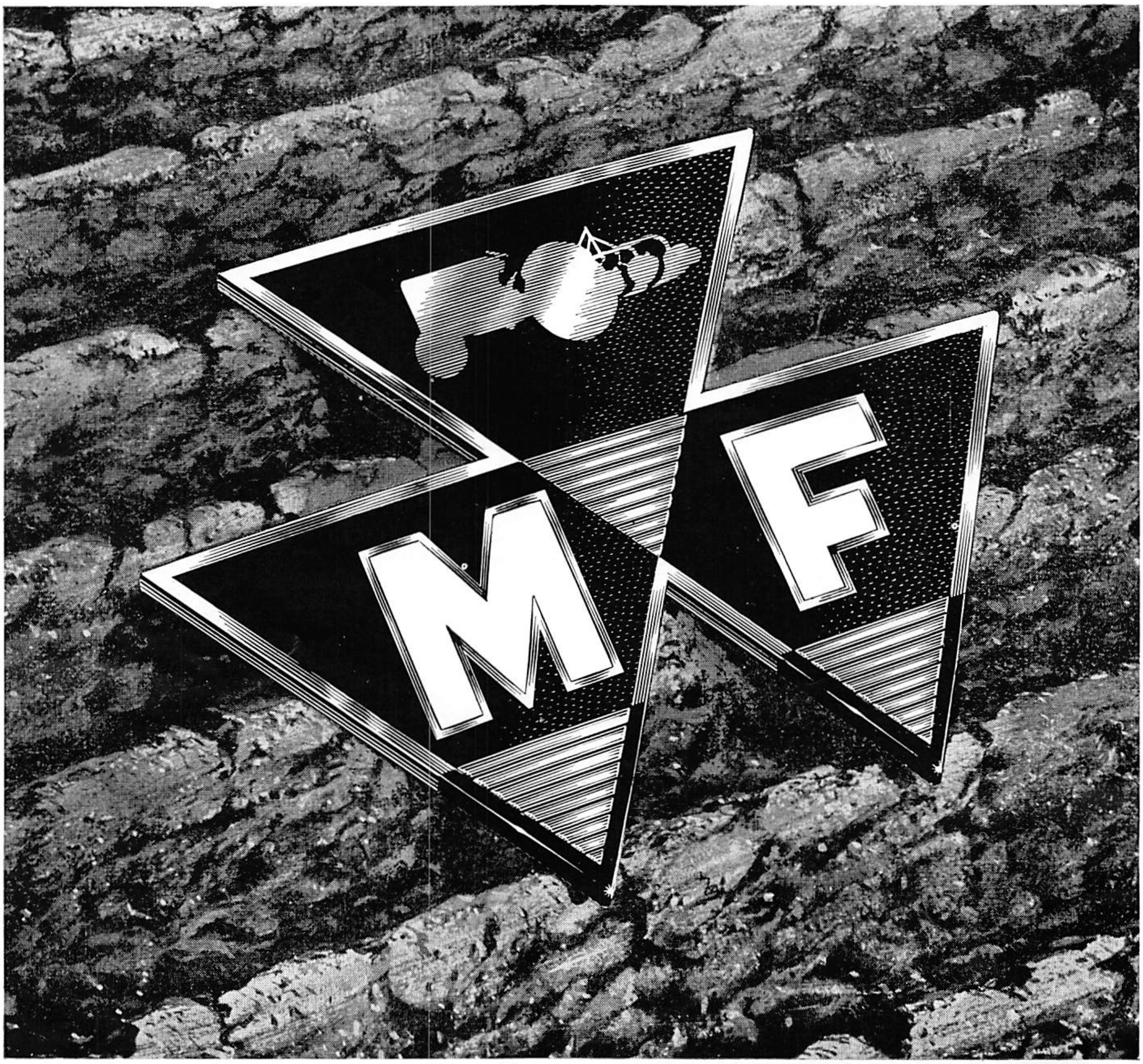
Griffin, A. G. .. .. Warwicks.

ELECTION OF HONORARY MEMBER

Sir Alexander Glen is a native of St. Andrews. He was born in 1893, and educated at St. Andrews and Oxford. He served with the Black Watch Regiment during the First World War and was awarded the Military Cross.

In 1919 he was demobilized with the rank of Major. Transferred from the Treasury to the Department of Agriculture for Scotland, 1925, he was made a Companion of the Order of the Bath in 1950.

He became Secretary of the Department of Agriculture in 1953, and was awarded the K.B.E. in 1956. He retired in 1958.


M
F

OPEN MEETINGS
in London 1959-60

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

October 13th, 1959

PRESIDENTIAL ADDRESS by W. J. NOLAN, M.Inst. Pet., M.I.B.A.E.

November 10th, 1959

PAPER : " Soil Erosion by Wind," prepared by the Agricultural Engineering Branch, Land and Water Development Division, Food and Agriculture Organisation of United Nations. (Name of speaker to be announced.)

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 Underdeveloped 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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