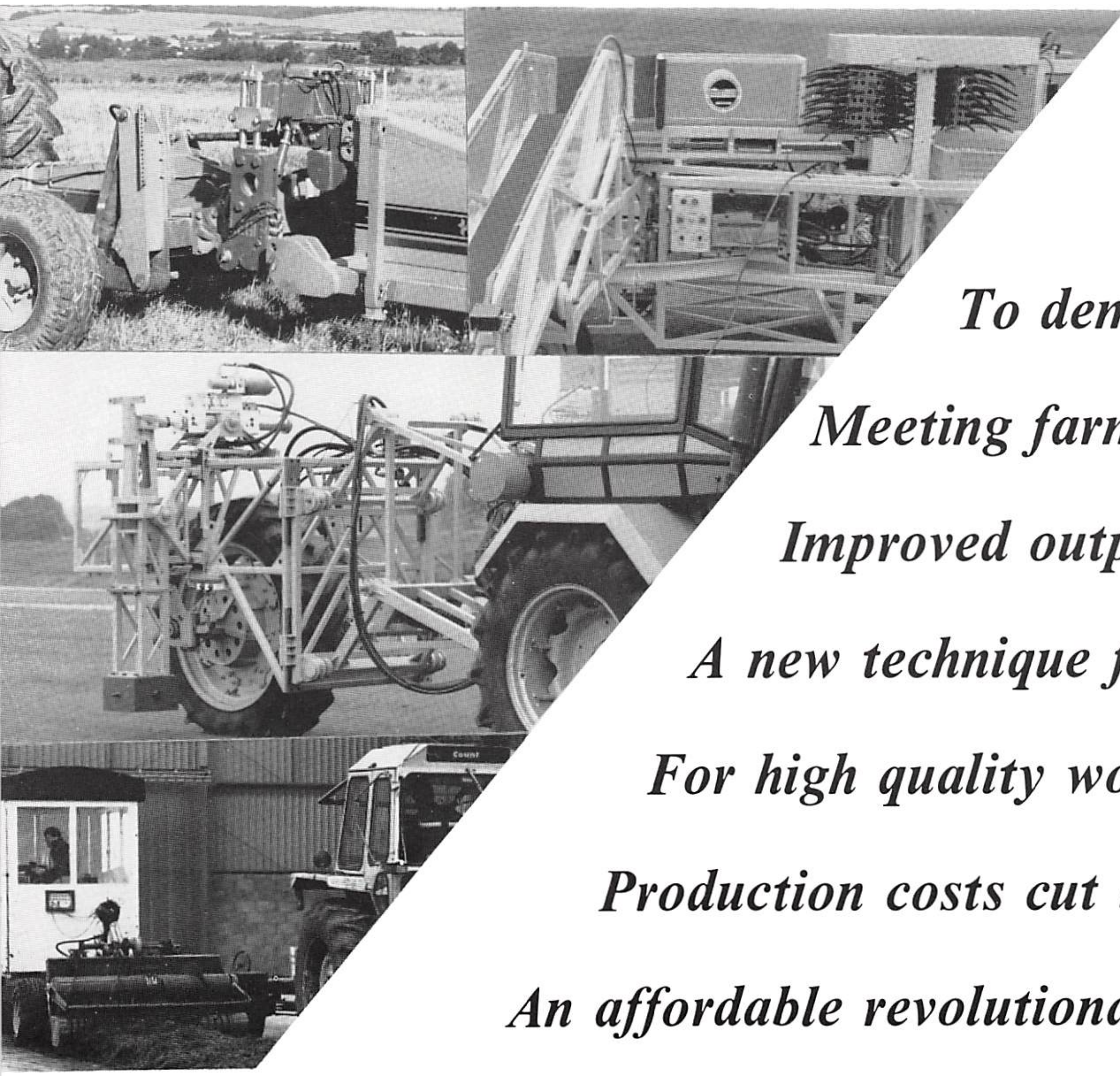
THE AGRICULTURAL ENGINEER

Volume 42 Number 4 WINTER 1987



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Journal and Proceedings

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Front cover shows performance monitoring equipment and prototype machines undergoing trials at the AFRC Institute of Engineering (to whom we acknowledge provision of the photographs for the composite picture).

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Editorial
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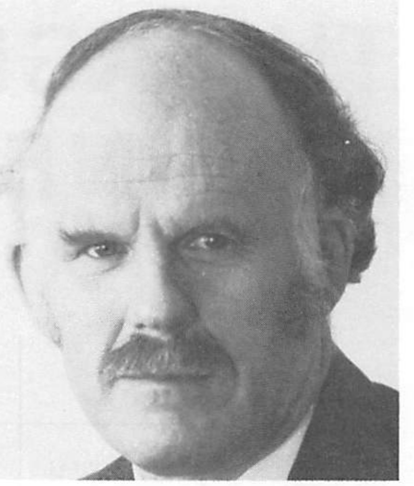


WITH the Presidential address and guest editorials from conveners of national and branch conferences appearing in recent issues, it has taken your Editor over a year to find space for his own editorial comment since he took over the job from Brian Witney. The latter relinquished the post when invited to become President elect of the Institution. Already, many tributes have been paid to Brian as President elect and I'm sure he will deservedly get many more as time passes. However, now that the opportunity has at last occurred, I should like to acknowledge his work as Honorary Editor.

