THE AGRICULTURAL ENGINEER

JOURNAL and Proceedings of the INSTITUTION of AGRICULTURAL ENGINEERS

Volume 31 Autumn 1976 No 3

Training Manager

Major Sugar Project in Nigeria

Commonwealth Development Corporation is providing management services for a major integrated sugar project being established at Numan in the N.E. State of Nigeria and substantially financed by the Federal Government of Nigeria which is the major share-holder. Operated by the Savannah Sugar Company Limited, the sugar cane estates will eventually extend to some 30,000 acres to produce about 100,000 tons of refined sugar annually. The project will involve a wide range of field operations, pumping and irrigation systems, with processing and refining plant and the development of a complete township with associated services to cater for an ultimate employment strength of approx 7,000.

The early appointment of a Training Manager is now urgently sought by the operating company. Responsibilities will include the assessment of present and future training needs in all areas of company activity, the formulation of company training policy and the development, administration and co-ordination of training programmes to meet phased staffing requirements at all levels of employment.

Candidates should not be less than 40 years of age and preferably married. They will have a background of progressive training experience based on line management and instructional experience, and combined with appropriate formal qualifications probably with a technical bias. Previous experience related to major agro/industrial operations in Africa is particularly desirable.

The appointment would be for a period of 2½ years in the first instance but with likely prospects of contract renewal. Commencing basic salary will not be less than Naira 9,000pa (equivalent to approx £7,900) and there is provision for terminal gratuity. Local medical attention is free (there is a resident expatriate Medical Officer) and rent free furnished accommodation is provided. Other benefits include mid-contract home-leave, family passages and assistance with educational costs etc.

Please forward details of qualifications, experience etc to Head of Personnel, Commonwealth Development Corporation, 33 Hill Street, London W1A 3AR, quoting Serial 1933.

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Cover picture: Self-loading wagon with more than 10 chopping knives. The unloading system spreads the ensilage very evenly over the clamp (see paper by Ir G A Benders).

Letter from the president

Presidential Address: Research in Agricultural Engineering

THE wide scope of the Presidential Address makes it impossible to summarise it adequately in the space available, but I think that a brief mention of some of the aspects considered may help members decide whether they would like a complete copy. The topic was chosen because I believe the wellbeing of the industry and, indeed, mankind is strongly influenced by Research and Development in agricultural engineering. After 30 years at NIAE I have views and experience to offer regarding the nature and organisation of independently conducted R & D and its relationship with that conducted by industry. I wanted to discuss particularly the relationships between agricultural engineers and other R & D workers of the associated disciplines, e.g. biology and chemistry.

Problems of take-up and application of results by industry have emerged and seem worth highlighting; some are of course created by the general economic situation but there seems cause for concern about the strength for growth of the UK machinery construction industry, multinational manufacturers apart.

What definitions do we use when talking about R & D? I have found the boundaries between research, particularly applied research, and development are rarely clear-cut. R & D covers the fields of science and technology. Science is concerned with discovering facts and relationships in nature and obtaining verified data. Technology involves putting these findings to use and cannot claim the authority of science. Development is a technological process in which scientific knowledge is used whenever possible, but incompletely understood empirical observations often have to be used. Hence development may be almost indistinguishable from applied research if it is conducted in a logical manner to determine design requirements and pave the way to an optimum solution. When considering the Institution's future, I stressed that it was not only important to attract the best young brains to agricultural engineering for R & D but to find men trained to have technical competence, critical ability and commercial feeling to examine the problems and potential of innovation. Although all branches of our industry are ultimately involved in the outcome of R & D, it was interesting to find that more than 60% of Institution members have close interests. The records showed that about 20% are R & D practitioners, about 16%, although within manufacturing classification, are involved in decision making or promotional aspects involving R & D and 27% are interested in its trends for advisory and educational purposes.

A few quantifying examples of the importance of machinery in agriculture have been given and the aims and characteristics of R & D in agricultural engineering are discussed. The relationship between reducing labour requirements and increasing productivity are shown graphically, with a breakdown showing trends in machinery, labour and feedingstuff costs. Indications of the importance of machinery and its cost in relation to labour emerged from a survey made on 838 farms in the SE region in 1971. If the sample was representative and applied to the 3M acres of crops and grass in the region then £30M was spent on labour, about £47M on machinery costs and £52M was invested in machinery. Similar impressions of the importance of mechanisation came from the Report of the Canadian Royal Commission on Farm Machinery in 1971. It was estimated that the $2000 – 3000M annual benefit from improvements in farm machinery technology probably exceeded the benefits from all other agricultural improvements.

I share Blaxter's view (ref) that the central feature of the post war growth in yield was the vastly increased application of energy to the agricultural industy. More powerful machines increased timeliness and more milking machines and parlours freed labour for other tasks. More fertiliser, spread more evenly, and the application of spray chemicals markedly increased energy input but paid dividends in protecting crops and increasing yields. The efficiency of all these new developments owes something to R & D in agricultural engineering. For the future, as well as continuing to increase efficiency in energy use, increasing output in the UK may be more important than labour reduction.

Innovations may come from painstaking research designed to find an optimum solution to a problem. But they spring from bright ideas followed by practical development work. A good example of this is the first Ferguson linkage and weight-transfer system. Research followed later.

Examples are given of research which is necessary to help understand how basic phenomena span vital areas, for example spray droplet formation and movement in crops. An obvious difference between these step by step research and development tasks and *ad hoc* development is that the former are usually extremely expensive. They require systematically conducted and statistically sound studies. For many reasons costs have escalated and, in the main, therefore governments, plus only a small number of firms, pay for research on fundamental problems of importance in agricultural engineering. It is an interesting fact, however, that the extent of the R & D investment and engineering for production by the world's largest machinery manufacturer exceeds the total funding by the UK government for research in agriculture. This, alone, highlights the care which must be taken in choosing only the most important tasks for government sponsored research.

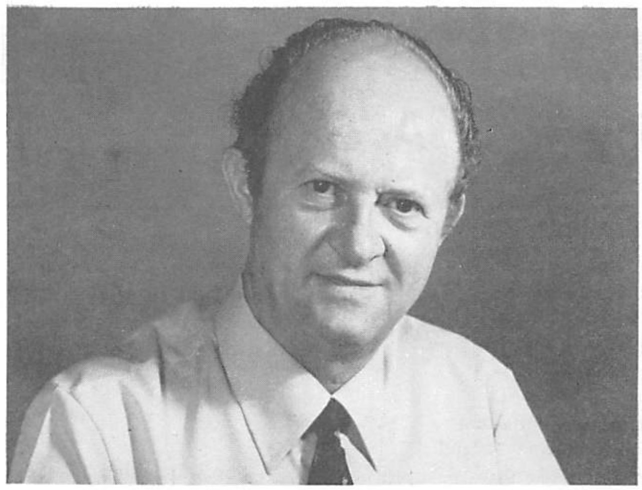
When analysing the problems of introducing innovations to manufacturers the inertias which create caution on their part are seen to be numerous. I do not, of course, imply a lack of innovative spirit. Nevertheless, there have been increasing amounts of imported power driven machinery for secondary tillage and forage conservation. I have drawn attention to the estimates by Dr E Jones concerning the proportion taken by the government in all forms of "value added" during manufacturing or processing. The problems of British industry in relation to Japan, West Germany and the United States have been indicated. The role of the National Research and Development Corporation in helping the uptake of developments from institute and private sources has been described and this may be of interest to some members.

The Director of NIAE was the first ARC Institute Director to introduce a formal system for project proposal and review. More recently the strategy for government sponsored R & D has been aided by the setting up of the Joint Consultative Organisation and many Institution members serve on its committees in the five broad areas concerned with animals, arable crops and forage, engineering and building, food science and technology and horticulture. It must be of some concern to the agricultural engineering industry that the proportion of government funds used on work within ARC and the department of Agriculture and Fisheries for Scotland is only about 6.5% of total research funds. The aims of the Agricultural Research Council and the present arrangements proposed by Lord Rothschild, whereby the Ministry are the main customers for research and development and commission this through their R & D contractors, have been summarised. Already over 500 recommendations have been raised in the JCO and will understandably take time to digest and pursue. The JCO discussions doubtless prevent short term needs being overlooked; it remains to be seen whether longer term strategies, hitherto often developed by researchers, will be improved.

My list of the future topics for research and development which I believe are of great importance, fall within the broad category of trying to make the most of our natural resources. How far the R & D worker should take development work before handing over to industry has been discussed and this is certainly one of the most difficult problems facing both parties. The few members concerned

Engineering developments in forage and grain conservation

G Shepperson B Sc(Agric) FIAgrE



WHEN speakers at the annual conference in 1971 dealt with engineering in forage conservation, it was the problems of harvesting, handling, processing and storage, which formed the main basis of the papers. It was realised then that the practical application of research and development findings could do a great deal to reduce losses between the mowing and feeding of grass and clover crops and in the production of a high quality roughage. Five years later the economic basis for consideration of the technical aspects of conservation has changed. As Mr Raymond says in his paper, there has been a change from a period in which "cereal compounds were so cheap that livestock farmers could barely afford not to rely on them" to the present time. Now serious consideration must be given to whether we can continue either to import large quantities of increasingly expensive protein and cereal feeds for cattle, on a purely cost basis, or indeed whether we are morally justified in doing so when the same products are eminently suitable for feeding directly to human beings in other less fortunate parts of the world.

Above all else the aim of the conference reported in this issue was to bring together nutritionists and farmers with biologists and engineers, whose research work is leading to a better understanding of the drying and conservation process and whose development work is directed towards the application of these findings to field use.

It was appropriate that a contribution from a Dutch research worker, Ir G A Benders, was chaired by Mr R W Waltham, President of the British Grassland Society, who has developed his own successful system for the production of high quality silage. In Holland the emphasis is on producing a high dry matter silage from leafy grass and handling it with self-loading wagons, or using bulk handling methods in which the density of the crop is increased before loading to the silo. There seems to be a trend away from the use of machinery and power for short chopping and little or no use is made of additives. These methods appear to have great potential for the small sized Dutch herds (and hence small silage requirement) and may well have a place in parts of the UK where there has been a slow acceptance of silage making.

Rapid wilting, following high speed mowing is now considered essential for most methods of conservation and equipment for this purpose has been developed both at Wageningen and at Silsoe. Mr W E Klinner has outlined the desirable features of a mower conditioner and has emphasised not only the mechanical requirements but also the need to treat and handle crops without causing excessive losses of the most valuable parts of the plant. Even with the most effective swath treatment, however, there seems to be a barrier at about the 30 to 35% moisture content level below which the field drying rate is severely reduced and the crop is put at risk for a disproportionately extended period.

One answer to this problem has been to harvest hay whilst it is still moist and then to dry it by artificial ventilation, thereby producing more tonnes/ha of a higher quality crop than can normally be obtained by field haymaking. Although technically effective methods of "barn drying" have been available for many years, handling problems have prevented their wide scale acceptance. If hay can be successfully dried in large bales there could be a significant increase in the number of farmers using this completely mechanised method of handling. Research reported by Dr M E Nellist has shown that many aspects of drying are common to both grass and grain; the use of the computor can markedly reduce the amount of experimental work required when a new technique or newly developed piece of equipment has to be evaluated. Some of the problems that may arise when attempting to dry hay bales weighing over half a tonne have also been considered and possible solutions have been suggested.

Any method of drying however may interrupt both the farm cropping and the forage handling system since it is not usually economic to install equipment to deal with the complete area of forage whilst it has optimum feeding value. The successful application of an additive to hay as it is being baled, to prevent deterioration in store, would provide a valuable alternative to drying. Research and the development of experimental equipment at NIAE are beginning to show that heating and moulding can be reduced by propionic acid and other products, provided application is even and at the correct rate. Development of production equipment for on-farm use will need to be completed before this technique provides a reliable alternative.

The benefits of conservation of high quality forage can only be fully exploited, however, if as much care is given to their feeding as to their production, and the need to consider the total ration and the strategy of using it has been clearly stated by Mr W F Raymond.

It is appropriate to mention that shortly after this conference the Rt Hon Frederick Peart, Minister of Agriculture, Fisheries and Food, speaking at the Dairy Trade Federation Conference announced the introduction of new incentives for investment in equipment for grass conservation; at the same time Dr Keith Dexter, Director General of ADAS, concluded that "greater production and utilisation of grass has enabled more cows to be kept on fewer acres".

Acceptance of ideas expressed by the speakers and delegates at our Institution Conference in May, followed by their widespread application on farms would help to ensure that the additional input of capital for conservation would lead to an even greater utilisation of grass products in practice.

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with running R & D Departments will I believe be interested in views expressed by leading research administrators. Optimism must be tempered with a feedback to engender critical attitudes and there must be resilience against inevitable disappointment. The right ethos of a laboratory is difficult to achieve and can be quickly destroyed by actions which lessen self confidence.

Regarding the future, there is increasing concern that government funds for all types of R & D must meet the country's most urgent needs. The conclusion of Sir Ieuan Maddock, that a major part of the G.N.P. comes from activities which are not particularly sensitive to technological advance and only marginally affected by R & D, surely does not apply to the agricultural scene. Bearing in mind the influence of its efficiency on agricultural engineering, the support for R & D and the means to ensure its use by British manufacturers must surely be recognised as a matter of high priority. An additional and subsequent thought is that since in the UK we have the human and scientific resources to conduct R & D relevant to European conditions, why do not the multi-national companies give further consideration to establishing R & D centres in the UK? T C D M

Reference

Blaxter, K L, "The limits of Agricultural Improvement."
Lecture to the University of Newcastle agricultural Society 10 December 1973

Copies of the full text of the Presidential Address can be obtained from The Secretary, Institution of Agricultural Engineers, West End Road, Silsoe, Beford MK45 4DU. Requests from overseas should be accompanied by 50p to cover postage.

Methods of harvesting and conserving silage and hay in the Netherlands

by Ir G A Benders

1 Introduction

IT will be easier to understand methods of fodder conservation as they are practised in Holland if some general information is given about cattle husbandry in that country.

Farms with dairy cattle	90 000 (approx)
Dairy cows/farm	24
Acres/farm	36
Livestock units/acre	1.0
Units N/acre grassland	200
Acres grassland	3.3 million, including 90–95% permanent grass
Housing in cubicles	30%, with a herd average of 70 cows

About 3 million of the total area of 3.3 million acres of grassland is cut for silage and hay yearly. Formerly a large part of the mown grass was made into hay but now more than half of the area is made into silage. On progressive farms there is much more silage than hay, and on farms with over 70 cows nearly 75% of conservation is in the form of silage. About 85% of all silage made at present has a dry matter (dm) content of more than 35%. Thus, wilting is practiced on a large scale and silage additives, which were not popular, have virtually ceased to be used.

The primary aim of grassland management is to provide the cows with high quality grass in summer time. Fodder conservation can help a great deal and is complementary to grazing. Most farmers will spread the first cut, comprising about 50% of the total area, over a period of three to four weeks and will start cutting early: If possible, in the first half of May.

The field wilting period for silage is usually about five days, and losses of dry matter during this time can be limited to 1% per day. A six to seven day field period, however, will lead to as much as 10% dm loss and this will be increased to 20% if wilting time is extended to ten days.

On most Dutch grassland farms there is very little machinery available and only cutting, tedding and raking is done by the farmer. Loading, transporting and handling is done by contractors who have heavy machinery and tractors and the skilled workers to operate them. The contractor is usually very well integrated into the dairy farm plan at an early stage; he can use machinery economically and write it off in a short time.

2 Mowing and tedding

The conventional fingerbar mower has been replaced almost completely by the rotary mower in the Netherlands. The two-drum types, with a working width of 1.70 m, are the most popular machines, but contractors are now looking for mowers with more capacity. The latest development is a front mounted mower on a specially constructed tractor power unit (about 135 kW) with a working width of 4.80 m. The mower is a combination of three two-drum mowers with flexible connections to allow vertical movement through an angle of up to 20°; it is being used together with a battery of three conditioners, covering the same width, mounted on the rear of the tractor (fig 1).

As in the UK several trials were carried out in Holland to improve

Instituut voor Mechanisatie, Arbeid en Gebouwen (IMAG), Mansholtlaan 10–12, Postbus 43, Wageningen 6140, Netherlands.

Paper presented at the Annual Conference of the Institution of Agricultural Engineers, held in association with the British Grassland Society, at the Bloomsbury Centre Hotel, London on 11 May 1976.

Fig. 1. The 4.8 m mower in front and three conditioners on another three point linkage in the rear.

the rate of drying in the field. The conclusions are almost the same, the only difference being that there is little beneficial effect on drying in our leafy grass after treatment with roller-crusher type machines.. In our opinion the combination of mowing and conditioning is an important step forward in the improvement of conserved fodder. Most farmers are still losing at least one day of effective drying by waiting until the day after mowing before applying the first tedding to their crops.

Subsequent treatments with a tedder, in our short and leafy grass, is absolutely necessary and it is wise to ted twice daily, if possible starting the day after mowing and conditioning. Therefore a machine with a good working width is needed and rotary tedders are the most useful for our circumstances. They can also be used for raking, leaving a uniform windrow that can easily be handled by harvesting machinery.

3 The self-loading forage wagon

The self-loading forage wagon is very popular in Holland and is used for zero-grazing, silage-making and hay-making. It is a relatively simple and cheap machine and fits very well into the Dutch systems of silage and hay production. Most of the silage is stored in simple clamps, without walls, up to 1.75 m high and 6 to 8 m wide; the length of the clamp depends on the available amount of grass. When the wagon is driven over the clamp, the grass is spread as evenly as possible. Alternatively the wagon dumps the grass in a heap in-front of the clamp and from there it is ensiled with a rear-mounted buck-rake.

Knives installed in the packing mechanism chop the forage and make spreading easier. Some modern wagons have more than 10 knives and a spreading mechanism that reduces handwork on the clamp to a minimum (see cover photograph). Rotary spreaders mounted on the three point linkage of the tractor which is being used to consolidate the grass have also proved to be very useful (fig 2).

The reason why Dutch farmers prefer this system is that it can be operated by two men, capital costs are low and the contractor can work without the help of the farmer. Working rate is also very satisfactory. Using a wagon with a load capacity of 1800 kg of wilted grass (800 to 900 kg dm) over a distance of 500 m from field

Fig 2. Rotary spreader mounted on the tractor used to consolidate the ensilage. Handwork at the clamp is eliminated.

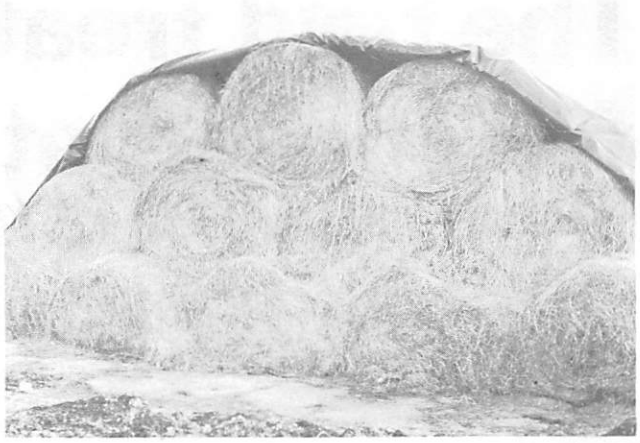


Fig 3. A silo clamp after a 10 month storage. The holes between the bales in the lower layers are filled up.

to clamp, it is possible to bring in four loads an hour. This is equivalent to 1 ha/h, or 3500 kg dm under normal conditions. When the wagon is used for hay-making the dry matter capacity is about the same as for silage and it is also possible to achieve four loads/hour. The hay may be dumped in front of the hay-blower and pushed in by hand or it may be loaded to a dump box from which it is fed to the blower.

Silage clamps are usually sealed with two polyethylene sheets, each 0.15 mm thick. These sheets have to be checked periodically throughout the whole storage period to keep them airtight and so prevent losses.

The system described is so simple and low cost that there seems to be no possible alternative. But there are also disadvantages. One of the main reasons that farmers are looking for other methods is that the area needed to site the clamps is a handicap, especially on the bigger farms. It should also be concreted as otherwise it will be very muddy during the winter.

We are trying to solve this problem by increasing the density of conserved forage in the field and by building a higher clamp.

4 Normal pick-up balers

The standard type of pick-up baler can be used for silage-making with wilted material and the bales can be handled by the methods used for straw. In particular, the impaler loader used in the flat-8 system seems to offer the best solution.