Until one has undertaken this job, it is difficult to appreciate how much work is involved and to get it done within the strict time schedule laid down by Norman Stuckey. I cannot remember Brian being late for anything, although there were some "near run" occasions. During his period of office, he instituted the Ag Eng Items, (I can no longer remember the actual meaning of the initials ITEMS — it can be found in vol 38, no 4, p 94), but in broad terms it includes short notes on education, courses, commercial machines, new techniques, etc — those things that do not warrant a full paper but are interesting and useful pieces of information to the reader. This is just one example of Brian's work resulting in my inheriting a Journal in good shape and one with a framework for acceptance of a wide range of copy.

This leads me into answering readership demands for more papers of a pragmatic nature and with a commercial orientation. The reply is yes, by all means let us publish them but the demand cannot be met if suitable copy is not received. Certain people from the right sort of circles for such papers have been approached and even "nagged" but the result has been disappointingly small. If you are one of those Institution members who asked for commercial and pragmatic papers, perhaps you can put word processor to printer yourself, or even the old fashioned pen to paper.

However, I hope we shall continue to receive technical papers, conference papers and scientific papers for refereeing. Our Journal has one large advantage over most scientific journals — it is not read by scientific and research engineers alone — it can be found in all areas of our profession and industry and is, therefore, a very good vehicle for bridging R & D with commerce. I trust the readership will remember that. It is interesting that we are beginning to receive a greater number of papers on marketing, an area in my view, of which the Institution takes insufficient notice both as a subject area and as an area of recruitment. I realise that many sales personnel are not necessarily engineers and therefore, could cause problems over the proportion of registrable engineers in the Institution.

If the R & D wing of our industry is to carry out really useful work, a great deal more liaison is needed between those at the sharp end, actually selling and using machines and the designers, inventors and boffins working in governmental or commercially sponsored research.

It should be remembered that to be effective, liaison needs a two way approach. It is not a case of the researchers seeking out the users or salesmen seeking out the researchers, but one where all sides of the industry are actively co-operating. I hope our Journal can play a part in providing a vehicle for such co-operation by publishing material from all "airts" of the industry.

In common with many firms and organisations during the present reduction in trade in our industry, the Institution and hence, the Journal, must extend its remit to cover engineering in other land based industries, as well as agriculture. The present and short term futures for agricultural engineering do not offer much hope for increase in industrial activity. Therefore, opportunities in areas such as forestry, leisure, fish farming (yes! it's classified as land based!), peat harvesting, etc. must be sought. In this context, your Journal will be pleased to receive suitable copy with an engineering bias from these and allied industries.

Your Editorial Panel have been taking a close look at our advertising revenue and methods of obtaining it — at present, the advertising revenue needs a close look even to find it! A new media pack is under production and a drive for advertising is to begin. Members of the Institution can help us, and hence Institution finances, with this drive in two ways, viz: (i) by mentioning the Journal to possible advertisers and pointing out that it is circulated amongst company executives who make purchasing decisions and (ii) mentioning the Journal if answering advertisements.

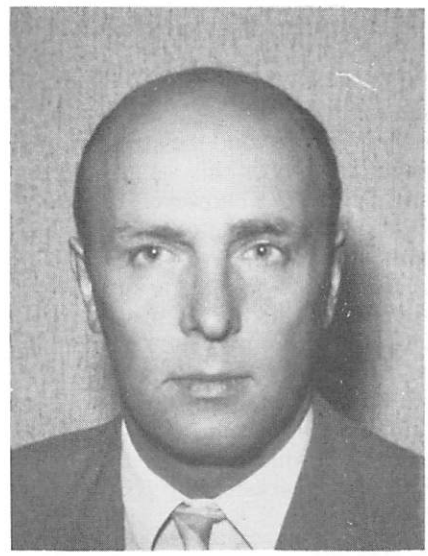
I should like to take this opportunity to thank the Editorial Panel of: Allan Langley, who carries out much of the sub-editing work; Tim Chamen, who organises book reviews, the annual index and some of the photographic material; Danny Boyce, who is organising the media pack design production with the help of Peter Redman, Mike Willis and Linda Palmer; Norman Stuckey, who produces it all and keeps everyone on the straight and narrow; and last but not least, our Secretary, Geoff Tapp who with his team carry out the daily administrative chores.

My final observation is an attempt to give some encouragement to those of us who still practice agricultural engineering. Although poor trading conditions have wrought many adverse changes to the companies and organisations involved in our industry, (as I have experienced!), I take heart that a great divergence of technology remains, some small companies as well as large ones continue to survive, our profession still spawns "characters" and our work continues to be the most interesting of all. Hence, as a past sage said, "be not dismayed that roses have thorns, but rather be thankful that thorns have roses".

Marketing research: has it a role in applied research and development?

S D Knox

The innovator makes enemies of all those who prosper under the old order, and only luke-warm support is forthcoming from those who would prosper under the new. N Machiavelli 1513



Summary
DIFFERENCES between applied research and development in both public and private sector organisations are highlighted in the content of new products. Particular emphasis is laid on the role of government sponsored research.

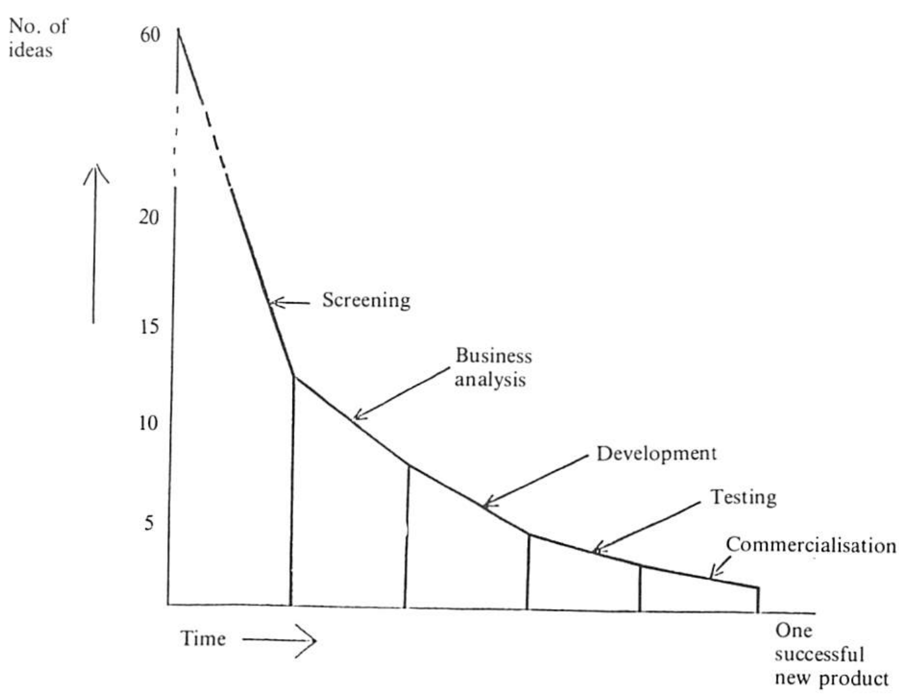
1 Introduction
IT would appear that nothing much has changed in the last 500 years. The task of marketing innovation remains a very precarious pursuit. Within the last ten years the stakes have been raised even further, particularly within the agricultural and food markets, as the investment recovery time, or the payback period, has been curtailed by senior management anxious to raise their returns on investment in static and declining UK markets. The same picture emerges on an international basis within the developed economies as competition intensifies across national boundaries. However, despite these pressures, new products remain the life blood for survival and long-term growth within these very industries.

Successful new products are the fruits of basic research and product development, so it follows that if there is to be an increasing dependency on new products to make substantial contributions to company profits in the short to medium term, then it must be recognised that winning concepts and development prototypes have to be identified at the very early stages of development for both commercial and marketing reasons.

Simon Knox is Lecturer in Agricultural Marketing and Management at Silsoe College, Cranfield Institute of Technology, Bedford.

2 The UK food industry and new product innovation
The UK food manufacturing companies have been quick to recognise this *quid pro quo* and are increasingly adopting market research techniques which expose the development product — concept or prototype — to consumer evaluation and scrutiny as an aid to decision making at each stage of the development process. A five stage development programme, first proposed in 1968 by Booz *et al*,

Fig 1 New product development



From Booz, Allen, Hamilton 1986

Table 1 Success rates of new products in the food industry (UK)

Year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	Total
Total food products launched	53	76	94	92	64	81	55	70	73	72	730
Turnover, £4 m+	1	1	2	5	2	5	1	4	7	3	31
Proportion successful, %	2	2	2	3	3	6	2	6	10	4	4

From Madell 1980

has been adopted by many food manufacturing companies in some derivative form. Figure 1 shows the "decay curve" from concept screening to the commercialisation stages. It is beyond the scope of this paper to discuss this sequencing in any detail: it has, however, been very well documented (Kotler 1976). Marketing research has been accepted as a pre-requisite to successful product innovation. However, even when marketing research has been carried out there is still a high probability of commercial failure. A 10 year study (Madell 1980) of new products launched into the UK food market, suggests about a four per cent success rate. It is interesting to see from table 1 that during the latter half of the 1970s the success rate has been closer to eight per cent. Nevertheless, the statistics are still not encouraging.

3 Public sector versus private sector research and development

The discussion, so far, has been confined to the commercialisation of research and development projects in the private sector where the integration of research and marketing goals is likely to be at its best. The management of such projects is likely to be under the wing of either a product champion or a matrix management team which should impose a level of continuity from the concept stages to product launch.