As with other methods airtight sealing is the most important condition for the successful production of high dry matter silage in bales. Mostly the silage made during one day's working is sealed with a sheet of 0.15 mm polyethylene and the silage made on the next day is placed against the first clamp. The whole clamp is then covered with a heavy sheet that can be used for about 4 years.

5 The round baler

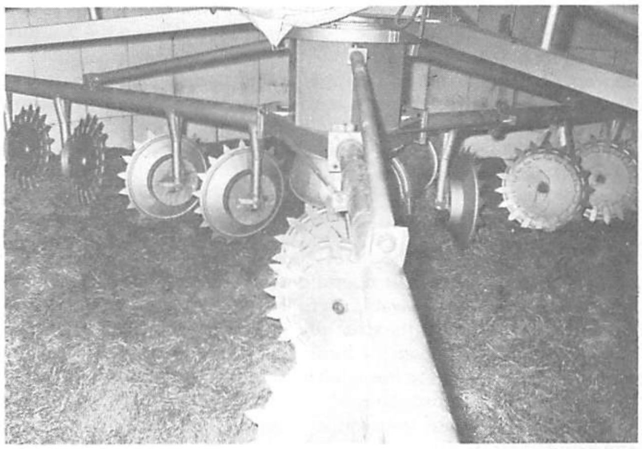
The round baler is the latest machine to be used to increase the density of grass in the field. We are using it in our present trials to make bales containing about 250 kg dm (1.20 m dia and 1.70 m in length). These bales can be handled with the front-loader on a 55 hp tractor. In the clamp the bales are stacked in three layers respectively of five, four and three bales (fig 3).

The method of sealing used is the same as with small bales. One of the advantages of the round bales is that they settle into a triangular shape in the silo filling up the holes between them. The dry matter density was found to be 150 kg/m^3 and 250 to 300 kg of dry matter were stored for each m^2 of ground area. We found also that, to prevent secondary fermentation, it is wise to seal not more than is necessary for 3 weeks feeding in single units, each sealed with 0.15 mm polyethylene sheeting.

6 Tower silos

Another way of storing silage is to use towers of various types. The problem with these silos is that the unloaders were developed for handling maize ensilage or other chopped coarse material and not for our leafy young grass. There are now unloaders on the market for handling long material (fig 4). The principle is to make the ensilage move to the centre of the silo and to the suction pipe from the blower which was used to fill the silo. The results are promising. Conveying silage, containing about 40% dm, directly to the barn for feeding, over a distance of more than 50 m, has proved to be practicable. Another problem is filling the silo. In a trial carried out last summer, we found that a suction blower with a 38 cm pipe seems to be the best for filling silos up to 30 m high with grass (chopped or unchopped). The measured capacities were very high, more than 60 ton/h. The only way to obtain the maximum capacity was to use two forage boxes delivering on to the same supply belt. The risk of blockage is very low compared with other blowers.

Fig 4. (below) The top unloader for long ensilage. The suction pipe of the blower is shown in the centre.



One of the research requirements is to develop a forage box that produces a uniform supply of grass to the blower.

7 Conclusions

The present conclusion about fodder conservation in the Netherlands is that silage-making is the best method for our climatic conditions and intensive grassland management. Hay-making is only possible in combination with cold or warm air drying in the barn and this will continue to be the case until we have found a treatment which so increases the drying rate that hay can be made at 75% dm after only 3 or 4 days drying in the field. Research work must be done, in our opinion, on machinery that will press grass, containing 40–60% dm, in the field to a dm density of more than 200 kg/m^3, and also on forage-boxes that will give a consistent supply of crop to blowers.

Postal difficulties

POSTAL communications to and from the Secretariat continue to go astray; apart from introducing our own courier service (which is impracticable) there would appear to be no solution to this present-day problem.

If any member does not receive a reply to any correspondence within, say, one month of posting, it would be helpful if he could contact the Institution Secretary.

All Postal Orders should be made payable to "The Institution of Agricultural Engineers" and crossed & Co.

The field treatment of grass for conservation

by W E Klinner FI AgrE Mem ASAE

1 Introduction

FIELD drying of surplus grass for winter feeding is the most time honoured form of conservation in livestock farming. Recent advances in conservation technology now allow harvesting at dry matter contents below the 80% level at which crops become normally safe for extended storage as hay.

From the moment a crop is cut degradation and dry matter losses occur due to the adverse effects of light and rain and the activities of micro-organisms. To minimise these effects, field exposure time must be minimised and this, in turn, requires drying rates to be maximised. The speed at which surface and sap moisture evaporate from cut crop in the field depends on many factors but particularly on the capacity of the drying air to absorb moisture and carry it away, on the physical condition of the herbage and on the spatial arrangement of the plant tillers on the ground. Unlike the weather, the last two factors can be influenced by different treatments at appropriate times throughout the drying period. Such treatments have composite effects, and it is the purpose of this paper to report recent work on this subject and to discuss the possibilities of further advancement. Information available from other sources has been reviewed recently elsewhere. [1]

2 Mechanical treatments

Mowers are the first machines to be used at the start of the conservation process; their operational characteristics affect mainly the initial structure of swaths and, hence, the micro-climate within. In subsequent treatments structure changes can be brought about with equipment designed for loosening, inverting, mixing, spreading and gathering. Complete inversion by sideways turning is particularly appropriate when a pronounced vertical moisture gradient exists or when the soil beneath the swaths is appreciably wetter than that in the exposed strips alongside.

The physical state of the crop is sometimes affected by the mower, but to change it drastically requires machines which can cause bruising, lacerating, splitting, bending or scuffing. For maximum advantage to be obtained, such 'conditioning' treatments need to be given at cutting.

2.1 Traditional treatments

For several decades the traditional crop treatment system has consisted of mowing by reciprocating knife mechanisms using single or double shear, followed by swath tedding or turning. Rotary mowers and spreading tedders have become available since the early 1960's and are now being widely adopted because of their high working rates and tolerance of difficult conditions. However, complete replacement of the earlier equipment will take many more years. The traditional treatment method has been used for many years as the control in field drying experiments at the NIAE.

In the swath the drying of the crop is closely linked to vapour pressure deficit — VPD — because this reflects the capacity of the ambient air to absorb moisture [2, 3]. VPD is the difference between the actual vapour pressure of the air and the saturated vapour pressure at the same temperature. It is calculated from the air temperature and relative humidity.

Crop drying rate is also influenced, together with dry matter losses, by the type and frequency of post-cutting treatment. An example of these effects with unconditioned crop is included in table 3. It shows the greater severity of tedding compared with turning, leading to faster drying but increased dry matter losses.

Another factor which can be shown to be important in the field is stubble length. The linear correlation in fig 1 indicates that on

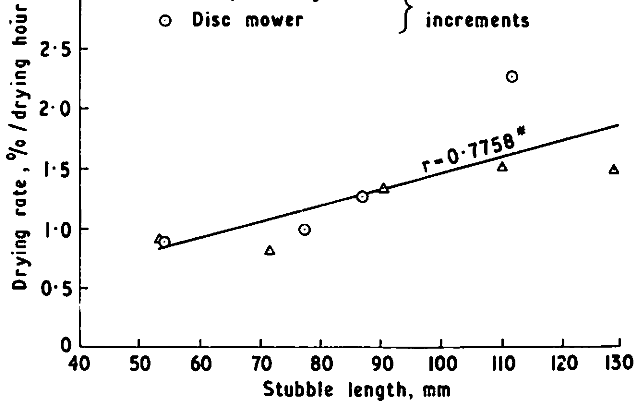


Fig 1. Effect of stubble length on the drying rate of unconditioned crop to 65 dm content.

overall average, with unconditioned crop, the drying rate to the 65% dm level can be doubled by an increase in stubble length from about 50 to 130 mm. In terms of crop dry matter available for harvesting due to the longer stubble, this could represent a reduction of around 8-10% in short-term crops of relatively low density in the cutting stratum and in the region of 15% in more dense-bottomed crops such as permanent grass. The important functions of the stubble seem to be to insulate the crop against soil moisture uptake and to allow and promote the inflow and circulation of air from beneath. It should also be relevant that any increase in the stubble fraction constitutes a decrease in the crop fraction which needs to be dried. If stubble length affects crop drying rate, then the uniformity of the stubble must make a contribution to the uniformity of drying. The latter is important to the effectiveness of any post-harvest treatment and to the storage behaviour of the product. To achieve uniform stubbles, the ability of the mower to follow ground contours is vital and this, in turn, is governed by the suspension of the cutting unit.

2.2 Advanced treatments

Recent NIAE work has been concerned initially with studying the performance characteristics of modern rotary mowers, established types of conditioner and alternative swath treatment equipment. By substituting rotary mowers for the reciprocating cutterbar in comparative experiments, but keeping post-cutting treatments identical where appropriate, the effects of the alternative cutting mechanisms could be isolated. With conditioning machines the frequency of post-cutting treatments had to be adapted to the differing needs of the treated crops.

For non-conditioned herbage the first treatment after cutting was always immediate tedding, and this was followed by further tedding or by turning, as and when required. The tedder used was of the double swath, overshot type, except when the effectiveness of a rotary spreading tedder was investigated. A summary of the results is given in table 1 for a selected range of machines, which are those in common use.

All three types of horizontally cutting rotary mower increased the average crop wilting rate appreciably, but only the four-drum mower had a worthwhile sustained effect. However, in every case less dry matter was available for harvesting. The losses are attributed primarily to secondary cutting and other forms of fragmentation caused by repeated contact with high-speed components during the

National Institute of Agricultural, Engineering Wrest Park, Silsoe, Bedford.

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Table 1 Summarised results of field drying experiments with commercial machines

base machine	no of expts	mean change relative to control: drying rate, % to 40% d m c	drying rate, % to 65% d m c	baled d m yield %	no of post-cutting treatments
two-drum mower	7	+10	−1	−2	+0.1
four-disc mower	13	+19	+1	−7	+0.1
four-drum mower	7	+24	+8	−9	0
reciprocating mower with tandem crimper	16	+54	+61	0	−1.2
reciprocating mower integral cleated crusher	8	+72	+83	−7	−1.5
flail mower	25	+84	+96	−2	−2.0

conveying process. It is these effects which are thought to be responsible for the improvements in drying rates.

The three machines for mowing and simultaneous conditioning gave substantial improvements in the short-term and sustained drying rates, together with worthwhile savings of post-cutting treatments. On overall average there was no yield penalty with crimping and an insignificant one with flail mowing, but with crushing by cleated roller mechanism it was appreciable.

To some extent the flail mower result is misleading because in respect of yield this form of treatment was extremely variable. In 14 experiments in a 4-year period flail mowing gave a saving in dry matter over the control in only four instances. Flail mowers were capable of coping with difficult crop conditions, but practical problems included scalping of undulating land, occasional serious soil contamination, and the need to use tractors of at least 60 kW if good performance and work rates were to be maintained in heavy crops. Crimpers were prone to wrapping in uneven swaths and in wilted crops, and reciprocating cutterbars blocked easily in difficult conditions and gave poor stubbles at high forward speeds. For maximum effectiveness all three established forms of conditioning required a high standard of management.

Correlation of the results obtained from power and performance measurements with the ten most important machine systems evaluated at NIAE has given the relationships shown in fig 2. The

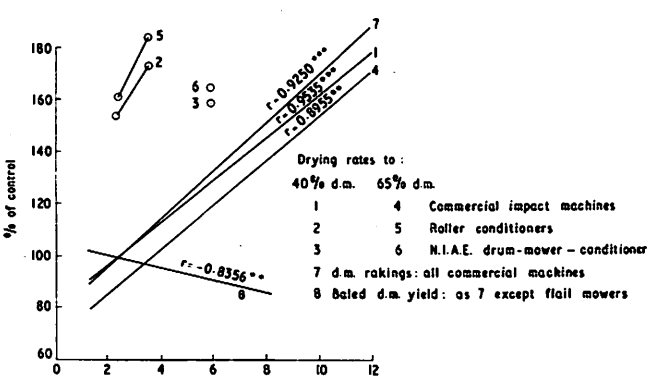

Fig 2. Effects of power applied to the crop during cutting and the primary treatment per metre of working width at 6.5 km/h.

useful power applied to the crop ignores the no-load power consumption of the machines and relates to a forward speed of 6.5 km/h and a unit working width of 1 m for mowing and the primary post-cutting treatment only. With regard to drying rates a distinction had to be made between the machines which achieve the crop treatment mainly by impact and those which utilise other means. The impact machines give the response shown in lines 1 and 4, whilst the roller conditioners are much more efficient, lines 2 and 5. For all the treatment systems the machine recoverable rakings, which may be regarded as an index of fragmentation, line 7, are inversely related to the dry matter yields available as hay at harvest, line 8. The exception to the latter is flail mowing which has been found to give yields in proportion to the relative frequency of post-cutting treatments.

With regard to crop quality, the evidence is that herbage which is severely treated mechanically is particularly prone to leaching of soluble constituents, notably the carbohydrates, when rain falls between cutting and harvesting. Deterioration during the storage period can be shown to be related to crop dry matter content at the beginning of storage and is usually less in conditioned material.[4] This is probably so because at the time of harvesting the dry matter content estimated by inspection more accurately reflects the true dry matter content of crop which has been conditioned. This point illustrates one important contribution which a convenient, accurate herbage moisture meter could make.

Development work at NIAE has led to a design of an experimental mower-conditioner which endeavours to take account of the findings with commercial machines but is adapted better to the special requirements of a variable climate.[5–7]. A moderated impact treatment causing mainly surface abrasion to the crop was thought to be most appropriate. All the treatment characteristics aimed for are listed in table 2 with their potential benefits.

Table 2 Desirable effects of a mower-conditioner

1. physical treatment limited to crop surface:
   - reduced surface resistance to moisture loss
   - low initial and secondary fragmentation
   - minimal loss of crop structural strength
   - loose, durable swath structure
   - favourable micro climate
   - rapid moisture loss
   - good weather resistance
   - low leaching losses
   - few post-cutting treatments
   - low dry matter losses
   - low power demand
   - low conservation cost
2. treatment severity proportional to crop thickness and yield
3. exposure of bottom growth on swath surface
4. large swath surface area
5. no mechanical swath compaction, eg by wheels
6. uniform stubbles
   - uniform drying: pre and post harvest
   - good utilisation of drying conditions
   - effective additive treatment
   - reduced deterioration during storage

In the NIAE experimental machines the conditioning effect is achieved by open V-form metal elements which scuff and abrade the cuticular crop layer without causing serious fragmentation and deterioration of the water shedding characteristics. More work is done on the basal parts of plant tillers and in dense areas of a field than at the top of the plants and where the crop is thinner, so that the drying rate is evened out along the length of tillers and within the crop mass. By a 'back combing' action the cut crop is bulked up, turned cut ends uppermost as much as possible and deposited in a loosely arranged swath. A special, single-point mower suspension ensures accurate contour following, and the semi-rigid conditioning elements have been made resistant to damage. The final prototype which incorporates all important refinements is semi-mounted, with a cutting width of 2.1 m, and based on a 2-drum mower.

Two earlier mounted versions have been used to evaluate the new conditioning principle alongside commercial comparison machines. Broadly the effect on drying rate has been found to be nearly identical with that for crimping but less than for flail mowing. Average dry matter yield at baling was highest at 15% above the control, and drying was appreciably more uniform than with any of the comparison treatments. On the occasions when rain fell between cutting and baling, leaching of soluble carbohydrates was less than with crimping and flail mowing, probably due to the lower levels of tissue damage. As shown in fig 2 the efficiency of power utilisation in respect of drying rate with the drum mower based experimental machine is intermediate between the impact machines and the roller conditioners with reciprocating cutterbars.

2.3 Relationship of primary to secondary treatments

Post-cutting treatments are aimed at boosting the diminishing rate of water vapour removal by restructuring the herbage layer. The interactions between the type of primary and secondary treatment and crop drying rates and losses are illustrated in table 3; this example relates to a crop of S.24 perennial ryegrass which was wilted for a fixed period of 5 days in poor drying weather.

In terms of crop drying performance the figures show the consistent advantage of tedding over turning and of conditioning by the two methods over non-conditioning. A consequence of the more severe tedding treatment is the greater dry matter loss. Compared with

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Table 3 Effects of post-cutting treatments

	final d m content, %	relative change, % drying rate	d m yield	in vitro digestibility (DOMD)
reciprocating mower:				
undisturbed control	35.7	0	0	0
immediate tedding, later turned x 2	39.5	+44	−4	+2
immediate tedding, later tedded x 2	42.5	+78	−11	−6
NIAE mower-conditioner:				
turned x 2	46.9	+129	−8	+1
tedded x 2	51.9	+186	−14	−2
flail mower:				
turned x 2	47.4	+135	−6	−2
tedded x 2	52.2	+189	−24	−8

traditional forward or rearward acting swath tedders, the more recently introduced horizontally acting, rotary spreading tedders give an entirely different arrangement of the herbage. The whole of the field surface area is covered by crop, not always uniformly, and most plant tillers are horizontally aligned. Comparisons between a 2-row overshot and an articulated spreading tedder have given the results summarised in table 4.

Table 4 Comparison of swath retention and spreading

% change due to spreading; means for six treatment systems.

		poor weather	fair weather
drying rate to	40% d m c	−26	−20
	65% d m c	− 7	+22
baled d m yield		− 2	− 4

The indications from the detailed results are that crop cut by reciprocating mower benefits from spreading generally without serious yield penalty. When a mechanical treatment is given deliberately or incidentally at cutting the short term effect of spreading is almost invariably to retard drying. Longer term the effect on drying rate seems to be detrimental only in poor weather, but additional dry matter losses are practically unavoidable. These extra losses appear to be higher in more favourable weather and can amount to over 10% in severely conditioned crop.

3 Chemical treatments

Effects which benefit the conservation programme can also be induced chemically. They fall broadly into two groups, namely those which increase crop drying rate and those which prevent or reduce spoilage through microbial activity. An advantage of chemical treatment is its low capital requirement; this is offset at present by the unpleasant handling properties of many of the materials and their undesirable effects on operator environment and equipment. Several of the field techniques which have received publicity recently are still in the experimental stages, with development proceeding simultaneously in commercial and government sponsored organisations. The sections which follow are a brief assessment of the present state of progress. Application of chemicals as silage additives is not covered.

3.1 Pre-cut desiccation

The principle of desiccant treatment of uncut crops is well established in the production of herbage seeds, oil seed rape, potatoes, peas, beans, etc. Most of the chemicals used are manufactured primarily as herbicides and are not approved as forage desiccants; some are systemic, and translocation can adversely affect crop regrowth. Organic acids, notably propionic and formic acid, are known to be acceptable crop additives and have proved to be effective desiccants in the laboratory. This has encouraged evaluation of their potential as forage desiccants in field studies[8–12]. Better results have been achieved with formic rather than propionic acid. Various forms of deflector, to improve application to the basal parts of the crop, have not increased effectiveness in practice. Wetting agents have also been ineffective, but the optimum mean diameter of the spray droplets has been shown to be 250–500 μ. With formic acid as a 25% solution, application rates of 2–5 l/tonne of fresh crop are recommended, depending on the crop and purpose.

The mechanism of desiccation seems to be that the plant cuticular waxes are disarranged by the acid, and the cuticle and deeper tissues are damaged; this in turn leads to increased transpiration from the plant cells. However, the effect is not sustained, and after an initial increase in dry matter content, sometimes to around 30% within one day, no further marked change takes place for six to nine days; then a gradual reversal sets in, probably due to regrowth. As with mechanical conditioning, good weather has a favourable effect, and after rain the treated crop again dries faster to its previous dry matter content than untreated crop.

3.2 Preservative application

For many years farmers have been using additives to help preserve their hay. The proprietary chemicals available for this purpose are largely based on organic acids, usually propionic acid. Few manufacturers claim that their products allow hay to be baled wetter than normally, and any such claims are modest.

Spoilage of hay baled at dry matter contents lower than is safe for storage is associated with heating, moulding and decomposition. The temperature of stored hay is a good indicator of the metabolic activity which is taking place. Table 5 lists the stages of deterioration by temperature levels and illustrates the benefits which effective preservative application would have.

Table 5 Heating and associated decomposition of damp hay

threshold temperature, ~ °C	effect of metabolic activity
25	accelerated loss of nutrients and dry matter; slight harmless moulding
30	accelerated development of harmless moulds
	development of pathogenic moulds:
40	mycotic abortion organisms
45	farmers' lung organisms
72	chemical oxidation leading to spontaneous combustion.

The effectiveness of propionic acid as a preservative is probably due to it lowering the pH-value of the crop plus inhibiting microbial activity at a specific pH[13]. Application rates which have given effective control in the laboratory[14] have proved to be inadequate in practice. On a farm scale variable results have been reported with hay preservatives in general. Probable reasons for the discrepancies are uneven distribution within the crop mass[15] and high losses of the volatile liquid during application.

Work in recent years at the NIAE has been concentrated on minimising the practical problems of application and developing effective equipment and suitable techniques. The ultimate objective is to reduce field exposure time and so decrease the weather dependence of haymaking. This is particularly relevant in relation to the new large packages, for which crop dry matter content is more critical than for conventional hay bales. As a first step the penetration of preservative into a simulated windrow was investigated in the laboratory. The maximum recorded depth achieved with spray nozzles of different types was under 150 mm. A possibility for improvement was thought to be momentary thinning out of the windrow by accelerating the hay, and applying the spray at the point where the stream velocity is greatest and density lowest. To test this theory, a windrow applicator was built by adapting a single-row tedder. The machine has been used in the past three seasons for acquiring data on the effectiveness of preservatives in relation to different crops, dry matter contents, application rates and methods. Two simulated commercial applicators mounted above the pick-up of a conventional baler have been used alongside at different times for comparison purposes. The summarised results are given in table 6. In fig 3 an example is shown of the temperature control obtained in one comparative trial with two applicators in S.23 ryegrass, using propionic acid. Total field time of the hay after cutting had been three days.

Relative to entirely field made hay, treatment by the windrow applicator with propionic acid gave savings of 1½ days of field time and 8% of dry matter in one comparative trial. On two occasions when hay was barn dried as a control for acid treatment, hay quality and dry matter losses were similar.

Table 6 Effectiveness of three applicators

	baler applicators *fine spray*	*broad spectrum spray*	*NIAE Windrow applicator*
distribution variation, %*	90	83	39
application loss, %*	59	56	46
pathogen development in relation to no of treatments	3 in 3	7 in 9	1 in 34

*at up to 2% application rate

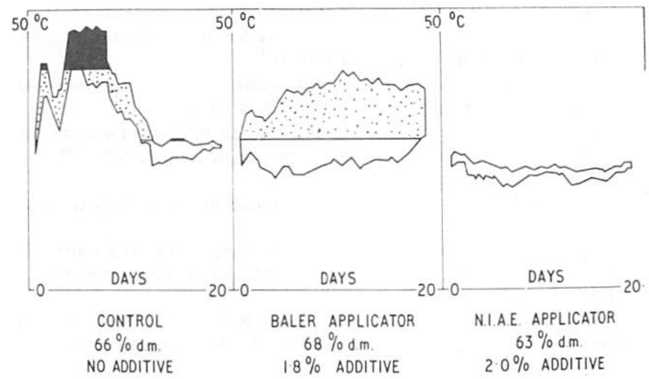

Fig 3. Heating of untreated and acid treated ryegrass hay-maximum/ minimum temperatures.

During the field experiments in 1973, 1974 and 1975 the mean ambient air temperatures were 18, 20 and 22°C respectively. The corresponding average losses of propionic acid with the windrow applicator at the 1–2% dosage level were 41, 51 and 58%. The figures indicate the scope for improvement which exists. Two approaches are open. They are to reduce airborne losses by better directional control plus optimisation of droplet size, and reducing the volatility of the liquid. The first is being pursued at NIAE at present; already a change to droplets of up to 800 μ has greatly reduced the unpleasant smell during propionic acid application. The second approach has received attention at Rothamsted Experimental Station and has led to the inclusion in recent NIAE field trials of fully neutralised ammonium propionate, following promising results in the laboratory. The liquid is non toxic and its volatility and corrosive properties are considerably less than those of propionic and formic acids; therefore, it is more pleasant to handle and work with and less detrimental to machinery. The effectiveness of both materials depends on the content of acid radical, so that volumetrically nearly twice as much ammonium propionate as propionic acid needs to be applied.

In table 7 the comparison of propionic acid with ammonium propionate treatment indicates that increasing the liquid quantity has little effect on the distribution, but the losses of effective material are shown to be considerably lower with the less volatile ammonium propionate. The comparisons were made with the windrow applicator in crops of fescue and ryegrass at several application rates.

Table 7 Effect of preservative on distribution in the bale and application losses

	propionic acid	*ammonium propionate*
mean variability, CV, %	32	31
mean loss, %	59	37
application factor to compensate for mean losses	2.5	1.6

Since the actual amount of preservative retained by the herbage is all important, ammonium propionate may have a considerable advantage, but the tank capacity on the harvesting unit would have to be at least half as large again as for acid. Fig 4 shows all the results obtained so far at NIAE with the windrow applicator. Approximate zones of high, moderate and low risk of heating are marked, but it must be stressed again that the high loss factors have to be considered when estimating the actual application rate. Reducing these factors and improving the economy of preservative application are of immediate concern and will require input from chemists, botanists,

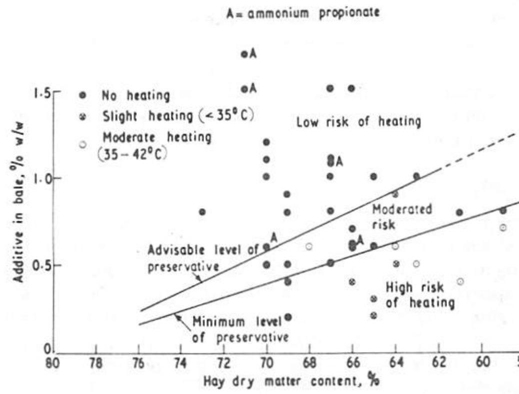

Fig 4. Effectiveness of preservative retained on herbage in relation to crop dry matter content. Treatment by NIAE windrow applicator.

mycologists and engineers. Currently the chemical cost of treating hay on a fresh weight basis with 1% of propionic acid is about £3.20/tonne. The limit for satisfactory treatment at present is a crop dry matter content of around 60%, because at this stage of drying conventional and large bales are often difficult to handle in to and out of store.

Efforts at NIAE to reduce total treatment cost have been directed towards eliminating the separate operation by combining application with windrowing. For this purpose a two-row overshot windrowing tedder has been fitted with spraying equipment. Further development and the evaluation of more suitable nozzles are proceeding. The next stage, which has already been started, is to develop an integrated system which combines the application of the preservative with windrowing and baling. Potential advantages are the saving of one operation, minimising the dwell time between application and harvest when losses can occur, and leaving the crop in individual swaths until the moment of baling. Fig 5 shows the system tried in

Fig 5. Experimental system for combined preservative application, windrowing and baling.

the late autumn of 1975. So far only fluorescent dye has been used with it, and results have been encouraging. The horizontal twin-rotor windrower has been modified for attachment to a specially built tractor front lift and pto. A central spray bar has been fitted at the front above the point where the swaths combine. By extending the drive shaft between the two rotors the 'reach' of the windrower, and hence its working rate, have been increased and the windrow produced has been made rectangular in section and sufficiently wide to match the pick-up mechanisms of in-line big balers. In consequence baling has been made easier and the package shape improved. For conventional offset balers transverse belt and single-rotor rakes have been adapted in a similar manner to front mounting and preservative application. There are some indications that with the large through-flow balers pick-up application can give acceptable results in conjunction with improved windrowing techniques.

3.3 The future for chemicals in conservation

Too little is known about the chemical treatment of plants, its effect on metabolic activity and the importance of crop physiology, of droplet size and velocity, of coverage, of timing, and of application technique. The ideal chemical would be one which is compatible with all livestock, which if applied prior to cutting would cause

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desiccation to any desired dry matter level without effecting serious nutrient losses and harming the root system, and which would have a beneficial residual effect. The potential even of partial desiccation is so great in the context of weather dependence and the costs of ventilation and high-temperature crop drying that continued research seems well justified. So far only liquid chemicals have been tried, but perhaps the application and practical problems with preservatives and desiccants would be eased by using powders, crystals, prills, granules or a mixture of these.

Conclusions

Rapid wilting of forages can be achieved readily with modern machines. Much can be done also for the farmer who makes hay; reducing the risk of nutrient loss between cutting and baling has been an important objective of recent work at the NIAE, as has uniform drying. The final increase in crop dry matter content is particularly slow and difficult to achieve in the field. In this context the most effective initial treatment methods available, combined with preservative application at around 65% d m c, offer the possibility of a significant reduction in total field time and weather risk. This should lead to more consistent hay quality which would simplify herd management and allow more accurate rationing. Chemicals in various forms and applications stand to make important contributions in conservation technology if research and development already in progress can be brought to satisfactory conclusions. Scope exists for improving crop treatment systems further and rationalising operations; in this, front mounting of machines could play an important role.

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The paper by M E Nellist (pages 55 – 60) is published as Report No 22 by NIAE, Silsoe.

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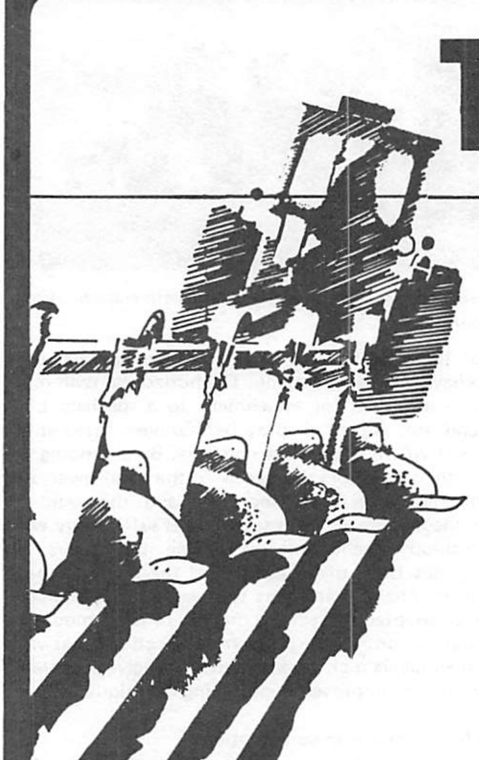

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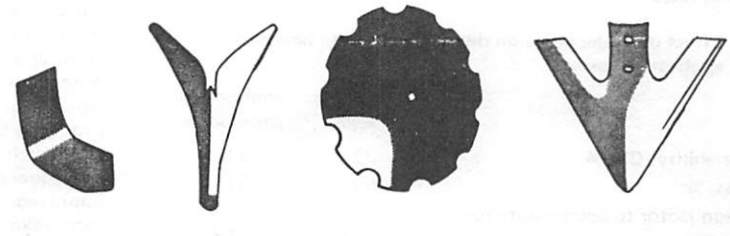

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Drying of hay and grain

by M E Nellist PhD MSc (Agr Eng) MIAgrE

1 Introduction

THE problems of drying hay and grain are concerned with improving the efficiency of energy use whilst maintaining crop quality. Almost without exception, existing driers and drying systems have been developed by empirical experiment and as such do not represent optimum solutions. The theme of this paper is that recent advances in research techniques have provided the means whereby drying problems can be solved with a precision and insight not possible previously and that we shall be able to calculate optima for drier design, drier operation and integration within the farm system. Mathematical modelling[1,2] is now providing a means whereby prototype designs or proposed methods of operation can be investigated without recourse either to expensive prototype hardware or many seasons of large scale experimentation. In this paper these recent developments are introduced as convenient examples specific to grain or hay. However, none of them is intended to be restricted to a particular crop except insofar as the necessary data may only be available for one crop or group of crops.

2 Grain

It is convenient to start with grain not only because it is the more important crop in terms of weight dried but because it is a relatively homogeneous material which has lent itself to the development of a variety of drying methods and drying theory. Drying theory cannot be applied to hay with the same precision.

2.1 Continuous flow driers (including automated batch driers)

Continuous flow grain driers for farm use are extremely simple and crude machines. Their limited annual use precludes the high capital cost that might be borne in an industrial situation. Because they are crude they are also relatively inefficient. Specific heat consumption for high temperature grain driers tested by the NIAE between 1960 and 1967 varied from 5.1 to 8.7 MJ/kg of water evaporated with an average of 6.7 MJ/kg[3–8]. These values are more than twice the latent heat of evaporation of water at 20°C (2.45 MJ/kg). Efficiency could be improved (a) if the driers were so designed that the heat of the exhaust gases was recovered and (b) if they could be used at higher air temperatures.

The following example shows how mathematical modelling can be used to predict the performance of a conventional drier and so investigate possibilities for its redesign. Consider a simple crossflow drier (fig 1) in which grain flows through a drying and cooling section at right angles to the flow of drying and cooling air.

We could measure the performance under different conditions of such a drier but it would be time consuming and expensive to do more than a few runs. Three or four runs per drier was the norm in NIAE tests and not a great deal can be learnt from this number. But if those three or four experimental runs can be used to show that a mathematical model of the drier produces similar results, then it is very easy to simulate many more runs by computer and predict the performance of the drier under a wide range of conditions. For the present example the NIAE model[10] was used to predict the behaviour of a drier giving a constant output moisture content of 15.1% wb for input moisture contents from 16.7% to 28.6%. A summary of the results is given in table I and in figure 2 the data are plotted on a scale of relative magnitude to their value at an input moisture content of 21.1% wb ie for 6% removal.

The quality most affected by input moisture content is throughput which is very much reduced at high moisture contents. Specific evaporation also decreases with initial moisture but not so markedly. Thus the drying cost per unit of dried grain must rise. Two other penalties of high input moistures are (a) the increasing range in final mc which can lead to storage problems and (b) the increasing residence time which can increase the risk of heat damage. But perhaps the most interesting feature is that above 19% mcwb the exhaust air temperature is constant and is a function of output moisture content. This is why exhaust air temperature has proved an effective means of controlling drier throughput.

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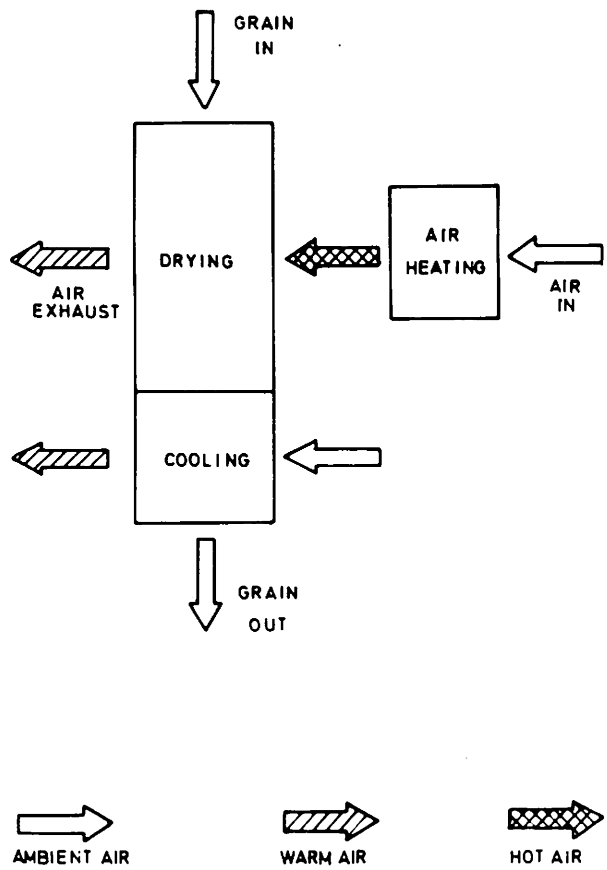

Fig 1. Schematic representation of a conventional crossflow grain drier.

Table I Effect of input moisture content of wheat on the simulated performance of a simple cross-flow drier with drying (66°C) and cooling sections of equal length and constant output moisture content of 15.1% wb (17.8% db)

Parameter	*Input moisture content % wb (% db)* 16.7 (20.0)	18.1 (22.0)	21.1 (26.8)	21.9 (28.0)	23.1 (30.0)	25.9 (35.0)	28.6 (40.0)
Throughput kg/h m^2	835	451	221	197	169	127	103
Evaporation rate kg H_2O/h m^2	10.0	12.0	14.0	14.4	14.9	16.1	17.0
Specific evaporation MJ/kg H_2O	7.66	6.35	5.45	5.31	5.12	4.75	4.48
Exhaust air temperature °C	30.6	43.1	46.5	46.6	46.5	46.3	46.0
Residence time min.	12.3	22.8	46.5	52.0	60.8	81.1	99.7
Range in final moisture content % wb	2.5	3.3	5.1	5.5	6.2	7.8	9.3

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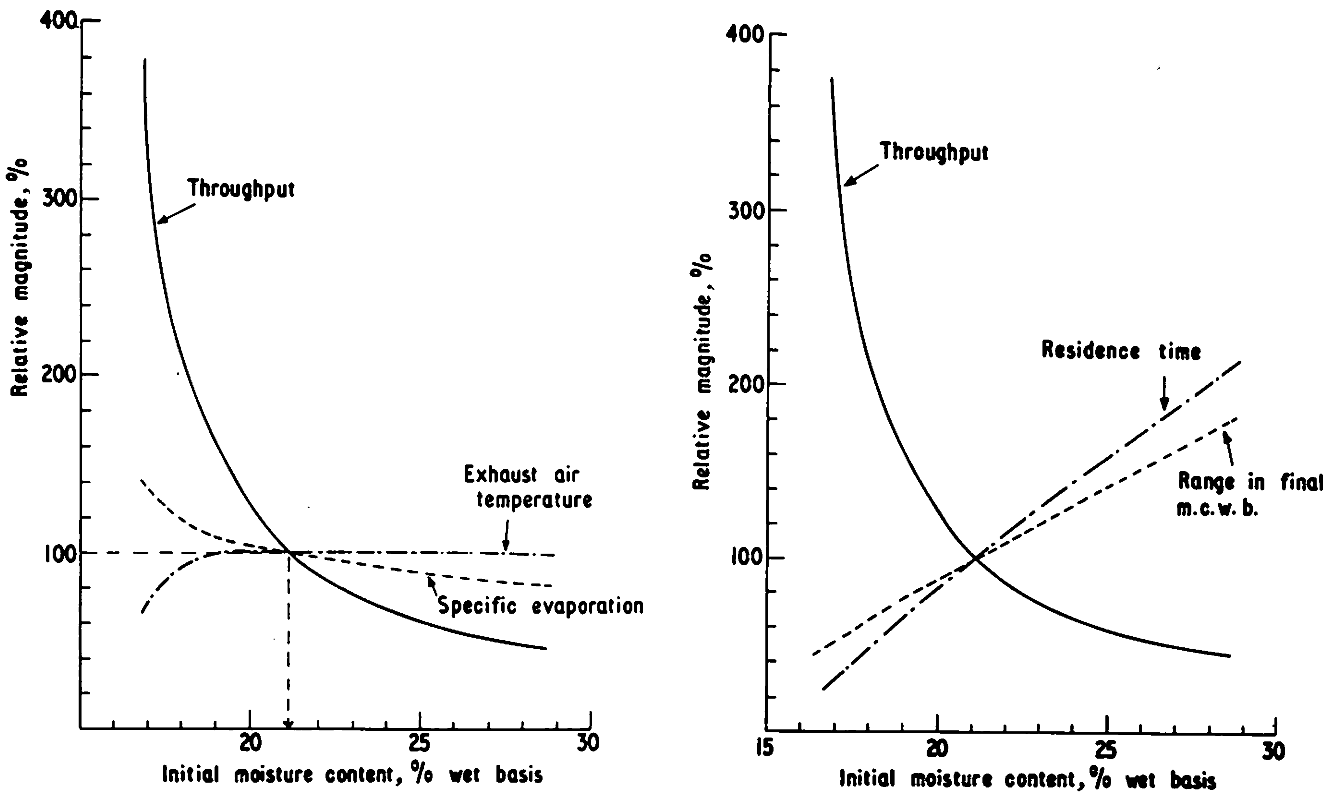


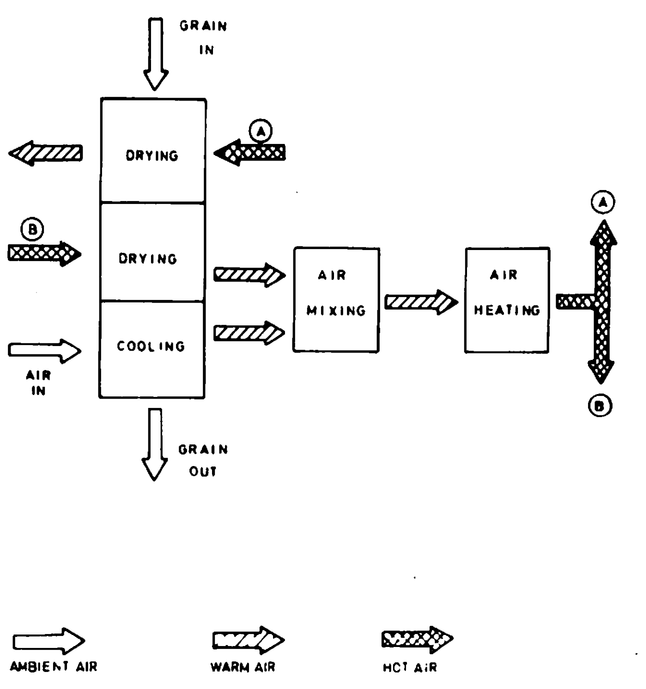
Fig 2. Crossflow drier performance at constant output moisture content.