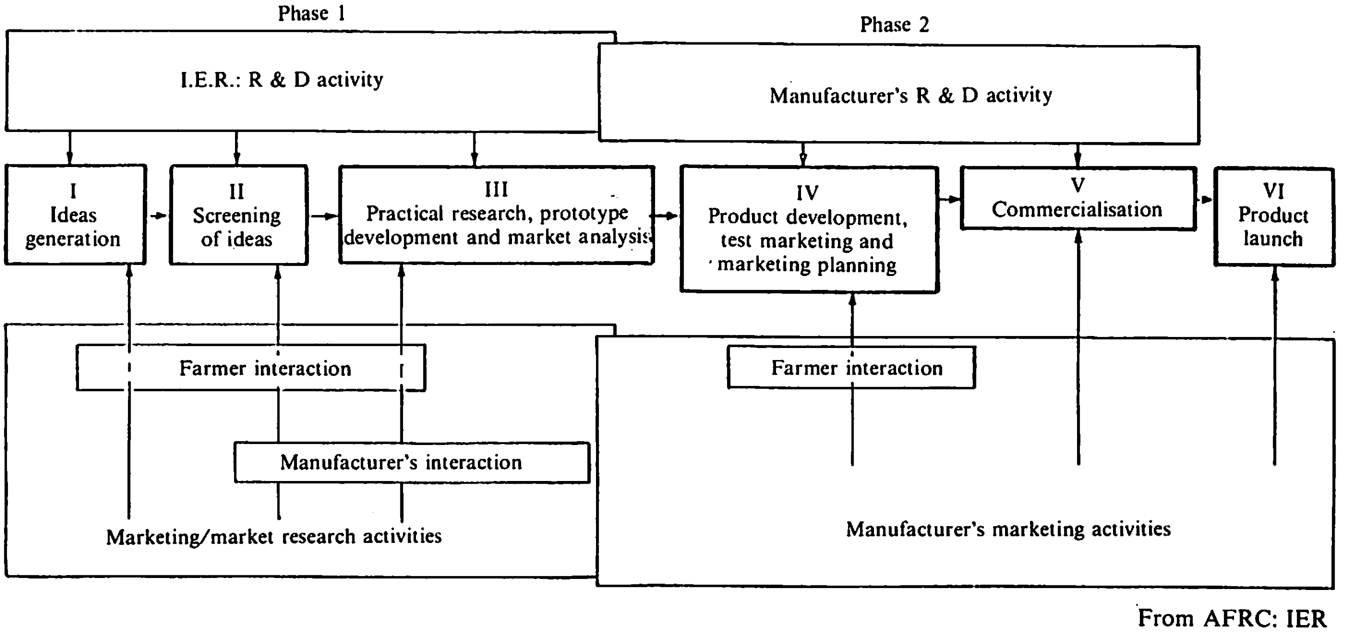
In comparison with this, the concepts and prototypes emerging from AFRC-based research and development will first have to be transferred to the private sector before the product development and commercialisation stages can be funded. It is the implications of this transfer in project management from public to private sector, which forms the main basis for discussion in the remaining part of the paper.

It is the author's belief that, because of this discontinuity in management, special attention should be paid to both the applied research and development activities and the marketing research requirements of such government establishments.

For the purposes of this paper and a separate AFRC paper (Knox and Legg 1986), a model for the Institute of Engineering Research has been developed to illustrate a typical new product development sequence. Figure 2 shows this to be a six-stage model, divided into two phases.

During the first phase, research and development activity is funded by the research institute whilst the

Fig 2 New product development paradigm



From AFRC: IER

second phase assumes commercial adoption and development of the product to the market launch stage. However, there is likely to be a period of overlap where prototype evaluation and market assessments should occur. This interface, denoted by stage three in fig 2, is a critical point in the innovation pipe-line from the research institute's viewpoint, since it is likely to involve a degree of "selling" to an interested manufacturing company, the adopting organisation.

At this stage, particularly with major projects, it becomes increasingly important to have detailed marketing information derived from interactions, both with the market place, in this instance the farming community, and also the likely adopting organisations. It is also a critical point from the adopting organisation's view since it is likely that development costs will begin to escalate between stages three and four. In other words, it is a cross-over point in the balance between acceptable risks and levels of investment (Ruston 1986). Figure 3 illustrates this point in diagrammatic terms.

The extent and quality of the marketing research carried out during the period between establishing technological feasibility and commitment to product development can significantly reduce the risk in the decision making process.

Before discussing marketing research techniques that can be used at this stage in the development, it is appropriate first to explore both the levels of marketing research effort which may be needed and the priority areas.