Reference to the block diagram of the drier (fig 1) shows that this basic design is likely to be inefficient because heat is thrown away in the air exhausting from both the drying and cooling sections. The leading American authority on grain drier simulation, Professor F W Bakker-Arkema has demonstrated how the simulation can assist in redesigning a drier of this type[11]. The crossflow drier example was used because test data were available from simple and improved versions made by the Hart-Carter Co. Thus it was possible to verify the computed results.

The basis of the modified design (fig 3) is to recover and recycle heat energy by (a) using the cooling air for drying and (b) recirculating a proportion of the drying air to ensure that it exhausts more nearly saturated. In the simulated comparison the new design consumed only 3.68 MJ/kg of water evaporated compared with 7.02 MJ/kg in the conventional design and a similar result was obtained experimentally. But once it has been established that the simulation can give answers comparable to experimental results, the real point of interest is that it can do it very quickly and it is very easy to study the sensitivity to design changes. For example, Bakker-Arkema showed that increasing the proportion of air recycled from 40 to 60% reduced the predicted specific energy consumption from 4.13 to 3.17 MJ/kg of water evaporated.

So here we have a powerful means of testing designs and proposed design improvements without having to commit ourselves to expensive trial and error with hardware. These techniques could also be used to investigate the possibilities of using higher air temperatures in continuous flow driers provided that the time-temperature-quality relationships can be defined mathematically. P H Bailey[12] has pioneered this approach but much remains to be done.

Fig 3. Schematic representation of a modified crossflow grain drier (based on reference 12).



2.2 Low temperature static bed driers

The potential efficiency of the low temperature drier is greater than that of the continuous flow drier. The average specific evaporation in 12 tests[13,14,15] was 3.5 MJ/kg and in one test was as low as 1.6 MJ/kg which is less than the latent heat of vapourisation of water.

Whereas the continuous flow drier can be approximated as a steady state process in which the heat and mass transfer is the dominant relation, the low temperature drier is in a non-steady state influenced by several variables. By definition it is a storage drier which cannot be filled instantaneously; therefore bed depth (and floor area in the case of an on-floor drier) are changing, and input moisture content may be varying with harvest weather just as will the drying potential of the air. Since the additional water that can be taken up by ambient air is relatively low, large volumes of air are used and drying times are large. Is there a case for the use of supplemental heat at all? If there is, how should it be used? Should it be used to reduce the night-time trough or increase the day-time peak temperature? Is it necessary to use it every year or just a proportion of years or in certain localities? What is the optimum filling policy in relation to performance and air distribution? Should ventilation be continuous or intermittent? These are just some of the questions for which we have little more than vague qualitative answers.

Attempts to answer them are now being made once again using the technique of mathematical modelling. The advantages of this technique are even more apparent in that the problem with physical experimentation on any scale is that each experiment has its own unique weather and grain inputs and is long and expensive. Computer experiments are cheap and quick but more important, the same set or sets of weather data can be used over a whole range of other variables. Studies of this type can be approached from the standpoint of drying physics or from that of 'systems' or 'operational research' but tend to become a mixture of the two particularly when the drier operation has to be optimised. Studies of both types have been carried out in America[16–18] and the Scottish Institute of Agricultural Engineering has made some progress with a model of the operational research type[19]. But on the whole for UK conditions this subject has still to be explored.

The final model of a complete drier or drying system is an amalgam of smaller models of various component parts. Prediction of the airflow and its relative distribution is one of the components being studied at NIAE. There are two aspects to the problem (a) the distribution of air along ducts and laterals and (b) the distribution through the grain.

The problem can be posed in several ways but, for purposes of illustration, suppose it is required to find the duct static pressure and hence the velocity at the surface, of a sloping mound of grain ventilated by a single lateral (fig 4). The flow of air will be non-linear

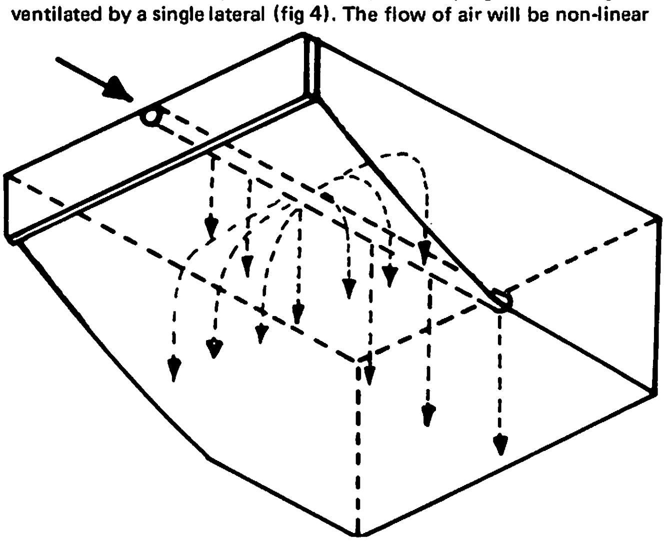


Fig 4. The single lateral duct problem.

at right angles to the duct and, if duct static pressure were constant, would vary with grain depth along its length. In practice the static pressure will vary along the length depending upon the balance of the grain pressure resistance and the change in static pressure caused by the change in air velocity as air leaves the duct. A computer program has been written to find this balance by the iterative solution of two separate numerical integration procedures. The first [20,21] is an improved version of Brooker's method[22] for non-linear airflow distribution and the second integrates a differential equation of flow along a perforated duct of constant cross-section[23]. The problem presented in figure 4 has been solved for a real case which was the low volume ventilation of an Intervention Board grain store via 20 m laterals, placed at 6.4 m centres (fig 5). For an air velocity of 15.8 m/s at the duct entrance, the static pressure along the duct increases to the distal end (the phenomenon of static pressure regain) but because of the increase in grain depth the final mean surface velocity is relatively constant. The program is versatile and can solve a variety of similar problems.

3 Barn hay drying

One factor inhibiting the wider adoption of barn hay drying has been the manual labour associated with filling the drier. The introduction in UK farming of large rectangular bales, some 20 times the size of conventional bales was significant because it offered scope for the complete mechanisation, not only of field handling, but also of loading the drier. Paradoxically, however, if all the handling has to be done by a tractor mounted gripping device, then the number of ways in which the bales can be stacked is very limited. Thus research and development has been concentrated on investigating systems of drying compatible with loading from the tractor seat. In practice this has meant that experimental work at the NIAE has so far been limited to batch drying, either of single bales or of tunnels of bales, although much of the single bale work was planned to yield information which would also be relevant to storage drying.

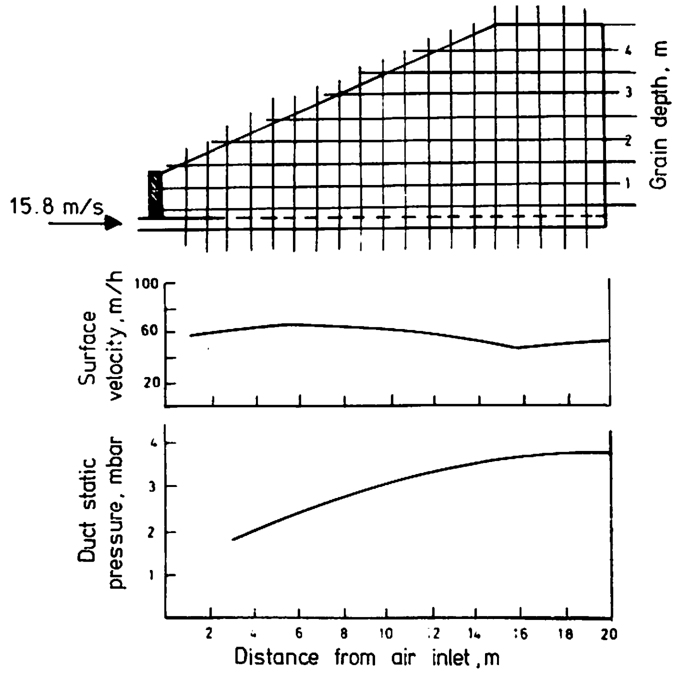


Fig 5. Computed effect of grain depth and duct static pressure regain on surface velocity in a wheat stores ventilated by 20 m laterals at 6.4 m centres.

3.1 Density and airflow distribution in large bales

Apart from size and handling characteristics the other differences, between the large and the conventional medium-density small bale, which have dominated experimental drying work have been the variability in density and shape resulting from the baler's mode of action. The method of packing inevitably produces a variation in density of the hay, from low at the rear or *gate* end to high at the front or *knot* end, together with local variations across the diameters of individual bundles. Figure 6 compares the frequency distribution of density in two large bales with that found in 28 small bales[24]. The mean bulk densities of the large are less than those of the small bales but there is a much greater within-bale variation in the former which is skewed towards a small percentage of very high values. Evidence from less intensive sampling of a much larger number of bales indicates that this variation is typical although it can be affected by operator skill at all stages from cutting to baling.

As an aid to the interpretation of the experimental drying results it is useful to consider the effect of density variations on air-flow through the bales. Figure 7 shows example surface velocity profiles along the central long axes of three single bales each ventilated from a floor aperture such that air can escape through the bale sides and top. These profiles have been calculated by a finite-element method[25] which can cope with simulated density variation. In the first case, (a), the density varies from 102 to 141 kg/m^3 from gate to knot end, which represents the average variation in density between bale ends found in a small survey. The effect is to distort the profile towards the gate end such that the maximum velocities at each end vary in inverse proportion to the densities. In the second case (b) a dense area of 340 kg/m^3 (shaded) is included in the position in which it has been observed in real bales. To maintain the same total flow it becomes necessary to increase the plenum static pressure by 30%. This results in higher maximum velocities through regions of low overall resistance but the velocity through the dense area remains extremely small. In the third case (c) the high density has been included as part of the uniform linear increase from the gate to the knot end. A seven-fold increase in plenum static pressure is necessary to maintain the total flow and this greatly increases the maximum velocity from the base of the gate end. However, the distribution is better than in the second case in that no area is completely starved of air.

Although attracted to areas of high density, the isobars within the bale are not significantly affected by the density variations. Thus pressure measurements are not a reliable guide to velocity distribution in a heterogeneous mass such as a large bale. Experimentally this is unfortunate because direct measurement of

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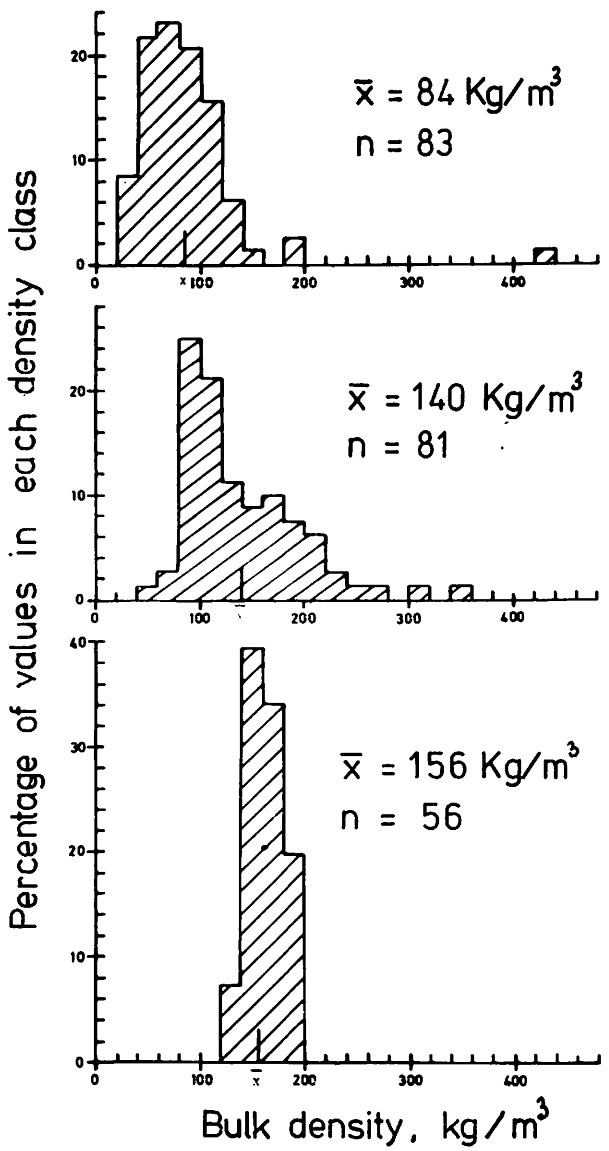


Fig 6. Distribution of bulk density of core samples taken from two single bales (top, middle) and 28 small bales dried as an equivalent) single bale unit (bottom).

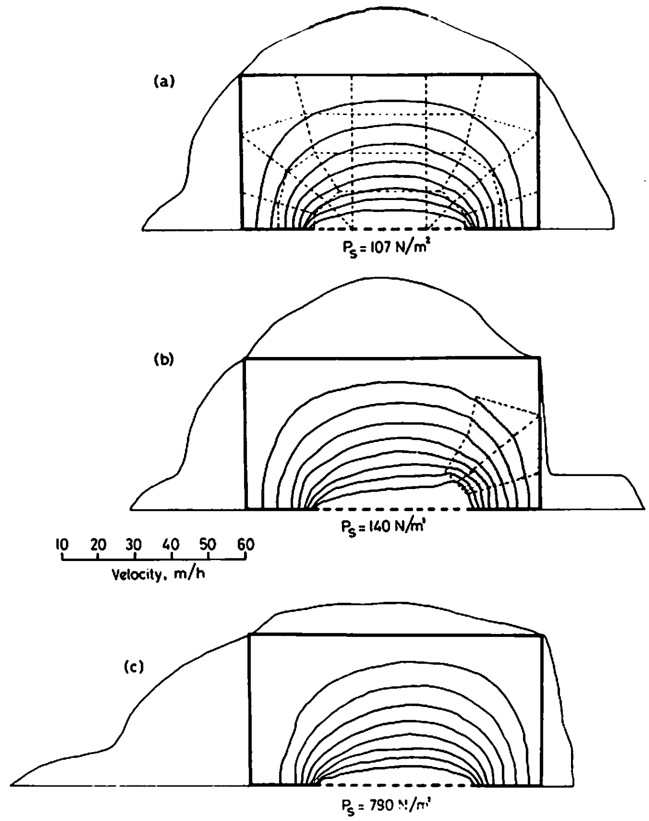
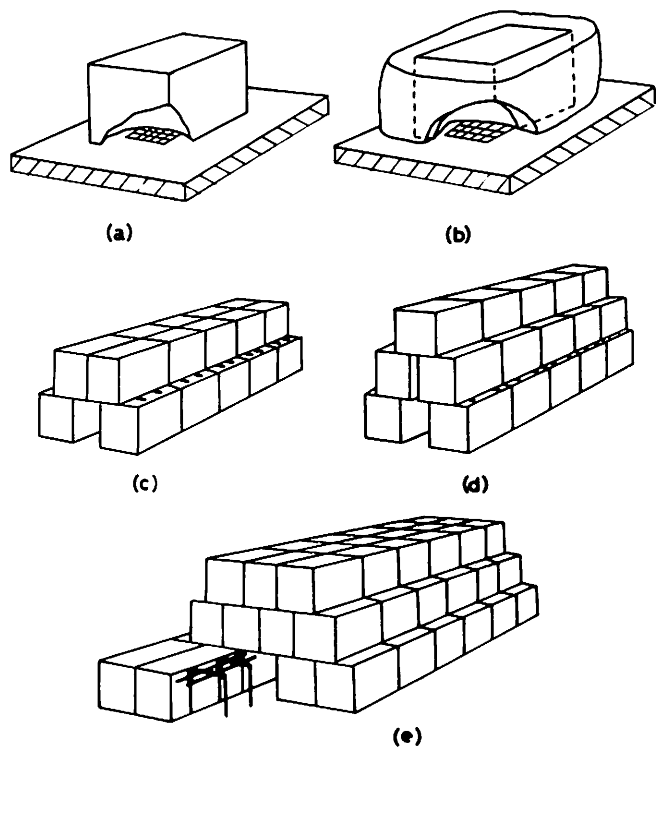


Fig 7. Computed effect of density variation on air pressure distribution and surface velocity through a single bale ventilated from a floor aperture at 914 m^3/h. (a) a linear variation from gate to knot end of 102 to 141 kg/m^3. (b) as (a) but including a denser area (shaded) of 340 kg/m^3; (c) a linear variation from gate to knot end of 102 to 340 kg/m^3.

Fig 8. (below) Arrangements for drying large rectangular hay bales. Floor ventilated single bale with open sides (a) and airtight sides (b); tunnels with four (c), five (d) and 11 (e) bales per arch.



low air velocities in the laboratory is difficult and on the farm becomes a formidable task. But again this is why theoretical calculations of this type are so valuable. Although we know that these answers may not be exact because they are derived from a simplified model using crude data, they have provided us with the insight necessary to understand some of the effect we have observed in the laboratory and on the farm, but which we have been unable to measure satisfactorily.

3.2 Experiments with drying bales singly and in tunnels

The NIAE experiments were carried out over a three year period with single bales under laboratory conditions at Silsoe[24,26,27] and with bale tunnels under farm conditions at Drayton EHF[28,29]. This paper provides an opportunity to draw together and compare results selected from the five separate unpublished reports.

The following arrangements of bales were considered (fig 8).

(i) Single bale ventilated from a floor aperture
(ii) Single bale ventilated from below but with airtight sides
(iii) Tunnel with four bales per arch
(iv) Tunnel with 11 bales per arch

Drying results for these four arrangements are compared in table II and further classified according to mode of ventilation – either continuous or intermittent. Valid comparisons of the 11 separate tests cannot be made because each one is unique in several ways. Weather conditions, crop, water removed, experimental apparatus

Table II Summary of results of NIAE experiments in drying large rectangular bales singly and in tunnels[24,26–29]

Parameter	*Single bales*						*Tunnels*				
	Continuous ventilation				*Intermittent ventilation*		*Continuous ventilation*				*Intermittent ventilation*
	Open sides		*Airtight sides*		*Airtight sides*		*4 bale arch*		*11 bale arch*		*11 bale arch*
	(a)	*(b)*	*(c)*	*(d)*	*(e)*	*(f)*	*(g)*	*(h)*	*(i)*	*(j)*	*(k)*
Moisture content % wb. Initial	27.9	24.6	40.6	35.6	34.0	36.2	38.6	32.0	31.8	25.8	35.8
Final	11.4	13.8	13.0	14.9	13.8	17.7	18.0	16.7	12.0	14.2	14.1
Water removed kg/Mg dried hay	229	143	465	321	306	290	335	240	290	135	338
Nominal airflow m^3/h/bale	3108	3078	1454	1165	571	827	1445	1419	808	1392	1380
m^3/h/Mg dm	5422	6073	3106	2437	1195	2306	3384	3133	2086	3529	3321
Total ventilating time h	151	64	107	158	170	158	271	221	359	117	158
Total residence time h	151	64	107	159	286	232	324	309	685	283	498
Specific air consumption m^3/kg H_2O evaporated	2736	1860	852	995	536	685	1967	2746	2338	2333	1123
Fuel oil consumption litre/Mg dried hay (i)	71.8	30.6	45.4	36.7	18.8	22.8	85.4	67.0	73.9	44.8	43.5
Cost at 4.4 p/litre (20 p/gall) £/Mg dried hay	3.15	1.34	2.00	1.61	0.83	1.00	3.76	2.94	3.25	1.97	1.92
Energy consumption MJ/Mg dried hay (ii)	2560	1089	1619	1308	671	812	3045	2389	2635	1597	1551
Specific evaporation MJ/kg H_2O evaporated (ii)	11.2	7.6	3.5	4.1	2.2	2.8	9.1	10.0	9.1	10.2	4.6

(i) For continuously-ventilated tunnels, fuel oil consumption is that used in each case by the diesel-driven fan. For the intermittently ventilated tunnel and the single bales, oil consumption is estimated from the average output of air of the diesel-driven fan, of 8720 m^3/litre oil.

(ii) Both energy consumption per Mg dried hay and specific evaporation are based on the estimated oil consumption assuming a net energy content of oil of 35.65 MJ/litre.

and experimental technique all varied. Computer simulated experiments are in hand to isolate and study the effects of individual variables but meanwhile we must draw what inferences we can from the experimental data available.

3.2.1 Specific air consumption

This measure of performance tends to eliminate the effect of variation in quantity of airflow and moisture removed and provides an indication of the energy consumption independent of the type of fan used. It is a crude but effective measure of efficiency.

Continuous ventilation of the tunnels and of the single bale with open sides requires from 1860 to 2746 m^3 air per kg water removed which is about twice the amount needed in a conventional storage drier for small bales or chopped hay[30]. For the single bale, preventing the air exhausting from the bale sides effectively reduced the specific air consumption to 852–995 m^3/kg water.

In theory air distribution in both the 4 and 11 bale arches is superior to that of the open-sided bale[21] and it is thought that the high specific air consumptions in the tunnels results from uneven flow caused by density variations and gaps between bales. Provided both bale shape and uniformity and tunnel building techniques can be improved then the efficiency of tunnels can probably also be improved.

A further reduction, to 536–685 m^3/kg water, in the clad single bale and to 1123 m^3/kg water in an 11 bale arch tunnel was achieved by using intermittent ventilation to complete drying. Respiratory heat accumulating in the damper areas during resting periods led to high drying rates during subsequent short periods of ventilation. Although this increased the efficiency of air use, it did so at the expense of a yet undefined quantity of dry matter.

3.2.2 Fuel and energy consumption

For purposes of comparison, fuel consumption, and hence running costs per Mg of dried hay have been based on the average quantity of oil used per unit of airflow in the four continuously ventilated tunnels. This is an over-simplification but is adequate for this purpose. Although oil or energy consumption per Mg of hay are also dependent on the quantity of moisture removed, the figures still reveal the benefit of low specific air consumption. The costs range from a means of £3/Mg in continuously ventilated tunnels to less than £1/Mg in the intermittently ventilated single bales with linear airflow. If an energy input of 1 to 1½ MJ/kg dry hay is accepted as a reasonable level of performance at which to aim, it is interesting to observe that this is of the same order as the difference in the metabolisable energy of good and poor quality hays. Assuming a net energy content of oil of 36.65 MJ/litre the estimated specific evaporations vary from 11.2 to 2.2 MJ/kg water evaporated ie at worst four and a half times greater and at best a little less than the latent heat of vapourisation of water.

3.2.3 Effect on hay quality

Analysis of the samples from the bales dried in the laboratory whether continuously or intermittently ventilated, indicated that the overall reduction in quality during drying was negligible. However there were considerable visual and analytical differences between individual samples from heated and unheated areas of a bale. It has not been possible to relate this deterioration to the precise amount of heating that occurred, but when heating did occur it was usually at the knot end of the bale and samples taken in those areas were often dense, moist and discoloured.

Analyses of these and similar samples from the Drayton work suggest that average dry matter losses in such heated areas are of the order of 5% but that badly heated areas may lose as much as 15%. It is important to note that such regions of high loss are only a very small proportion of the total bale and there is no evidence to suggest that overall losses are any worse than in other barn hay drying systems. Even in the worst samples very few dangerous mould spores were found and it would appear that, although temperatures at which thermophilic moulds could develop were reached, they were not maintained long enough for sporulation to occur. The presence of mycotoxins was not investigated.

3.3 Scope for improvement

In these experiments, intermittent ventilation was an effective means of improving efficiency because it dried small pockets of dense hay, usually in the knot ends of the bale, which had been by-passed by most of the drying air. From preliminary simulations of the drying and respiratory heating in single bales, we know that such benefit is only gained if there are areas of very low flow, something of the order of one tenth of the mean, and that, without the contribution to the drying made by the respiratory heat, these areas might never dry. If the drying zone were uniform there would be very little advantage to be gained from intermittent ventilation and so uniform hay densities and near-linear airflow must be the ultimate aim.

It seems probable that much will be done to reduce within and between bale variations by improved swath shape, baler operation and, baler design. Better bales will mean better tunnels and experience here should lead to tunnels in which the bales settle together rather than apart as they shrink. We believe, for example, that settling can be most effective if the bales are stacked as they are dropped from the baler but this is by no means a universally-held view. But even with all these improvements, it seems unlikely that

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the effects of irregular moisture content, density and non-linear airflow will be eliminated entirely. There is scope in the first instance for isolating some of the main variables and considering their influence on drying efficiency, quality and cost in uniformly dense hay. In addition more must be learned about the contribution made by respiratory heat, particularly where density is highly variable. Until we have this better understanding backed by experimental evidence, only very general guidance on tunnel drying can be given. From the evidence I have presented in this paper we would say that the upper limit to moisture content at baling should be 35% and that bales should be blown continuously at 1100–1400 m^3/h per bale for at least the first three days. Thereafter intermittent ventilation can be used provided only a small proportion of the hay is heating during rest periods and provided, of course, that the longer residence times on the drier are compatible with the haymaking strategy.

A fundamental disadvantage of drying in tunnels is that because of handling restrictions they must be built to their full thickness in one pass. Thus it is not possible to gain the advantages of true storage drying, in which, by adding hay in the direction of airflow so as to stay ahead of the drying zone, a really deep layer can be built up efficiently and with minimum risk to quality. The development of a means of overhead mechanical loading into a storage drier would be a most important step forward in the drying of large rectangular bales.

4 Conclusions

Although research into crop drying has been in progress for very many years, much remains to be done to improve drier efficiency and crop quality in farm practice. In the past decade, drying research has been lifted out of the doldrums by the advent of the digital computer as a powerful tool for solving complex problems in several variables.

There is scope in grain drying for improving the efficiency of both high and low temperature driers. For the former, this is mainly in the field of design to ensure the use of the highest possible air temperature without detriment to quality and the maximum recovery of heat from the exhaust air and grain. For low temperature drying, design problems are as concerned with air distribution as they are with heat and mass transfer and for maximum efficiency the management function becomes very important. But fundamentally the problems and methods of solution are very much the same.

These new techniques cannot be applied to hay with quite the precision that they can be to grain but, insofar as they enable us to simplify and gain insight into an even more complex interaction of variables, they are just as valuable. Results have been presented of recent experiments on barn-drying of large bales which in the short term have provided much useful information but which also demonstrate the uncomparable nature of such data. If answers to the questions which are asked about hay drying, eg the use of respiratory heat, dry matter loss, minimum rates of airflow, maximum moisture levels and optimum densities, are to be found then systematic simulation studies must be used to supplement and interpret such results.

Acknowledgement

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Arrangements for health and safety in agriculture in Great Britain

RESPONSIBILITY for health and safety in agriculture passed to the Health and Safety Commission on 1 March this year. After consultation with both sides of the agricultural industry, the Secretary of State for Employment has now accepted the Commission's proposals that the farm safety Inspectorates of the Ministry of Agriculture, Fisheries and Food and the Department of Agriculture and Fisheries for Scotland should be transferred to the Health and Safety Executive.

The Commission has already moved to further the policies initiated by the Agricultural Ministers last year by setting up an Agricultural Industry Advisory Committee as a successor to the Farm Safety Steering Group. This will enable the agricultural organisations to continue the valuable contribution they have made in the past to the resolution of problems of health and safety in agriculture.

HSE Agriculture Branch is currently based at Eagle House, 90-96 Cannon Street, London EC4N 6HT. Its Director is J C Weeks FIAgrE, President-Elect of the Institution.

Conservation and feeding of forage crops

W F Raymond MA FRIC

PREVIOUS papers have discussed some of the latest developments in the field treatment, harvesting and conservation of grass and forage crops to be made into hay and silage. The aim of this paper is to relate the information already given to the main object of the exercise (from the point of view of an animal nutritionist rather than an agricultural engineer) which is towards more effective feeding of the beef and dairy cattle and sheep on our livestock farms.

Problems of forage conservation have been studied for many years, but only recently has there been a more general interest in this subject. Partly this is because of the greater emphasis that was earlier given to grazing as the main method of using forages; but mainly it reflects the real farm situation of the last 100 years, during which cereals and concentrates have generally been cheap enough, in relation to returns from meat and milk, to make up a major part of profitable rations. As a result the quality of the "roughage" part of the ration was of little importance, and quite primitive methods of field hay-making were fully adequate. This situation changed suddenly between 1972 and 1973 – partly as a result of entry into the EEC, but mainly because of the sharp rise in world feedstuff prices. Thus between December 1972 and March 1974 returns from milk and beef rose by less than 15%, whereas the price of barley more than doubled. While returns from milk and beef have risen more than barley prices since then, the feed to product price ratio has not returned to the favourable levels of the 1960's, and seems unlikely to do so.

The present trade situation has also highlighted the very high proportion of these supplementary feeds that are imported. In 1973/74 some 820 000 t of crude protein (CP) were imported into the UK in the form of oil-seeds, fishmeal etc; of this some 60% (450 000 t of CP, in feeds valued at £80M at present prices) were fed to ruminant animals – a surprising figure because of the general view that most of these would go to pigs and poultry. In addition, some 3M t of cereals were imported, of which perhaps ¾M t were fed to ruminants[1].

Thus in terms of the economies both of the nation and of the farming industry, the need clearly emerges to reduce the amounts of cereal and protein concentrates which are fed, particularly when these are imported for feeding to ruminants. Most of these are fed during the winter, and it is this that has highlighted the need to improve the contribution to winter feeding of the other main component, namely conserved forage.

That we have already begun to find solutions to this problem perhaps reflects the foresight of those relatively few people – research workers in both Government and industry, farm advisers, and above all pioneer farmers – who, because of their belief in the importance of forage conservation, strove to improve the process right through the years when cereals and compound feeds were so cheap that livestock farmers could barely afford not to rely on them[2].

Thus this present meeting, between the Institution of Agricultural Engineers and the British Grassland Society, could hardly have come at a better time. As long as the main role of conserved forage was to produce "roughage" feed for winter rations based mainly on supplementary feeds, the main task of the engineer was to produce these conserved forages as simply and cheaply as possible. Quality, in terms of energy or protein value, was of little account, and even reduction of losses took second place to cheapness in the system – thus in the early 1960's the main test for a new forage harvester was not "did it work", but "did it cost less than £300!". As has been noted, this attitude deterred all but the most enthusiastic farmers from trying to improve their own conservation. More seriously, the relatively few research workers who were studying forage conservation tended to be inhibited in the approach they took by this general attitude that the process must be as cheap as possible – witness the opposition, some of it from leading farmers, when it was proposed to investigate systems of tower silage at Bridget's Experimental Husbandry Farm in 1967.

Despite this, important advances in forage conservation *were* being made, but the research effort has gained impetus with the new importance given to the subject, and the results of this research and development are now being more rapidly adopted into farm practice. In this a key feature is the increasing collaboration between the agronomist studying the growing of forage crops, the engineer studying methods of harvesting and conservation, and the animal nutritionist concerned with feeding conserved forages to different classes of farm stock.

The components of feeding value

Three main factors contribute to a high feeding value in a conserved forage, which is essential if present levels of supplementary feeding are to be reduced [3].

(a) It must have a high energy content, that is the forage to be conserved must be cut at a reasonably immature stage when it is of high digestibility. Much is now known about the rate at which the digestibility of different forages decreases as they become more mature; from this it is possible to predict with reasonable accuracy the date at which each forage should be cut to get the best compromise between yield and digestibility for the planned winter feeding programme. This means that the date of cutting of the crop should be determined by its stage of growth (digestibility) rather than by whether there is likely to be a spell of dry weather; thus conservation methods now need to be much less weather-dependent than they have been in the past.

(b) Particularly where they are to be fed to dairy stock, conserved forages should be of high protein content so as to reduce the need for supplementary protein. Again, this means cutting at a relatively immature stage, and also making sure that the leaves, which contain much of the protein of the plant, are not lost during conservation – as has so often happened with field hay-making. Silage has a clear advantage over present methods of making hay in providing protein for the winter; thus the average protein content of the silages analysed by ADAS during 1975 was 14.7% compared with only 10% in the hay samples – so that if one third of the acreage cut for hay had been made into silage, even by present methods, an extra 80 000 t of protein would have been available for feeding during the present winter[1].

(c) For conserved forages to make a high contribution to winter feeding they must have a high intake potential – that is animals must eat a lot of them. In this respect silage is at present generally inferior to hay – thus the dry matter intake from silage is likely to be less than that of hay made from the same crop, particularly if the hay has been barn-dried[4].

Energy and protein contents

As already noted, for hay or silage to be of high energy and protein contents, the forage must be cut at a relatively immature stage – the exact stage depending on the class of animals to be fed. Thus cutting must be as independent as possible of the weather, and this has given impetus to studies on improved field hay-making, including more rapid methods of wilting, as described by Mr Klinner, and the use of chemical additives to allow hay to be baled and stored at a higher-than-normal moisture content. The main problem here has been in the uniform application of chemicals to the hay as it is baled, so that no more than economic amounts need to be applied, but this will be solved and there will then certainly be an increase in the quantity of hay treated in this way. Hay can be baled from

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the field at an even higher moisture content ie needing a shorter spell of dry weather, if further moisture can then be removed from the bales in some form of barn-drier. This method is well suited to the smaller dairy farm, particularly where cows are still fed in stalls and the feeding of silage is therefore difficult.

In the majority of farm situations, however, silage is likely to be the optimum solution. Because only a limited amount of wilting is needed before the crop is lifted from the field, silage is less weather-dependent than any of the methods of making hay, and so gives the best opportunity for cutting the crop at the right stage of growth. During the mid-1960's tower silage appeared to be by far the most efficient method of ensilage; this requires field-wilting to something over 35% dry matter, so that some of the advantage of silage over hay-making is lost. But with better understanding of the ensilage process, in particular the importance of rapid filling and sealing, and the application of effective chemical additives, practical methods of silage-making involving much less field-wilting than with tower silage — and a considerably lower level of investment than in the tower-silo system — have been developed. More important, they have been rapidly adopted, so that close to 40% of conservation in 1975 was as silage, compared with only 15% in 1970. There is no doubt, of course, that an efficiently-run tower-system can give high-quality conserved feeds with very low losses. But the availability of these newer methods, many of them variants of the so-called Dorset Wedge System[5], which require less field wilting and less sophisticated equipment, makes the wider adoption of tower systems in the future unlikely.

The engineer has contributed much to these improved systems — in better field cutting and wilting equipment, in improved double-chop and precision-chop harvesters (which give a bigger load per trailer than longer material, and a crop that consolidates and ferments better in the silo), in methods of filling and sealing the silo, and in the improved mechanisms for mixing chemical additives uniformly with the crop before it goes into the silo. It is interesting here to note that most of the additives now used were developed before the war; but they seldom proved effective in practice, because the methods of spreading them on layers of crop in the silo did not mix them uniformly; a key development was to introduce the additive directly into the cutting chamber of the forage harvester, giving rapid and uniform mixing with the crop, with preservation starting immediately rather than being delayed until the crop is loaded into the silo.

The intake of silage

Additives not only give better preservation and lower losses in the silo; they can also have a major effect in improving the intake potential of silage, noted above as one of its limitations. Most current additives contain acid, and so give an immediate drop in pH when they are mixed with the crop. This seems to inhibit protein degradation, which can occur during the early stages of the normal silage process. The resulting silage is not only more stable, ie it is not subject to secondary deterioration, but stock are also able to eat more of it than of similar silage made without an additive. But the intake even of silage made with an additive may still be lower than that of the fresh crop, or of barn-dried hay made from the same crop; this appears to be because animal intake is now limited by the high acid content (low pH) of the silage. This has led to the search for new types of additive which will prevent protein breakdown, but which will not rely on low pH for preservation. For example, crops preserved with formaldehyde or mixtures of formaldehyde and acid are preserved at a much higher pH than normal (ie between five and six rather than below four) and have been shown to have higher intakes than when acid is the main preservative. But the level of application may now be much more critical than when normal additives are used; thus the addition of too much formaldehyde can markedly reduce the feeding value of silage by combining with protein and making it non-available to animals [6]. The problem will, however, be solved, with more precise methods of application, and improved additives. This will need close co-operation with the engineer, in developing applicators with the feed-rate more directly linked to rate of crop loading, and in particular in improving methods of sealing the silo; unfortunately these "minimum-fermentation" silages decompose more rapidly when exposed to air than conventional low-pH silage, so that sealing, both during storage and feeding out, must be more carefully controlled. But the outcome, silages with intakes as high or higher than that of the original fresh crop, could be so important that solutions will be found, and effective methods rapidly introduced into farm practice.

There is no doubt that, whatever ensilage method is adopted, there will still be an advantage in reducing the moisture content of most crops before they are brought in from the field — both to reduce the weight of crop that has to be hauled and handled into the silo and to decrease the risk of effluent loss from the silo. Even during a spell of wet weather the cutting and conditioning methods already described will, in general, give some increase in the dry matter content of the crop — enough so that most crops to be ensiled can be cut at the optimum stage of growth, whereas cutting even for tower silage or barn hay-drying may have to be delayed for a spell of dry weather.

Feeding conserved forages

By using improved methods of quick hay-making, barn-drying and ensilage forages can be reliably stored for winter feeding, containing higher energy and protein contents and with much lower losses than by more traditional methods. Hay is still the main form of conservation in the UK, and will continue to be made on many holdings where, for a variety of reasons, silage making and feeding do not fit the system. As already noted, cows in many dairy herds are still fed in cowsheds, for which hay is the most convenient feed. A change from hay to silage-making would involve not only new investment in equipment, but also a change to cubicles or loose-housing so that silage can be fed. But where a change in the buildings is already planned, new investment in silage-making will often be worthwhile. The same will generally be true for growing and fattening beef cattle and for autumn-calving suckler cows, but there may be less advantage with spring-calving cows, which cannot exploit the higher quality of the silage.

Most silage is now made in sealed horizontal bunkers or clamps, and animals eat it by systems of self-feeding or easy-feeding (in which silage is thrown down manually from the top of a high face). But many farmers are now looking into possible advantages of some form of mechanised feeding from the silo and there is much scope for engineering development here both in machines for cutting out silage and in methods of feeding it to livestock[7]. Cutting silage from the face and delivering it directly to feed-troughs can be used with small groups of animals. But where more animals are kept, and particularly where they can be divided into yield or performance groups, delivery by means of a forage-box could have a number of advantages:-

(a) Silage from two or more silos can be fed at the same time, which is most difficult to control with any system of self-feeding. In this way a "balanced" feed can be made up from, for example, maize silage (low protein) mixed with a high protein grass or clover silage, while a mixture of lower quality can be made up for feeding to the lower-yielding groups in a dairy herd. Machines, for which there still appears scope for improvement, cut and load the silage directly from the face into the forage-box. This in turn can be fitted with load cells or some other weighing device so that the required weight of each component of the mix can be metered into the forage-box. These are then mixed, either by paddles fitted inside the box, or by the unloading mechanism as it delivers into the feed-troughs. The weighing device also allows the required weight of feed to be delivered to each group of animals to be fed[7].

(b) A whole range of other feeds can also be weighed and mixed with silage — chopped hay or straw, sugar-beet pulp, sugar-beet tops, sprout tops and other "surplus" feeds as available. It is also possible to mix more concentrated feeds with the silage — rolled mineralised barley, alkali-treated straw (now being produced by BOCM) and pellets of dried grass or lucerne.

(c) The forage-box also opens up new possibilities in the feeding of urea[8]. Ruminants are able to utilise this nitrogen-containing chemical to substitute much of the protein in their rations; but urea can be toxic if it is eaten in large amounts at once, as when it is included in a compound fed at milking time. The forage-box allows this chemical to be mixed uniformly with the whole of the ration, so that animals eat small amounts of it at intervals throughout the day, with a greatly reduced risk of toxicity. An alternative method of ensuring a slow intake of urea is to mix it with molasses, cereals, minerals etc, in licks or blocks, but these are much more expensive sources of "crude protein" than pure urea.