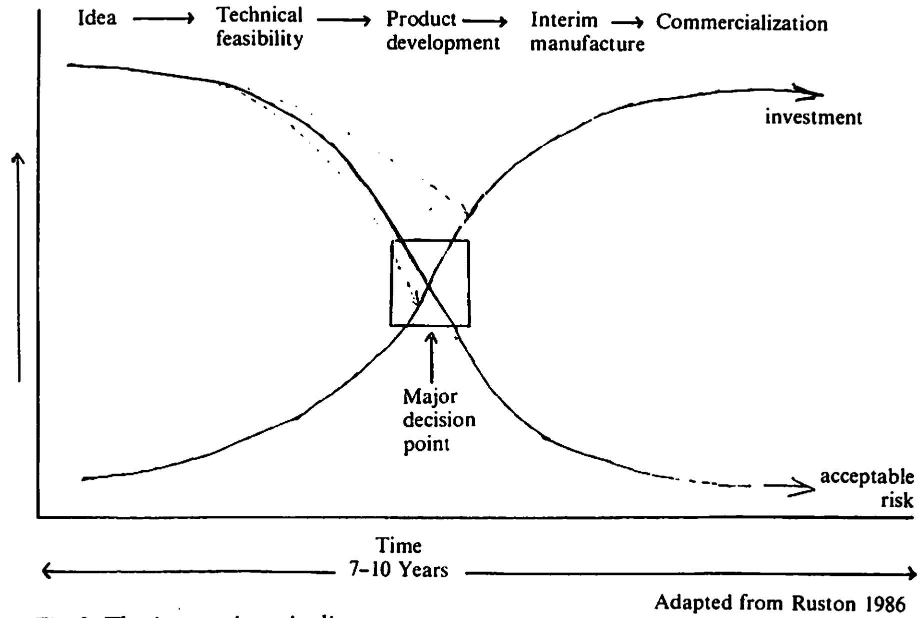


Fig 3 The innovation pipeline

4 The scope of marketing research in research and development

It would not be perspicacious to be too precise about exact market research requirements given that each research and development programme varies in complexity and level of risk. However, it is interesting to note that in a Canadian survey (Moore 1984), carried out amongst industrial product firms, about 95% of these firms commissioned marketing research during the earliest phase of the product development, as can be seen in table 2 (The author of the paper is not precise about relating the marketing research to actual stages in the new product development sequence, preferring instead to measure it in terms of chronological stages).

The median research efforts during this early phase was 150 man hours on each project with 17.9% of companies expending more than 2.7 man-months on marketing research.

The research demonstrates that a significant proportion of Project Managers took early and intensive market research very seriously.

In contrast and perhaps surprisingly, over 60% of firms did not carry out any further market research — possibly reflecting the difference between marketing industrial products and consumer products where the finished product would almost certainly require market testing as a risk reduction stage, prior to market launch.

When probed about early marketing research tasks, the respondents identified the need to understand the buying policies and procedures of potential adopter clients as a first priority.

Secondly, they confirmed the desirability to develop and evaluate comparative advantage on key product attributes in competitive markets situations. Both these research goals are very relevant to the market research needs of institutions at the developer-adopter interface stage.

A third finding which is equally pertinent to the "selling task" of our research institutions highlighted the need to help evaluate the buyer risk (table 3).

In the context of the agricultural engineering industry, this would involve assessing, for instance, the likely impact that the new product development would have on sales, profits and the established product

Table 2 Proportion (%) of man-hours of market research carried out during new product development +

Phase	Discrete and cumulative proportions,	proportion of labour time 0	>0–40	>40–150	>150–500	>500
First*	Dis	5.3	21.4	24.1	31.2	17.9
	Cum	5.3	26.7	50.8	82.0	100.0
Second	Dis	61.6	6.3	7.1	13.4	11.6
	Cum	61.6	67.9	75.0	88.4	100.0
Third	Dis	66.9	11.6	5.3	9.3	6.3
	Cum	66.9	78.5	83.8	93.6	100.0

\+ 112 industrial product firms in Canada with high NPD profiles
* Measures taken of man-hours in chronological one-third of the development period.

From Moore 1984

Table 3 Ranking of factors considered important for early market research +

1. When the characteristics of the organisational adoption process for the new product were uncertain.
2. When competitive advantage needs clarification and development.
3. When a high risk is involved to the adopting organisation. *High risk to the adopting organisation translates into high risk for the developer.*

+112 Canadian firms — From Moore 1984

portfolios of the potential adopter companies.

To summarise these research findings in the context of our research institutes, early marketing research should be carried out to develop a data base of knowledge both about the potential markets and the likely adopter companies that could be interested in the research project. Increasingly, determining competitive advantage, within market sectors, will also play a central role in marketing research since it is likely to have a major influence on the selection of suitable adopter companies and estimating their market share.