(d) In traditional dairy cow feeding the basal ration of hay or silage is available *ad lib* throughout the 24 hours, but supplementary concentrate feeds are generally fed while the cows are being milked. With the forage-box these supplementary feeds can be mixed with the remainder of the ration and so fed throughout the 24 hours. There are several points about this which could be relevant to engineering development. Firstly, as average milk yields increase, and particularly with the introduction of high-level feeding in early lactation, there can be problems in getting individual cows to eat the required amount of concentrate during the time they are being milked, and in extreme cases this can lead to a slowing-down of the whole dairy routine. Then to reduce labour at milking time automatic concentrate dispensers are being installed; these are becoming increasingly complex and expensive. Finally, there must be some doubt as to whether the feeding of large amounts of concentrates two or three times a day is nutritionally the most effective way of using them. We know that after each feed the pH in the animal's rumen rapidly drops (ie the rumen becomes more acid), and that in this condition it is less effective at digesting fibre so that the cow is making less-than-optimum use of the forage part of its ration. Evidence of the possible effect of this on efficiency of feed utilisation is lacking[7]. But there could well be nutritional advantage in mixing concentrates with silage and other feeds in the forage-box so that the animals get a "balanced" ration in every mouthful. This needs following up under UK conditions.

Clearly, total ration feeding can only be effective when the cows in a herd are divided into yield groups so that a separate feed mix can be made up to the feed requirements of each group, with more concentrates, less silage, etc, going to the highest-yielders. Even this may not be adequate to exploit the production potential of the highest yielders, and here again there is scope for development of equipment to provide extra concentrates to particular cows within the yield group — such as the feed dispenser used at the Cheshire Farm Institute, which is actuated to deliver an extra "feed" of concentrate by an electronic key suspended from the necks of the highest-yielding cows. These animals rapidly learn to get extra feed to "top up" the mixed ration available to the remaining animals in the group.

With such a feeding system the whole strategy of utilising conserved forages needs re-examination. It might appear sensible to feed the highest quality (high digestibility) silages to the highest-yielding group. But in early lactation this group is getting large quantities of concentrates so as to establish a high peak of lactation, and may eat relatively little conserved forage. The real scope for making greater use of conserved feed, and so cheapening the overall lactation feeding, seems to be in the second half of lactation. The level of peak milk yield largely determines the potential for the rest of the lactation. With reasonable feeding milk production from then on should drop at about 2½% per week, and it should be possible progressively to replace the concentrate and cereal part of the ration with conserved forage. This surely is the place to exploit the high-quality conserved forages available, for many experiments have shown that silage feed on its own can sustain levels of milk production in excess of 13.6 l/day in later lactation. This idea has already been tried out over a number of winters by Mr Ken Slater at the Cheshire Farm Institute at Reaseheath in a system he calls "Brinkmanship". One might prefer the less apocalyptic term, "Challenge Feeding" — but this time challenging the animal with high-quality conserved feed, rather than the more conventional challenge feeding with concentrates in early lactation. By feeding concentrates liberally at that time, and then making increasing use of high-quality silage in later lactation, Mr Slater has achieved a 5900 l average with the Friesian herd at Reaseheath, at a stocking rate of 2.47 cow/ha and a concentrate usage of 0.29 kg/l — little more than that fed to the national herd with its average yield of about 4100 l, and a stocking rate over 1.65 cow/ha. This herd in fact still self-feeds at the silage face. But only part of the concentrate ration is fed in the parlour, the higher-yielding cows being supplemented with the electronic feed-boxes, noted above, to which they have access close to the silage face. In fact, very few farmers are yet feeding their concentrates in a complete feed via the forage-box, though the American Feed Grains Council has recently imported 2 self-weighing forage-boxes to install on dairy farms to study the most effective use of this equipment. As a recent study by the ADAS Liaison Unit at the National Institute of Agricultural Engineering, Silsoe, reported, critical experience on the optimum design and use of forage-boxes is still lacking; in particular present automatic-weighing devices were considered to be unsatisfactory[9].

Here then is another aspect of forage farming where engineering expertise is needed. But as with all the other subjects noted in this paper — cutting and conditioning equipment, forage harvesters and applicators for hay and silage additives, and the design of barn hay-driers and bunker silos, work on the development of more automated systems of feeding conserved forages need to be carried out as a fully co-operative effort between the agronomist, the engineer, the animal nutritionist, the farm adviser, and equally importantly the farmers who will be using this new equipment. The species and stage of growth of forage to be harvested, the amount of conditioning and optimum chop-length needed, and the quantities and combinations of rations to be fed will all have an effect on the design and method of operation of new equipment. This collaboration can only be strengthened by the exchanges taking place at this present meeting.

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The Institution Spring 1977 Conference will be held on Tuesday 29 March 1977 at Harper Adams Agricultural College, nr Newport, Salop.

CROP PROTECTION:-

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Anyone requiring further information should write to:

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Edited summary of discussion

Paper by G A Benders

Dr I J Cooke (Gascoigne Gush & Dent Ltd) referred to the loading and unloading of long forage from tower silos and asked if problems were encountered with leafy silage which would compact in 25 m towers. He also enquired whether there was a danger of fire when long material which was well wilted, was stored in towers — the surface of the material necessarily being loose. Mr Benders replied that when power consumption was high the unloader was raised and power consumption thereby controlled. Heating and fire danger were minimised by compacting the stored material and covering with plastic sheet.

Mr C V Brutey (NFU) asked for practical advice in the matter of extracting baled material from a stack comprising round big bales which become triangular after compression. Mr Benders commented that no particular problem was encountered either in extracting the material or in feeding it. Small trailers with side access would handle the triangular bales or, alternatively, the bales could be cut using conventional silage pit cutting equipment.

Mr P A M Murray (Farmer) commented on the very long wilting times employed by the Dutch. He also mentioned his own experiences in trying to seal stacks of big bales with plastic sheets. Holes, arising from many different causes, were a perpetual problem. Mr Benders observed that the Dutch climate, particularly during spring, involved short sunny spells and periods of high humidity so that ten days to 14 days was customarily required for hay making. Hay could rarely be made in two days. He agreed about the maintenance problem with plastic sheets. Care was apparently the only answer.

Mr P R Woods (Howard Harvestore) asked about the relative quality of material from silage towers and from silage pits, thinking particularly of the larger intake, by animals, of high dry matter material. Mr Benders replied that the quality of silage obtained from pits was much the same as that from towers, the quality depending upon the standard of management by the farmer but fewer mistakes tended to be made with tower silos.

Paper by W E Klinner

Mr E Barnes (BP Nutrition) noted that the commercial applicator used by Mr Klinner for chemical additives produced a jet of liquid. His own preference was for finer droplet size. He also mentioned that BP research department had developed a propionic acid derivative with more preservative action than ammonium propionate.

Paper by M E Nellist

Mr P A M Murray suggested that automatic control of forage harvesting, when additives were being used, would relieve the operator of an extra burden in supervision of equipment. He also enquired as to the possibility of mowing and applying additives as separate operations because it was often not convenient to windrow in front of the baler. Mr Klinner commented that he was currently investigating swath variability with the view to introducing automatic control when ideal application rates for additives had been decided. Whilst agreeing that it was often better to windrow earlier, he was aware of the opinion that the hay should be left in single swaths for as long as possible to maintain the progress of drying. Clearly many different systems of operation were possible.

Mr G Newman (IRAD) asked if there was any evidence to suggest that those farmers who have been using conventional conditioners to make silage of erect species should change to the NIAE type. In replying Mr Klinner stated:

a) that the NIAE type of conditioner was not yet available commercially.

b) that he was concerned with investigating the problems of silage making rather than criticising existing machines. In doing this, however, he had encountered two types of crop which did not respond well to the conventional crimper. These were permanent pasture containing small fine grasses which did not take a permanent set and swaths of leafy grasses which settled quickly so that swath ventilation was poor.

Mr P G Finn-Kelcey (consultant) felt that in the barn drying of small bales much of the effect was achieved by air which passed around rather than through the bales. Might this not also happen with big bales? Dr Nellist commented on the large difference in volume between the two types of bales. He was particularly interested in the amount of air which could be induced to flow through large bales during field conditioning because he was convinced that this through circulation was essential for satisfactory drying.

Mr W S Shattock (ADAS) referred to Dr Nellist's comments on temperature of silage. Did the same apply to hay: is hay damaged by heating? Dr Nellist felt that a maximum of 40°C should not be exceeded. As long as heating times were short there would be little damage to the hay and little sporulation. Ideally, of course, there should be no heating at all. Heating in the bales should only be considered to overcome poor transmission of air through dense regions where the normal drying process was not possible.

Paper by W F Raymond

Mr S W R Cox (NIAE) drew attention to recommendations by Keel and Kaufman regarding frequent feeding and the alternation of feeds. He noted that this conflicted with the idea of intimately mixed rations recommended by the speaker. In reply Mr Raymond commented that use of a forage box enabled materials to be used as feeding-stuffs which might otherwise be rejected by cattle. He was aware of the Kaufman observations but felt that ideal diets would involve intimate mixing.

Mr P Wakeford (Electricity Council) enquired as to the logistics of separating high and low yielders with regard to the feeding of concentrates. Mr Raymond observed that in a herd of size 100–150 cows it was technically possible to divide the cattle into high, medium and low yielding groups and to feed concentrates accordingly. To some extent however this was self restricting for if all the cows were fed on the same complete ration, some topping up system would be required for the high yielders.

Mr J Parker (BGS) noted that with reduced labour forces, forage box and mixing arrangements must work for seven days a week and be very reliable. Mr Raymond observed that such a system was probably not suitable for the small farmer but evidence from the north of Scotland suggested that food which was mixed on a Friday would keep satisfactorily over the weekend. He also suggested that there might be possibilities for co-operative use of forage boxes.

Mr U G Curson asked about the best length of chopped material for feeding. Mr Raymond counselled "the shorter the better". Short chop material conserves better because it ferments rapidly and produces better silage; it is easier for the cow to eat short chopped material particularly during self feeding. Mr Waltham observed that chop length should be related to the dry matter content of the material. High dry matter material should be chopped to 1 in or less but a greater length could be used for low dry matter material.

Open forum

Mr P H Bailey (Scottish Institute of Agricultural Engineering) opened the general discussion by referring to the worsening fuel situation and the need to make more economic use of the resources available to us. Drawing each of the speakers into the discussion he made the following comments:-

The computer has enabled a large amount of investigational work to be done, backed-up by practical experimentation, to explain the drying process. Was it likely that manufacturers of dryers would be able to make use of Dr Nellist's models in developing or redesigning their products? Perhaps it would become possible for advisers to use computer models of whole farm systems when discussing future developments with farmers.

Referring to Mr Bender's paper he asked if problems arose from air gaps which occurred between the polythene covering and the bales in a silage stack. Further to this was there a problem in dealing with the long material from round bales in forage boxes.

Gordon Shepperson, he said, for some years had felt that the problem in hay making was that of handling the material. This problem now appears to have been solved but to have been replaced by a drying problem. Could this now be solved in turn? Directing his remarks now to Mr Raymond, Mr Bailey asked if it was reasonable to use Mr Klinner's techniques to deal with leafy barn dried hay.

The speakers replied in turn: Mr Benders observed that if a batch of feed suitable for a three week period were contained in one stack, deterioration was not a problem. The forage remained stable under the sheet until the stack was opened and then deterioration was minimal in the short period during which the forage was consumed. Regarding forage boxes, it was necessary for short chopped material to be used — the big round bale was not the answer here. Dr Nellist was optimistic about the prospects of successfully modelling the drying process for round bales. He felt that the difficulties would not be severe once the problem had been closely examined and defined. Mr Klinner felt that the handling problems of big hay bales for feeding had not been solved completely and further development was necessary. He also foresaw problems in the drying of large round bales but felt that potential may exist for the use of preservatives. It was necessary to discover ways in which the farmer could apply chemicals easily to the forage — probably on the baler pickup. Mr Raymond reminded the conference that the quality of barn dried hay reflected accurately the quality of the material put into the process. Certainly it was sometimes possible to obtain a higher D value when the material was a little more mature but this increase did not continue for very long. He also raised the question of the desirability of milling and pelleting leafy material which had been made as barn dried hay. With the use of forage boxes new criteria were needed to enable the engineer to mechanise complete ration feeding. This was a materials handling problem.

Mr R J Wilkins (GRI) invited further comment on leafy crops and stated that GRI was currently comparing barn dried hay with dried grass in both long and pelleted forms. The results so far showed that there was little difference between the two conserved products or treatments nutritionally. Grass was harvested to obtain D values between 65 and 72 to give leaf rather than stem. Would it be possible to use a mower conditioner incorporating a spreader to set up structured swaths which would intercept the maximum amount of solar radiation? Dr Nellist noted that if grass were cut early and wilted quickly barn drying produced excellent quality hay. Mr Klinner had observed that leafy grass responds well to flail treatment and if the grass is spread then rapid drying follows. However he was concerned about the potential losses in multiple cut systems when the crop is subsequently put into windrows for high capacity machines. Also raking created the danger of stones being incorporated into the swath. He suggested that a possible progression was for the mowed crop to be windrowed bringing two swaths close together. It might be that the drying rate would be retarded but there would be a compromise in that little further moving would be necessary before the next machine process.

Mr R Morrison (East of Scotland College of Agriculture) observed that some agricultural advisers recommended the making of hay at a more mature stage for beef animals, this gave greater yields. Regarding the application of additives to hay at about 35% moisture content the weight of bale which resulted would be similar to that used in barn hay drying. If the cost of additives was similar to that of fuel used in barn drying, could the use of BHD be justified? In reply Mr Raymond observed that it was a case of "horses for courses". A farmer not equipped for high digestibility hay could be well advised to adopt Mr Morrison's idea — or consider making silage. Mr Klinner expected an agreement of costs when material was baled at about 35% but was in doubt as to the relative costs of drying and the addition of additives at higher moisture content levels.

Mr N J Strickland (ADAS) referred to the greater intake of hay by animals compared with silage consumption. Would it therefore not be desirable to increase the feeding of hay in order to save concentrates? Possibly the mechanized feeding of hay should be considered for the future. Mr Waltham commented that realism was necessary in a climate where rain produced good growing conditions for grass. Bad weather and high dry matter forage conservation systems did not go together. Mr Raymond agreed that the classical view regarding the relative intake of hay and silage was as stated but if more concentrates were fed, a greater reduction of hay intake occurred than of silage. He expressed the view also that newer techniques for applying additives would improve silage intake.

Mr P A M Murray wished to explode the myth which he felt was developing at the conference, that high grassland output could only be achieved by use of silage. With the application of 200 units of nitrogen before the first hay cut and with the use of proper techniques and equipment there was no reason why hay should not demand a lower labour input than silage. Good hay making techniques were quite capable of combating English weather.

Mr R A Powell (ICI) enquired about long term future predictions. Leaf fractionation has great possibilities: Barn dried hay, silage or dried grass could be made from the dewatered solids. Did Institution members see this technique being developed on a farm scale: indeed were most of the problems not of an engineering nature? Dr Nellist observed that squeezed material will dry without trouble; however the logistics of the process would not be easy on a farm scale and it would appear most likely that off farm development would take place in the first instant. Mr Bailey commented that in the long term, considering the energy problem, this was the only way in which we should be able to afford to dry grass.

Dr J G M Wood (consultant), in a written contribution, contrasted Ir Benders' statement that additives "have virtually ceased to be used" with Mr Raymond's view that chemicals were the panacea of conservation problems. He observed that other panaceas such as high temperature grass drying and vacuum silage had "vanished like mirages".

Referring to his own experiences in grass conservation research, Dr Wood suggested that conservation systems must be tailored to the skill of the farmer and the local May/June rainfall risks. Each system had its advantages and difficulties and research must concentrate on minimising the snags. He felt that the most efficient tower conservation system was obtained using the modern, simpler and cheaper top unloaded towers. The difficulty of wilting, in wet areas, was much reduced if the 15 to 20 m high towers were used in conjunction with field machinery of the type described by Mr Klinner.

Mr C Culpin in summing up the days proceedings, commented that nothing which had been said during the day led him to change his view that we could and should go ahead with improvements in silage and hay making techniques with the view to reducing losses and improving overall quality.

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Food for the millions

Ghana's third international trade fair in retrospect

THE problem of providing food and fibre to supply a rapidly growing population and expanding local industries is becoming more and more acute, especially in the developing countries where technical skills and production methods in agriculture have not been keeping pace with population growth and aspirations to industrialize. Many newly emerging African countries including Ghana have, since political independence, been searching for policies and strategies that will lead to a break-through in agricultural production.

It was with such pressing problems in mind that the third Ghana International Trade Fair was held from 1 to 15 February 1975. The theme *Food for the millions*, was chosen to reflect current problems and present day development programmes. It implied that emphasis at the Fair was to be on products related directly or indirectly to food production.

In keeping with this aim, a massive worldwide publicity campaign was launched with a view to attracting experienced manufacturers of agricultural machinery and other inputs to agricultural production, as well as those engaged in agro-based industries.

After passing through the first phase of agricultural tractorisation Ghana now has three distinct types of agricultural mechanisation: the peasant farmer with his cutlass and hoe practising shifting cultivation, then those farmers using animal-drawn (bullock) equipment, and the third group of farmers using modern tractors and implements, including combines for their farming operation. Participating countries and firms therefore had to satisfy these different groups of Ghanaian farmers at the Fair.

The 15-day Fair attracted 27 countries (including 13 from Africa) and 300 individual firms. Although the larger proportion of exhibits at the Fair turned out to be for the non-agricultural sector, there was a fairly wide range of exhibits in the field of agricultural machinery which were of interest to farm machinery users and engineers in Ghana.

Eighteen different makes and 25 models of tractors could be identified. The size varied from small 3.75 kW (5 hp) IMT single-axle tractors from Yugoslavia and Japan, to the 63 kW (85 hp) Ford 8600 and Ursus C 385 models. Unfortunately, only very few of these tractors were fitted with safety cabs. Possibly this was done with a view to making their prices low and more competitive.

A wide range of field implements was also shown. Along with the conventional tractor-mounted implements, there were hand-operated planters and a range of animal drawn ploughs, ridgers and planters, mostly from China. The Chinese also brought with them small rice transplanters designed for irrigated rice production on small fields. These transplanters are the first of such machinery to be brought into the country. Rice has hitherto been produced mainly under the dry system of cultivation.

Also on display were various types of crop sprayer, obviously meant for the local cocoa farmer for swollen shoot and capsid control, and for weed and pest control among rice and cotton farmers.

Various irrigation equipment, notably pumps, and vivid pictorials showing models of irrigation projects and systems in other countries were also exhibited. To show current trends in irrigation practice, a local company, Motorola Communications (Ghana) Limited, gave a continuous run of a film on a computerized irrigation control system.

Exhibitors did not forget the emphasis being placed on grain production in Ghana at the present. They therefore brought on display a wide range of grain harvesting and processing equipment. Included in these were reaper-binders, stationary threshers for rice, and different makes and sizes of self-propelled combine harvesters, ranging from the compact Chinese Dongfan 12 and Dania model 900, to the big size MF 620.

Equipment for processing included imported rice and coffee hullers, corn mills (Hunts), and a complete East German rice mill. These were in addition to locally manufactured cassava graters, sets of "gari" and "kokonte" making machines, and equipment for village level palm-oil extraction industry.

On the whole, the range of agricultural machinery shown at the Fair was varied and satisfactory. The problem facing Ghana now is the judicious selection of some of these machines which will suit local conditions. To do this successfully, local field tests aimed at adapting some of the machines into the existing levels of farm mechanisation appears to be the best course for a solution.

A Twum

AROUND THE BRANCHES

South Eastern

AN active end to the 75/76 season was rounded off with another demonstration and a farm walk.

The branch held a demonstration over two days on turf equipment on 16 and 17 June. The organisation was carried out through the dealership of Ernest Doe of Ulting. The meeting was an action affair with most of the equipment being used by visitors at some time during the display.

The branch also held a farm walk evening on the 17th at Strutt and Parker Farms at Terling, Essex to see something of the unique 8000+ ha operation.

THE current country-wide problem of water shortage is abundantly apparent to many farmers and growers. What to do about it, is not quite so obvious.

Some of the answers were shown at an IAgrE demonstration day on water harvesting and irrigation. A wide range of equipment from reservoirs and mains supplies right through to field and bench watering were shown at the open day at Writtle Agricultural College in Essex. Organisation was by South Eastern Branch Secretary Nigel Oldacre.

In the field demonstrations the emphasis was on low labour input. There were two extremes of capital input and a good bit in between.

One of the most ingenious systems in the show was a demonstration by Watkins Naylor & Co Ltd, of Hereford, of the Baars system, originating in Holland but now made in England. Both field scale and parks/sports ground systems are available as tractor mounted or pedestrial controlled trolley versions. The basic idea is a flexible, fireman's type hose with the sprinklers built in at suitable intervals. As the hose is unrolled the sprinklers are also spread out, ready connected. When the water pressure is switched on, this automatically forces the sprinklers to the erect position for correct water distribution. When the pressure is switched off, the sprinklers collapse and the whole system can be rolled up. Hoses are 76 mm circular woven pvc-nylon and the nozzles themselves are standard Wright Rain sprinklers.

Wright Rain demonstrated several pieces of equipment. Of several pumps on show, including relatively small ones, the action for the whole demonstration surface main was provided by a Wright Rain pump driven by its own 6-cylinder diesel engine. The company showed both its large mobile field units. Many visitors were familiar with the large yellow, tractor-mounted, rotating boom fitted with sprinklers. The new Touraine unit, made by Wright Rain at their French factory was also in action. This is a very neat and tidy, big output system delivering through a rain gun. It was obviously easy to handle and move about. The larger Touraine 90 will haul its rain gun automatically over 300 metres and can cover a claimed 5.4 ha per day with only two moves of the system.

Eastern Tractors brought along much of the Farrow irrigation equipment with semi-automatic systems using both sprinklers and rain guns. Farrow also showed a simple and obviously inexpensive carrier for the flexible pipes used by their mobile rain gun unit.

In the static demonstration area again it was cost and cost-benefit that were the centre of attention. Low cost in the commercial sense was displayed by Butyl Products Ltd, of Billericay, with butyl lined water storage tanks. The relation of cost to benefit was touched on by ADAS who, very aptly this year, chose to show how irrigation cost/acre could be related to potato yields and margins per acre.

Several manufacturers concerned with glasshouse watering were present in the nearly completed, new amenity glasshouse facility at the college. Cameron Irrigation Co Ltd, were present to discuss their contribution to the efficient use of water with automatic controls. Nethergreen Products Ltd, showed their range of controls, mist propagation and watering equipment. Nethergreen have a refreshingly progressive development of plastics in greenhouse watering. Both Cameron and Nethergreen were showing "Bondina" capillary matting too. Another manufacturer was Access, with a range of exceptionally inexpensive but effective "stitched" polythene watering pipes.

To complete the cover, E J Woollard (Contracts) Ltd, showed an oscillating spray line for container grown plants under outdoor conditions. This sort of equipment has been around for some time and isn't "news" any more. Nevertheless, Woollard's equipment was obviously doing an economic job quite conveniently and, no doubt, will be around for some time to come.

There were two important technical developments that were high-lighted by this demonstration. Firstly, at least some of the designers were concerned with low cost equipment that might not give a long life but would do the job. Where higher capital was involved, the emphasis was on a reduction of labour input. There was another important feature of this demonstration; the mix of interested growers, manufacturers, advisers, the Institution of Agricultural Engineers and Writtle Agricultural College. This was an indication of the involvement of all interests in properly integrated and developed solutions to growers' problems. W B

Yorkshire

THE sympathy of the audience was immediately with Robin Jarvis of Terrington Experimental Husbandry Farm, speaking to the Yorkshire Branch at Malton on 19 February, when he emphasised in his opening remarks that whatever new systems or methods are proposed it is only the eventual yield and profitability that matter. A nationally recognised expert on the crop, Mr Jarvis' subject was Mechanisation of the potato crop.

Mr Jarvis acknowledged that results of trials on one field could not necessarily be repeated on an adjacent field. He could therefore in many instances report only their particular findings at Terrington and comment on their likely repeatability in other parts of the country.

The first essential was a good seed bed and cage wheels alone were recommended for tractors on cultivation work. Pto-driven implements tended to be preferable in that they did not require weight transfer.

Deep cultivation was unnecessary in that roots would happily penetrate through soil in good condition but which had received no primary cultivation. Whatever system of seed bed preparation was adopted, the bringing up of unweathered soil from below the surface should be avoided.

The 36 in row width often gives higher yields at Terrington, possibly because the ridge is consistently full. The wider spacing allows more room for the tractor wheels.

Farmers generally pay too little attention to detail during planting, and in particular to the seed rate. High speed and early planting are widely believed to be necessary but a one week delay of the whole planting season will often reduce total yields by less than half ton/acre overall. This compares with over a ton/acre lost if sprouted seed is unduly damaged and a further half ton/acre reduction in yield resulting from uneven spacing from hopper-type machines.

Using bulk bins for chitting appears to reduce yields by up to half ton but much work remains to be done in this area. Sophisticated containers appear to give no advantages.

No one seems to know the optimum fertiliser positioning relative to the seed. Traditionally accepted norms appear to have arisen quite by accident.

Finally, Mr Jarvis turned to the well-worn appeal for less damage during harvesting. Points he advocated included: removal of agitation from the harvester, reduced web speed (most important but difficult to effect on some models) and the minimum forward speed.

RICHARD SMITH, product specialist Lubrizol International, speaking to the Yorkshire Branch at Wakefield on 30 March on Oils for farm equipment, opened his discussion by explaining the origin of universal oils, which he said were all based on engine oils with load bearing additives for transmission duties and further additives for hydraulic systems. However, the development of multifunction oils was handicapped by the need on later tractors to cater for such things as hydraulically operated wet brakes, and oil operated pto engagement clutches. One of the main problems in this direction was to develop an oil which would give adequate friction characteristics without excessive noise. He went on to explain that this problem had led to some manufacturers having an oil developed especially for their needs.

Mr Smith discussed the various engines used for oil development such as Caterpillar, Ford and Petter, all used for a particular aspect of oil development, however he did point out that although these tests were very informative and useful, before an oil could be approved, extensive in vehicle tests had to be carried out.

The one danger in having different oils in tractors was the risk of problems when the oils became contaminated when tractors were coupled to ancillary hydraulically operated equipment.

The lecture was well illustrated by slides showing the development of oils and condition of components before and after tests.

BOOK REVIEWS

Food for life

THIS book provides a general review of the living organism and includes sections on the biological, chemical and environmental factors essential to food production.

Individual components of food are described and an explanation is given of the way in which each substrate breaks down to serve nutritional needs.

Mechanisms of food spoilage are reviewed and methods for successful food preservation described.

Ways in which social and economic factors can control the supply and utilisation of food are considered.

The effect of political interests on food distribution is discussed and reference is made to the problem of world population growth and future food supplies.

The book is primarily concerned with defining the interacting principles of the biological, physical and social sciences that determine how food is produced, processed, distributed and consumed. It is, therefore, likely to provide useful background reading for the professional agricultural engineer.

Food for life, F E Deatherage, Plenum Press *BAM*

Soils and Field Drainage

THIS monograph brings together information on the soil properties influencing drainage design against a background of soil series as defined and mapped by the Soil Survey of England and Wales.

The variables in drainage design and their effect on drain performance, and the influence of climate and land use on the drainage requirement are reviewed. Recognising the practical difficulties of obtaining design data such as hydraulic conductivity and drainable porosity directly in the field, emphasis is placed on the more readily assessible properties, such as texture and structure, which influence the value of these parameters.

The system of soil classification and the mapping units used by the Soil Survey are described and a balanced view is presented of the use to the drainage designer of existing soil maps. Current UK drainage practice is correlated with soil series in two areas to illustrate the scope of the technique; the results of drainage experiments on different soil series are presented.

This monograph is well written and well presented and would prove very useful to both practising drainage personnel and students.

Soils and Field Drainage, edited by A J Thomasson. Technical Monograph No 7, published by Soil Survey of England and Wales, Rothamsted Experimental Station, Harpenden, Herts, price £1.30 with map, £1.00 without map.

G S

Display advertising

orders and copy for the December issue should be sent to the Advertisement manager by 5 October 1976

Branch programmes 1976/77

East Anglian Branch
Hon Secretary J B Mott MIAgrE
Norfolk College of Agriculture, Easton, Norwich NOR 54X (tel 0603 742105).

September 22 Day visit to IAgrE, NCAE and NIAE, Silsoe, Bedford.
23 BAGMA microfilm parts system, by D Rich (Technical Services Manager BAGMA), The Crossways Restaurant, Scole, 20 15 h. This talk follows a committee meeting.

1977
February 25 Dinner, Park Hotel, Diss, Norfolk, 19 30 h for 20 00 h.
March 24 Annual general meeting, 19 30 h. Followed by Current and future trends in bale handling, by J K Avis (marketing director, Farmhand [UK] Ltd).

East Midlands Branch
Hon Secretary E F Beadle TEng(CEI) MIAgrE
Lindsey College of Agriculture, Riseholme, Lincoln (tel Lincoln [0522] 22252).

October 5 Visit to be arranged, 14 30 h.
28 Large tractor design (provisional), Notts College of Agriculture, nr Southwell, 19 30 h.
November 17 Direct drilling, Kesteven Agricultural College, Caythorpe, 19 30 h.

1977
January 11 Day conference on Corrosion, in association with Department of Industry, Nottingham University, 10 00 h.
February 22 Development and production of farm machinery, joint meeting with I Prod Eng, Lindsey College of Agriculture, Riseholme, 19 30 h.
March 17 Drainage machinery developments, Brooksby Agricultural College, nr Leicester, 19 30 h.

Northern Branch
Hon Secretary Dr P R Philips BSc(Hons)
6 Keyes Gardens, Jesmond, Newcastle-upon-Tyne NE2 3QX (tel Newcastle 811312 ext 55).

October 5 Climatic control of livestock housing, by Dr A D Trapp (Department of Agricultural Engineering, Edinburgh University), Northumberland College of Agriculture, Kirkley Hall, Ponteland, Newcastle, 19 30 h.
November 2 Protein from natural gas, by D W J Beatty (protein department ICI), Northumberland College of Agriculture, 19 30 h.
30 Modern farm machinery — the contractor's view, by D W Scott (J S Scott & Son Ltd, Doncaster), Northumberland College of Agriculture, 19 30 h.

1977
January 11 The use of aircraft in agriculture, by P H Wilkins (Agrikem, Roxburghshire), Northumberland College of Agriculture, 19 30 h.
February 1 Noise — how much; how harmful? by T T McCarthy (Department of Agricultural Engineering, University of Newcastle-upon-Tyne) and Dr J Steel (Department of Industrial Health, University of Newcastle-upon-Tyne), Northumberland College of Agriculture, 19 30 h.
March 1 The braking of tractors, trailers and agricultural vehicles, by Dr M J Dwyer (tractor department, NIAE), Northumberland College of Agriculture, 19 30 h.
22 Annual general meeting, Northumberland College of Agriculture, 19 30 h.

North Western Branch
Hon Secretary R B Kitching NDAgrE Tech(CEI) MIAgrE
4 Northall, Much Hoole, Preston PR4 4QN (tel Preston 44123).

September 21 Farm buildings (speaker from Atcost Ltd), Lancashire College of Agriculture, Myerscough, nr Preston, 19 30 h.
October 21 Heat recovery in livestock buildings. Speaker and venue to be confirmed.
November 18 Tractor and trailer brakes (speaker from Girling Ltd), The Derby Room, The Library, Leigh, 19 30 h.

1977
January 20 Problems in design and development of agricultural tractors (speaker from Massey Ferguson Ltd), Lancashire College of Agriculture, 19 30 h.
February 15 Glasshouse irrigation and hydroponics, by B Watkinson (Dep. director Fairfield EHS), The Becconsall Hotel, Hesketh Bank, nr Southport, 19 30 h.
March 17 Annual general meeting, followed by talk and buffet, The Royal Oak Hotel, Chorley, 19 00 h.
May 24 Day trip to see collection of vintage tractors.
June 16 Pumped drainage. Evening visit to two farms at Carnforth. Introduction by F B Baxter, Divisional Drainage and Water Supplies Officer, Preston.

South East Midlands Branch
Hon Secretary J R Dawson CEng MIMechE MIAgrE
26 Larkway, Brickhill, Bedford (tel Silsoe 60000).

October 18 A metallurgist's impression of agricultural engineering research in the USA, by Dr M A Moore (NIAE, Silsoe), National College of Agricultural Engineering, Silsoe, 19 30 h.
November 22 Forum: Making the most of straw. Speakers: Dr R W Radley (NCAE, Silsoe) — Economic aspects of straw handling. W E Klinner (NIAE, Silsoe) — Straw densification work at the NIAE. I Sangster (BOCM/Silcock Ltd, Basingstoke) — Straw — a processor's point of view. B Wilton (University of Nottingham) — Whole crop cereal harvesting and the use of straw as a fuel. National College of Agricultural Engineering, 18 00 h.

1977
January 17 Modern slurry handling techniques, by G F Shattock (consultant), National College of Agricultural Engineering, 19 30 h.
February 16 The mechanisation problems of large scale arable farming, by R W Patrick (British Crop Driers Ltd, Navenby, Lincs), Shuttleworth College, Old Warden, Biggleswade, 19 30 h. (Joint meeting with the Bedfordshire Discussion Group of the East of England Agricultural Society).
March 7 Annual general meeting, 19 00 h. Followed by Power take-off driveline dynamics and overload protection devices for agricultural machinery, by D A Crolla and A A W Chestney (NIAE, Silsoe), National College of Agricultural Engineering.

Southern Branch
Hon Secretary A D B Gardiner TEng(CEI) MIAgrE
Rycotewood College, Thame, Oxon (tel Thame [084421] 2501).

September 17 Grass production management, by N Horsham, The Grassland Research Institute, Hurley, 19 00 h. Wives cordially invited. To round off this first meeting of the autumn there will be a barbecue and bar.
October 22 Agricultural Lubricants, by Graham Firth (Shell UK Ltd, oil, heating and agricultural division), Civic Hall, Fleet, Hants, 19 30 h.
November 19 Slurry handling. Organiser: M Wardrop (Holloway Marketing Company), West Sussex School of Agriculture, North Heath, Pulborough, 19 30 h.

1977
January 21 Forestry tractor development (speaker from the Forestry Commission), Merrist Wood Agricultural College, Guildford, 19 30 h.
February 18 Hydrostatics for agricultural engineering, by D Hillam (Sundstrand UK Ltd), Rycotewood College, Thame, Oxon, 19 30 h.
March 18 Annual general meeting, followed by two short papers by members of the Southern Branch, 19 30 h (venue to be confirmed).

South Western Branch
Hon Secretary W Blackmore CIAgrE
Hillview, 12 Spurway Road, Canal Hill, Tiverton, Devon.

October 14 Slurry storage — mechanisation and management, by D A Williamson (Mechanisation Advisory Officer, ADAS, Kent), Exeter College.

November 18 Potatoes — storage design and equipment, by O Statham (Potato Marketing Board), Webbs Hotel, Liskeard, Cornwall.

1977

January 13 Grass drying — present and future methods, by B Fraser-Smith (Aylescott Driers), Taunton, Somerset.

February 10 Tractor hydraulics and their external application following the introduction of Q cabs, by D M Brain (chief design engineer, Twose of Tiverton Ltd), Seale Hayne College, Newton Abbot.

March 10 Mechanised bale handling, by D A Bull (ADAS liaison unit, Silsoe), Totnes.

Western Branch

Hon Secretary H Catling NDAgrE MIAgrE
Engineering Dept, Royal Agricultural College, Cirencester, Glos (tel Cirencester [0285] 2531).

October 13 Short papers by Branch members: ADAS/trade liaison, by A J Bradshaw; Twenty five years of farming and inventing, by R H F Jeffes; Education and training of agricultural engineering mechanics, by J D Pemberton; Agricultural engineer — design or accident, by K A L Roberts, The Old Bell Hotel, Warminster, Wilts, 19 30 h.

November 10 Progress in the development of tyres for use in agriculture, by G Pocket (Goodyear Tyre & Rubber Co [GB] Ltd), The Old Bell Hotel, Warminster, 19 30 h.

1977

February 9 Annual general meeting, 18 30 h, to be followed at 19.45 h by Whither the Institution by T C D Manby (President IAgrE), The Old Bell Hotel, Warminster.

March 9 Complete ration feeding, by L Dewey (Cadbury Park Farm Ltd), The Old Bell Hotel, Warminster, 19 30 h.

April 6 Afternoon visit to Esso Oil Refinery, Fawley, Hants.

West Midlands Branch

Hon Secretary C L Powdrill NDA NDAgrE TEng(CEI) MIAgrE
Warwickshire College of Agriculture, Moreton Hall, Moreton Morrell, Warwick (tel Moreton Morrell [092685] 367).

September 27 Turbo-charging agricultural tractors (report of APICO Ltd), Massey Ferguson Training School, Stareton, nr Kenilworth, 19 30 h.

October 25 Forum: Performance! But how do you quote it? Panel: Dr M J Dwyer (NIAE), J W Roberts (David Brown Tractors Ltd) and a farmer, Massey Ferguson Training School, 19 30 h.

November 29 Digestive slurry systems, by Dr S Baines (WOSAC), Massey Ferguson Training School, 19 30 h.

1977

January 31 Hedge and verge maintenance equipment, by E A McLaren (Bomford & Evershed Ltd), Massey Ferguson Training School, 19 30 h.

February 28 Agricultural engineering in overseas countries, by C Voss (formerly with FAO), Massey Ferguson Training School, 19 30 h.

March 28 Annual general meeting, 18 30 h, followed at 19 30 h, by Tractor/trailer braking, by J E Gannon (Girling Ltd), Massey Ferguson Training School.

Wrekin Branch

Hon Secretary J Sarsfield MIAgrE
Staffordshire College of Agriculture, Rodbaston, Penkridge, Stafford (tel Penkridge 2209).

October 4 Irrigation problem areas and prospects, by I E Flowerday (Wright Rain Ltd), Harper Adams Agricultural College, 19 30 h.

November 1 A look at bearing design and manufacture, by R Coleclough (Fafnir Bearings Ltd), Staffordshire College of Agriculture, 19 30 h.

29 Mechanical silage feeding from horizontal silos, by G Amos (ADAS), Shropshire Farm Institute, 19 30 h.

1977

January 18 The infancy of iron-making, by S B Smith (Ironbridge Gorge Museum Trust), Staffordshire College of Agriculture, 19 30 h.

February 1 Keeping up to date with the combine, by N Brough (New Holland Ltd), Harper Adams Agricultural College, 19 30 h.

March 1 Annual general meeting, 19 00 h, followed at 20 00 h by Harnessing the horsepower, by C Woodcock (Kleber Tyres Ltd) and R Griffiths (Brockhouse Transmissions Ltd), Staffordshire College of Agriculture.

29 Wrekin Branch Conference:- Crop protection — the facts, the faults, the future, Harper Adams Agricultural College.

April 29 Annual dinner, Park House Hotel, Shifnal, 20 00 h for 20 30 h.

Yorkshire Branch

Hon Secretary J R Ashley-Smith MSc(AgrEng) TEng(CEI) MIAgrE
David Brown Tractors Ltd, Meltham, Huddersfield, HD7 3AR (tel 0484 850361).

September 30 Stirring the soil, by K Evans (Howard Machinery), Holmfield House, Wakefield, 19 45 h.

October 21 Developments in irrigation equipment, by M S Martin (Wright Rain Ltd), Buckles Inn, Askham Richard, 19 45 h.

November 18 Visit to sugar beet factory, York. (Special joining arrangements will be confirmed to Yorkshire Branch members nearer the time).

1977

January 17 Aircraft in agriculture (speaker to be announced), Holmfield House, Wakefield, 19 45 h.

February 10 Bale handling, by R Nicholls (farmer) and J Edmunds (ADAS), Talbot Hotel, Malton, 19 45 h.

March 10 Annual general meeting, followed by The agricultural tractor, 1943 — ? by H Ashfield (David Brown Tractors), Holmfield House, Wakefield, 19 45 h.

April 5 Off-highway vehicles — a manufacturer's view of users' problems (speaker to be announced). Joint meeting with NE Centre, Automobile Div. I Mech E.

THE INSTITUTION OF AGRICULTURAL ENGINEERS AUTUMN NATIONAL CONFERENCE 9 NOVEMBER 1976

Registration forms for UK members are inserted.

Overseas members who wish to attend should write to:-

Mrs E Holden
The Institution of Agricultural Engineers,
West End Road,
Silsoe, Bedford MK45 4DU.
Telephone: Silsoe (0525) 61096.