5 The approaches to marketing research in agriculture

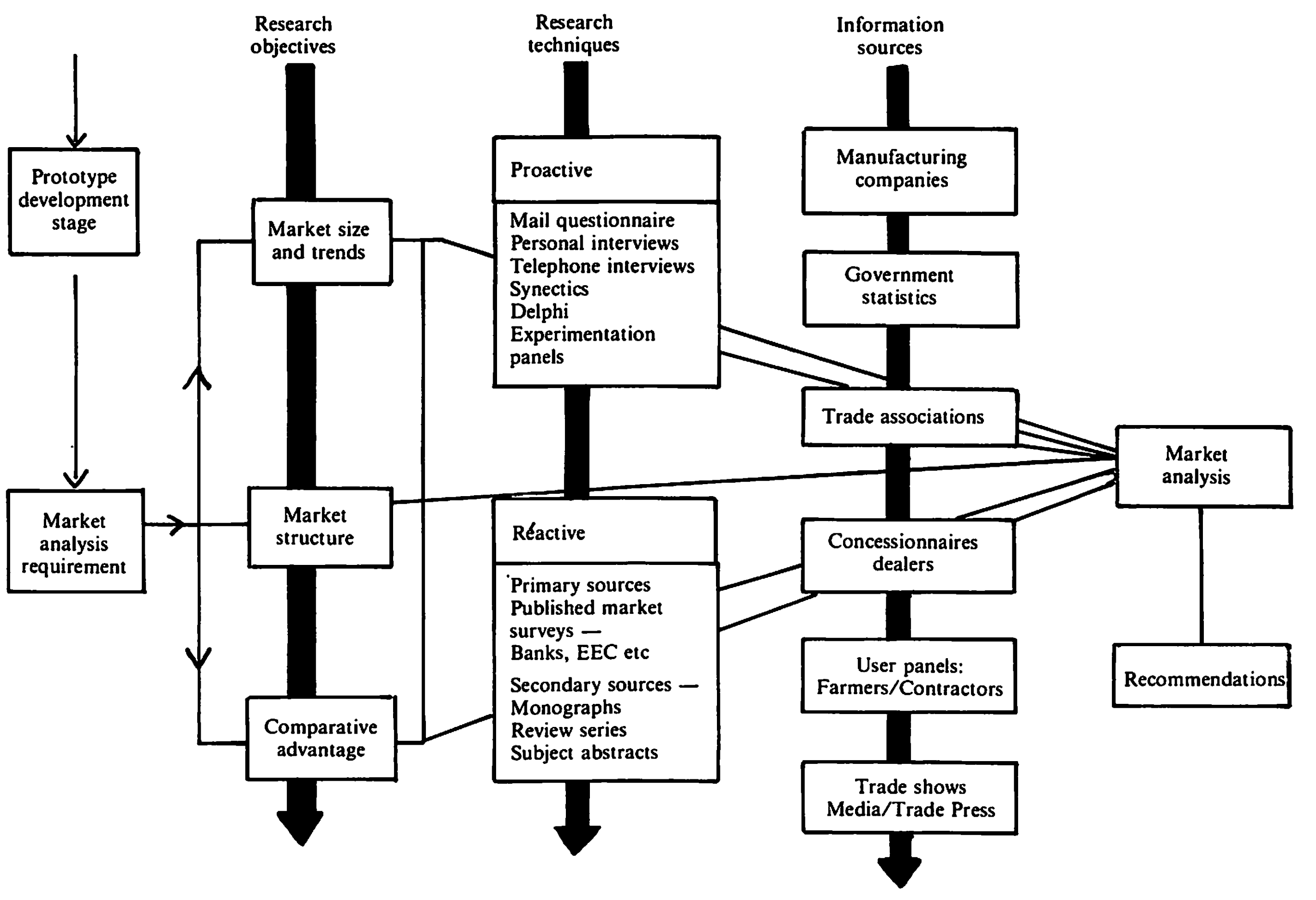
There are a large number of marketing research techniques that can be used to assist in decision making in agricultural engineering research. Broadly, they can be divided into two types; proactive and reactive research (Macdonald 1986).

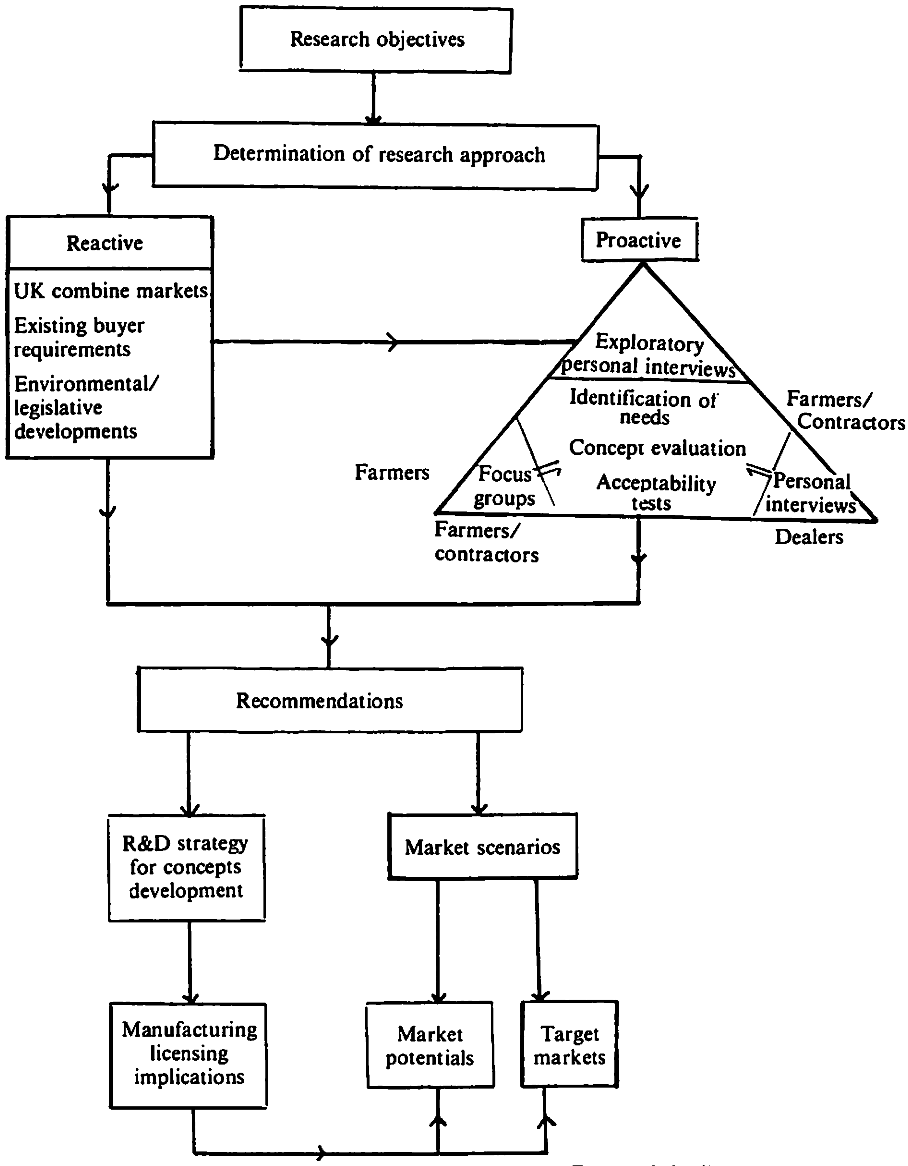
Proactive market research implies an interactive communication with the market place whereas reactive research is dominated by desk research and published data analysis. At stage three of the developmental model, (fig 4) both types of research are appropriate. Assuming that the marketing research objectives conform to those previously discussed in the developer-adopter situation, fig 5 serves to illustrate the likely links between specific research objectives, research techniques and information sources. In this situation, there is no pre-determined formula that can be applied to select the most effective means of information gathering. Chosen research technique(s) will influence the choice of information sources and vice versa. Both will be dependent upon the research objectives which will vary, in some degree, upon the nature of the new product being developed.

6 A case history

It may be helpful to draw upon a case history in order to illustrate the need

Fig 4 An appraisal of marketing research requirements at the developer-adoptor interface: AFRC:IER





From MSU, Silsoe College

Fig 5 Case study: the "stripper rotor" concept to combine harvesting

for selectivity. For this purpose, the researcher looked to the work of the Marketing Services Unit, carried out on behalf of the (Hill *et al* 1986) British Technology Group (BTG), regarding the market potential for the AFRC:IER "grain stripping rotor" concept.

As many will be aware, a prototype has already been developed to harvest grain by stripping the crop *in situ* leaving the straw standing in the field. In the context of the UK market study, the research aims were to assist the BTG in formulating a licensing strategy and, to provide a guide to research and development priorities based upon projected marketing scenarios. Thus, the main focus of the research was to gauge farmer adopter preferences, for a number of optional different market sectors.

It was not a requirement at this stage to determine, in detail, likely interested adopter organisations. As a prelude to the proactive research sequence, desk research was carried out to determine the main characteristics of the existing combine markets. From this work, and through a number of exploratory personal interviews with expert opinion holders, a series of research hypotheses was generated. Figure 4 illustrates the sequence of both proactive and reactive research, highlighting the inter-relationship between these two types of marketing research.

The main part of the proactive research involved testing these hypotheses through a combination of personal and group interviews with farmers, contractors and dealers. A range of farm sizes and types were selected on a wide geographic basis. On each occasion, a semi-structured questionnaire format was adopted. The moderator divided the discussion into three parts:

The identification of needs (both fulfilled and unfulfilled).

Concept description/evaluation (technical and economic).

Acceptability tests.

Although only a preliminary study, it was possible to critically examine various options through these interactions and to gauge farmer expectations, according to their farm size and type. In conjunction with the desk research, the market potential was estimated in a number of different market scenarios which relate to target markets and sources of supply. The research work also indicated that the adoption rate would be enhanced if a particular introduction sequence was to be followed. Thus, a preferred research and development strategy was recommended which has implications for the manufacturing licensing arrangements.

7 Conclusions

There are important differences between applied research and development in both public and private sector organisations, in the context of new product development.

With regard to government research institutes, such as the IER, a six stage model is proposed which delineates the activities of both the Institute, as the developer organisation, and the subsequent adopter manufacturer. It is argued that the transition period of product management, from the public to private sector, is a critical decision point since it is at this stage that risk evaluation can best be judged in the face of escalating costs.

There is an onus upon the research institute to carry out suitable marketing research during this stage for a number of strategic reasons. This research is likely to include:

— The identification of suitable adopter organisations.
— The development and

exploitation of competitive advantage.

— The requirement to explore the market potential of the new prototype to assess the risk factors facing adopter organisations.

A recent research paper, which explores the marketing research activities of industrial product firms, is discussed in order to re-emphasize both the importance and the scope of marketing research commissioned at this stage in the development of a new product.

Finally, the marketing research techniques and information sources currently being used by the agricultural industry are placed in context through a brief cast history discussion of the "stripper rotor" concept to combine harvesting.

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Letter

Water hyacinth and soil fertility

I HAVE just read with interest Alan Casebow's paper in the Summer 1987 edition of *The Agricultural Engineer*, and thought you might be interested in some further facts and figures.