NATIONAL OFFICERS – 1976/77 SESSION

ELECTIONS to Council at the Annual General Meeting on 11 May 1976 were announced in the June (31/2) issue of the Journal. Other appointments are as follows:

Council

Chairman, Membership Committee	J C Turner
Chairman, Examination Board	J A C Gibb
Branch Representatives	
East Anglian	B J Bell
East Midlands	R D S Barber
Northern	R Cowen
North Western	G R Hobbs
Scottish	J Palmer
Southern	R H Brice-Baker
South Eastern	W R Butterworth
South East Midlands	B A May
South Western	I J Cryer
Western	K A L Roberts
West Midlands	D G Mitchell
Wrekin	J Sarsfield
Yorkshire	J Maughan

Executive Committee

President	T C D Manby
President-Elect	J C Weeks
Immediate Past President	J V Fox
Past President	J M Chambers
Vice-President	B D Witney
Hon Treasurer	U G Spratt
Deputy Hon Treasurer	G E E Tapp
Hon Editor	B C Stenning
Chairman, Membership Committee	J C Turner
Deputy Chairman, Membership Committee	W T A Rundle
Fellow	J A C Gibb
Member	J H Neville
Companion	D Macmillan
Associate	R Chambers
Co-opted	
ERB Technician Engineer Board	M G Clough
ERB Technician Board	C V Brutey
Alternate to Representatives Technician Engineer and Technician Boards	R J Fryett
BCIGRA Representative	D P Evans
RoSPA Agricultural Safety Committee	E F Sudron
Co-opted until January 1977	
Autumn 1976 Conference Joint Convenor	U G Curson
Co-opted until April 1977	
Spring 1977 Conference Convenor	I D Gedye

Membership Committee

Chairman	J C Turner
Deputy Chairman	W T A Rundle
Fellow	P Wakeford
Fellow	(vacant)
Member	D G Mitchell
Member	K A L Roberts
Companion	A J Gane
Technician Associate	E H Mander
General Associate	G W J Goddard
Co-opted	
Chairman, Education Group	J A C Gibb
ERB Technician Engineer Board	M G Clough
ERB Technician Board	C V Brutey
Alternate to Representatives Technician Engineer and Technician Boards	R J Fryett
Ex-Officio	
President	T C D Manby
President-Elect	J C Weeks

Education Group

(A sub-committee of the Membership Committee)

Chairman	J A C Gibb
Fellow	J C Turner
Fellow	R D S Barber
Fellow	G C Mouat
Fellow	I D Gedye
Member	D L Bebb
Member	J G Shipman
Companion	R H Brice-Baker
General Associate	J Kinross
Ex-Officio	
President	T C D Manby
President-Elect	J C Weeks

Editorial Panel

Chairman and Honorary Editor	B C Stenning
Members	G Spoor
	B A May
	J H Neville
	G Shepperson

Other Appointments

Education Honorary Adviser	J C Turner (assisted by R J Fryett)
Careers Honorary Adviser	J C Turner (assisted by R J Fryett)
Appointments Register Honorary Adviser	D H Sutton (assisted by Mrs Ann Stevenson — Secretariat Assistant)
Professional Institutions Council for Conservation Council	B A May (alternate J H Neville)
Professional Institutions Council for Conservation Executive	B A May (alternate J H Neville)

Secretariat Services

News Letter — Hon Editor	R J Fryett
Overseas Liaison Correspondent at Secretariat	R J Fryett
Acting as National Press Officer	R J Fryett
IAgrE Membership Admissions and Transfers — Enquiries	R J Fryett
IAgrE Subscriptions and Records	Mrs Edna D Atkinson (Secretariat Senior Assistant)
ERB Registration	R J Fryett
ERB Subscriptions and Records	Mrs Edna D Atkinson (Secretariat Senior Assistant)
Conferences Secretary	Mrs Edwina J Holden (Secretariat Assistant)
Bursaries and Awards — Enquiries	Mrs Ann Stevenson (Secretariat Assistant)

ADMISSIONS

The undermentioned have been admitted to the Institution in the grades stated:—

Fellow (FIAgrE)

Parker E J	Kent	–	8 4 76	AD/RD
Simpson W H	Zambia	–	8 4 76	DM/FM

Member (MIAgrE)

Aneke O D	Nigeria	–	5 1 76	FE
Barker L H	Devon	6	5 1 76	–
Gander J A J	St Vincent	–	22 2 76	AD/FE/FM/RD
Kennedy-MacFoy O A	London	–	5 1 76	AD
Oodally G M	Mauritius	–	30 12 75	FE/TS/DM/RD
Razzaq Gilani	Pakistan	–	8 1 76	FE/TM
Rushton D H	Yorks	10	13 4 76	TS
Waddilove W	Cambs	5	2 3 76	AD

Companion (CIAgrE)

Fardon G J	Worcs	8	8 4 76	AB/BD/CS/FM
Long T E	Indonesia	–	8 4 76	–
Preston T A	Canada	–	8 1 76	ED

Technician Associate (AIAgrE)

Donaldson W C	Yorks	10	5 1 76	TS/FM
Gill M S	Wilts	7	28 3 76	–
Kofoed G	Zambia	–	23 10 75	ED/FM
Mitchell I D	Yorks	10	29 11 75	AD
Pearson S P	Senegal	–	8 4 76	–
Razavi M M	Iran	–	11 12 75	–
Watson A W	Cumbria	3	2 3 76	ED
Wilson A R	Sussex	13	23 9 75	ED

General Associate (AIAgrE)

Agama P A	Malaysia	–	5 1 76	FE
Basyouni M	Sussex	13	16 6 75	–
Bevan C J	Warwicks	8	29 4 76	CS
Bumby J G	Gwynedd	9	5 1 76	–
Caragher J F	Eire	–	6 3 76	EL
Evans J M	Powys	–	6 3 76	TS
Fraser-Smith B	Devon	6	6 3 76	FM/RD
Fronks R C	Dorset	7	8 11 75	AD
Holt T P	Cumbria	3	16 2 76	AD/FM
Igunnu J O	Nigeria	–	16 6 75	–
Jones A M	Devon	6	13 4 76	AD/FM
Kendrick R D	Powys	–	8 11 75	FE
Lamb K W	Salop	9	8 4 76	TS
Leyshon M	Brecon	–	8 11 75	FM
Makinde M O	Nigeria	–	29 11 75	FE
Mattey D J	London	–	15 2 76	–
McGahan I	Oxon	13	2 3 76	FE
Mooney P	Rhodesia	–	8 4 76	DM/RD
Njoku F U	Nigeria	–	8 11 75	BD
Phillips R	Essex	12	28 3 76	BD/CS/FE
Walker R A	Dyfed	–	3 2 76	FM
White A J	Devon	6	3 1 76	TS/DM
Wilks D J	Suffolk	1	15 2 76	FM

Graduate

Ademosun O C	Beds	5	7 2 76	ED
Frew T J	Surrey	13	25 3 76	DM
Omotunde J B	Nigeria	–	26 11 75	FE
Smith R T	Devon	6	8 11 75	FM
Szadowski K P	Berks	13	6 3 76	TS
Tensue Y	Beds	5	3 2 76	ED
Williams A R	Malawi	–	6 4 76	AD/FE/ED

Student

Blackford A J	Warwicks	8	4 2 74	–
Bourne O C	Guyana	–	10 11 75	–
Brooker D C	Kent	–	3 2 76	FM
Bryden S K H	Cornwall	6	8 11 75	FE
Burgoyne R	Middx	13	6 3 76	–
Clark S A	Beds	5	6 3 76	–
Feaver R N	Sussex	13	25 3 76	–
Fisher D P	Warwicks	8	4 2 74	–
Foyle S D E	Southampton	13	3 2 76	FE
Lockhart R	Staffs	9	25 3 76	–

TRANSFERS

The undermentioned members have been transferred to the grades stated:—

Fellow (FIAgrE)

Ma K Y	Malaysia	–	6 1 76	–
Warboys I B	Kent	–	8 1 76	–
Wood J G M	Surrey	13	8 4 76	CS

Member (MIAgrE)

Akinsete E	Nigeria	–	22 1 75	–
Bedingfeld D G	South Africa	–	5 1 76	TS
Bishop J	Essex	12	11 12 75	ED
Brown C A	Surrey	13	11 12 75	AD/FE
Burton R J G	Co Durham	3	6 3 76	AD/FE/RD
Constantinesco J A G	Italy	–	7 11 74	–
Couchman M G E	Peterborough	2	30 4 76	ED
Darcel C J	Hants	13	8 4 76	–
Fynn R P	Nicaragua	–	9 12 75	–
Giddings R M	Singapore	–	2 3 76	–
Godwin R J	Beds	5	8 4 76	ED/RD
Henry G P C	Cambs	5	2 3 76	–
St C Heygate C N	Devon	6	8 4 76	TS
Hughes R E	Suffolk	1	5 1 76	FE
Huzzey M D	New Guinea	–	2 2 76	ED
Jones R H	Staffs	9	29 11 75	–
MacCormack J A D	Aberdeen	4	6 3 76	BD/RD
McNicoll A	Angus	4	6 3 76	ED
Mahdi I K	Sudan	–	6 3 76	FM
Orr C R B	Leics	2	2 2 76	FE
Pragnell R E	Norfolk	1	5 1 76	AD/ED
Pringle R T	Aberdeen	4	6 3 76	AD
Sheldon M C	Surrey	13	3 6 76	ED
Shepherd H M	Aberdeen	4	5 1 76	AD/ED/RD
Storey S	Aberdeen	4	8 4 76	ED
Sweetman J A	Swaziland	–	6 3 76	FE
Tomlins C M	Malta	–	8 4 76	FE
Trapp A D	Edinburgh	4	2 2 76	–
Trevarthen R H	Leics	2	8 4 76	ED
Waggit P W	Berks	13	11 12 75	CS/FE
Watermeyer J M	Rhodesia	–	8 4 76	AD

Companion (CIAgrE)

Brice-Baker R H	Hants	13	8 4 76	–
Culy B W	Kenya	–	8 4 76	FE/RD

Technician Associate (AIAgrE)

Booth R	Cambs	5	2 2 76	ED
Brooks C F	Hereford	8	2 3 76	ED
Smeaton I C	Staffs	9	2 8 74	ED

Graduate

Ramalan A A	Nigeria	–	6 3 76	–

Retired rate

Potter F J	Norfolk	1	8 4 76	–

RE-ADMISSIONS

The undermentioned have been re-admitted to the Institution:—

Graham C J	Surrey	13	1 1 75	–
Nissim D L	Essex	12	2 3 76	FM

RE-INSTATEMENTS

The undermentioned have been re-instated:—

General Associate (AIAgrE)

Rathod R V	Kuwait	–	24 10 74	–

Graduate

Tayal S S	Canada	–	16 9 75	–

RESIGNATIONS

The undermentioned have resigned from membership of the Institution:—

Baster S	GA	Essex	12	22 4 76	No reason given
Davidson W R	GA	Glos	7	29 5 76	No reason given
Draper M J	M	Lincs	2	13 4 76	Economic
Forbes C P	GA	London	–	27 4 76	Economic
Hibberd K I	TA	Wilts	7	26 5 76	Economic
King P J	S	Wilts	7	29 3 76	
Leeds-Harrison P B	G	Beds	5	26 4 76	Economic
Moseley B A	G	Essex	12	1 1 76	Left industry
Patel H M	GA	Middx	13	19 2 76	Economic
Salter A J	GA	Staffs	9	14 4 76	No reason given
Staines E J	TA	Warwicks	8	11 6 76	No reason given
Street J	M	Warwicks	8	11 6 76	No reason given
Walker W J K	S	Rhodesia	–	3 3 76	Change of occupation
Wells R	GA	Beds	5	16 6 76	No reason given
Williams A F	F	Warwicks	8	14 4 76	No reason given

DEATHS

We regret to announce the death of the undermentioned members:—

Fail H	F	Northumberland	3	20 11 75
Lee R H	F	Herts	5	12 4 76

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TERMINATIONS

It is with regret that we have to announce the termination of membership of the Institution of the following persons who have failed to pay their subscriptions. They are therefore no longer entitled to the privileges of membership, which – in the case of corporate members and associates – includes the use of letters after their name.

Agboka V K	A	Ghana	–
Agunpopo F O	A	Nigeria	–
Baker P D	G	Glos	7
Ball R G	A	Peru	–
Bateman J B D	S	Glos	7
Browning J F (Miss)	S	Swaziland (gone away)	
Buck M F	M	Kent (gone away)	
Carrick G S	G	Glos (gone away)	7
Campbell D S	A	Cumberland	3
Campbell J H	M	Warwicks	8
Chatting T J	S	Leics	2
Combe D R	A	Australia	–
Corbishley R H	A	Warwicks	8
Costley A G	A	Beds (gone away)	5
Couper F X B	A	Rhodesia	–
Cox R S	A	Lincs (gone away)	2
Culverwell W H	A	Herts (gone away)	5
De Silva G S C	G	London	–
De Silva J A	G	London (gone away)	–
Fidler F S	A	Hants	13
Fyffe A E	S	Scotland	4
Garvie D W	F	Cornwall	6
Garwood M F	S	Hants (gone away)	13
Gill G W	A	Worcs (gone away)	8
Griffiths D H	TA	Worcs	8
Gyarteng O K	G	Ghana	–
Harrison L	A	(gone away)	–
Heath M H	A	Somerset (gone away)	6
Jepson J	A	Cheshire	11
Johnson G A	M	Flints	4
Johnson H B	M	Warwicks	8
Jones G O S	TA	Worcs (gone away)	8
Kenny P E	A	Yorks	10
Leith W F	A	Midlothian	4
McDonald R J	G	Northants	2
McDonogh K G H	M	Northumberland	3
Mann V B S	A	India	–
Marwaha R S	A	London	–
Myers J H	F	Australia	–
Nadarajah P	S	London	–
Nasir F A	M	Nigeria	–
Pound J P	A	Wilts	7
Pudge J F	S	Hereford	8
Richardson L I	G	Hants	13
Roberts B D	A	Cambs	5
Rodriguez J C	G	Argentina	–
Rooprai A S	M	Surrey (gone away)	13
Russell P J	TA	Essex	12
Scicluna-Spiteri A S	F	Malta	–
Slatter A J	S	Hants	13
Smith M H A	S	Cornwall	6
Tharmakulasingham K	S	London	–
Teather P J	A	Lincoln	2
Thomas P B	S	Devon	6
Tomlinson J R	S	Wilts	7
Tolson D	TA	Birmingham	8
Trevor M A T	A	Warwicks	8
Vaudin M B A J	G	Mauritius	–
Velauthapillai P	TA	Sri Lanka	–
Waldron R F	A	Yorks (gone away)	10
Wheelock R A	G	Gwent	7
Williams W A	G	Malawi	–
Withers C R	A	Devon	6

ENGINEERS REGISTRATION BOARD

The undermentioned have been placed on the ERB (CEI) Register:–

Technician Engineer (TEng [CEI])

Back H L	Iran	–	25 5 76
Bedingfeld D G	South Africa	–	1 6 76
Betts R J S	Sussex	13	1 3 76
Campbell C	Hereford	8	6 5 76
Constantinesco J A G	Italy	–	25 5 76
Cox J P	Dumfries	4	1 6 76
El Zubier A	Sudan	–	8 4 76
Henry G P C	Cambs	5	25 5 76
Hicks D M	Oxon	13	25 5 76
Holland D	Canada	–	1 6 76
Metianu A A	St Kitts	–	8 4 76
Moore A E	Worcs	8	8 4 76
Nissim D L	Essex	12	6 5 76
Odigboh E U	Nigeria	–	8 4 76
Orr C R B	Leics	2	1 6 76
Sackey E A	Ghana	–	20 1 75
Searle M S	Guernsey	13	1 6 76
Shepherd H M	Aberdeen	4	1 6 76
Taha M E	Sudan	–	8 4 76
Waddilove W	Cambs	5	6 5 76
Willcock D B	Kenya	–	6 5 76
Wyles P W	Notts	2	6 5 76

Technician (Tech [CEI])

Booth R	Cambs	5	1 6 76
Broomer K D	Hants	13	6 5 76
Poolman J R	Berks	13	6 5 76
Smeaton I C	Staffs	9	1 6 76
Wilson D G	Oxon	13	6 5 76

Occupational classification
AD – Advisory Services; BD – Buildings; CS – Consultancy; FE – Field Engineering; PR – Technical Journalism; TS – Technical Sales, Distribution and Service; DM – Design and Manufacture; ED – Education; EL – Electrification; FM – Farming; RD – Research and Development.

Branches
1 East Anglia; 2 East Midlands; 3 Northern; 4 Scotland; 5 South East Midlands; 6 South Western; 7 Western; 8 West Midlands; 9 Wrekin; 10 Yorkshire; 11 North Western; 12 South Eastern; 13 Southern.

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SEEKING EMPLOYMENT

Members of the Institution seeking new appointments are invited to write to Mrs Ann Stevenson
Institution of Agricultural Engineers, West End Road, Silsoe
Bedford MK45 4DU
marking the envelope "Appointments Register" in the top left-hand corner.

Conference

CORROSION IN AGRICULTURE

In association with the Committee on Corrosion of the Department of Industry, the East Midlands Branch of the Institution are holding a one-day Conference

AT NOTTINGHAM UNIVERSITY

ON TUESDAY, 11 JANUARY 1977

on the subject of

CORROSION IN AGRICULTURE

Further details can be obtained from:

The East Midlands Branch Honorary Secretary:

E F Beadle T Eng(CEI) MIAgrE,
East Midlands Branch Honorary Conference Secretary,
4 Grange Cottages,
Riseholme,
Lincoln.
Telephone: Office: 0522 22252 Ext. 34.

or the Conference Convenor:

B Wilton BSc(Ag) MSc (Agr Eng) FIAgrE,
School of Agriculture,
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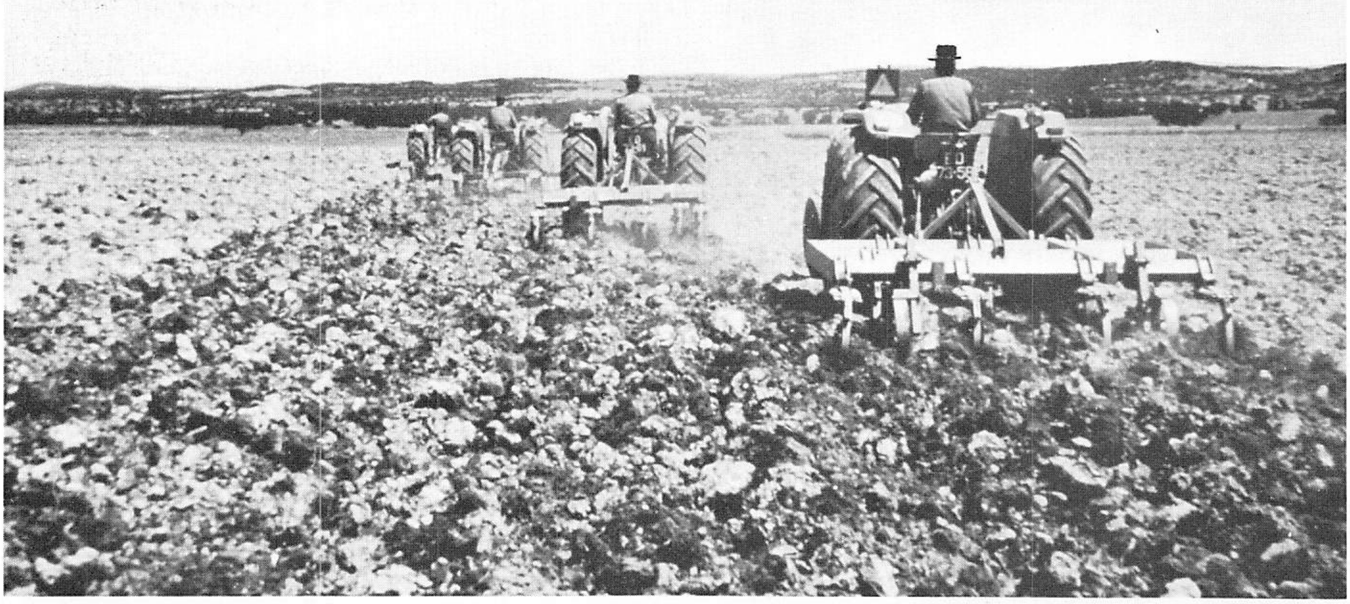

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