We sold Tunnel Estate, Fort-Ternan in 1983. At that time we left two of the ready made Hutchinson methane plants (Mk III No 3) still working. They were installed in 1957 and nothing had been replaced, only very minor repairs had been done, apart from periodic repainting. They were both cleaned out and refilled for the first time in 1982, at that time they were still producing just under half of their rated output of biogas.

My family and I cooked exclusively off biogas from 1955-1983, because from 1956 onwards there was no alternative system of cooking available. As a demonstration of the reliability of the Hutchinson methane plants, never once in that period did we have a cold meal due to lack of cooking facilities! I am claiming this as a record and wonder if anyone in India or China can better it!

The lighting plant had done 68,000 hours running on 100% biogas by the time we left the farm, except for the teaspoonful of petrol used to start it each time. I think it most unlikely that it would have lasted that long on the kerosene fuel for which it was designed.

The water pump was driven by a 6/1 Lister diesel engine that averaged 12 hours a day from 1960 to 1983 on a mixture of diesel and biogas (approx 25%–75%).

CRF, Ruiru soil tests — Comparison of methane sludge and inorganic fertilizers on soil properties (in mille equivalent % and parts per million).

Units	*Before treatment*		*NPK*		*MS*		*NPK and MS*	
	Top	*Sub*	*Top*	*Sub*	*Top*	*Sub*	*Top*	*Sub*
pH	5.5	5.5	5.2	5.4	6.2	5.9	5.9	5.4
Na,me%	—	—	—	—	—	—	—	—
K,me%	3.45	3.0	2.18	2.55	5.65	4.23	5.35	3.3
Ca,me%	5.1	1.7	3.8	1.9	10.8	3.8	8.4	2.2
Mg,me%	4.7	2.5	3.2	2.15	7.05	3.85	6.3	2.45
Mn,me%	0.77	0.72	0.81	0.75	1.04	0.75	0.97	0.69
P, ppm	15	5	17	8	78	17	69	7

Source: CRF Ruiru

NPK — One dressing of 15:15:15 at 250 lb/acre & 6 cwt Ca/Am/N
MS — Methane sludge

Our coffee was never sprayed, nor received any artificial fertilisers, and I still do not understand why "Coffee Research" are reluctant to acknowledge that Coffee Berry Disease and nutrition of the coffee plant are closely related. Enclosed are some interesting soil analysis figures obtained by the Coffee Research Foundation (CRF).

The Coffee Research Foundation, Box 15 Koru, still has in daily use a Hutchinson methane plant (Mk III No 4) which I supplied in 1966. Nothing has been replaced on it, except for the odd coat of paint. Regrettably, the methane plants we left at Fort-Ternan have been abandoned as the farm has been divided up into small holdings.

We are currently marketing the Hutchinson methane plants from the new address. I will be pleased to post leaflets on the plants to anyone who wishes to receive further details.

T H HUTCHINSON
Energy Consultant
PO Box 1,
Tunnel Technology,
Koru, Kenya.

UK technology in Middle East markets

J M Boardman

Summary
THIS is a personal view from Iran which may provide useful feedback to UK manufacturers of agricultural machinery for export sales to certain Middle East countries.

1 Design considerations for the farmer

For farming people in Islamic countries "asset capital" is very different in scale to "living and working capital" and they are accounted separately. They are not intermingled as in the West for a number of reasons, viz mortgage and hire purchase based on interest is unlawful, "asset capital" is both inheritance and legacy (to be kept safe) for their heirs. There is no farming insurance, and traditional farming is very near to village by village self-sufficiency necessitating relatively small living and working capital for outside spending.

A piece of expensive machinery would have to be purchased, by cash, from the asset capital of the farmer with the certain knowledge that it will gradually wear out, sooner or later failing to function and the value of it depreciate to scrap. Hence, the farmers regard a maximum period of two years for pay back of the purchase price when used on the system of contract work on neighbours' farms.

For greater assurance of reliability, farmers will pay quite high premiums for West European and American machinery against products of the same type from China, India or Turkey. If a machine cannot pay for itself in two years of hard use and without breaking down in that time, then it is not marketable. Once the machine has paid for itself, repair and service costs will come out of the "living and working" account, effecting profitability the same way as in the West (with the exception of water pumps), the reliability risk having passed.

Jonathan Boardman is a Design Consultant with the Iranian Government.

Machines and equipment that by UK farming standards have too great a capacity for the owner's modest requirements, are worked for long hours in the Middle East because the system of machine utilisation is very different. Although there are a few co-operative farms and large estates, the vast majority of farmers have only a few hectares, and, after completing work on their own land, farmers are keen to contract themselves with their machines to their neighbours' farms for a charge set just a little less than that of hand labour. A farmer may own only one piece of equipment, so for mechanisation of other tasks through the year, he will hire somebody else with their equipment on the same system of charging. Thus, the problem of machine over capacity does not arise in regard to farm size. However, small machines are required for manoeuvrability and access to the small fields and narrow (2.5m) roads, (sometimes walled). With barn machinery, supply is limited by transportation difficulties.

Machinery owners are characterised by an eagerness and an ability to learn rapidly the operation of a machine of which they have no previous direct experience; therefore, the learning may start from a very low point. Operation of a device that requires reading a handbook or even a transfer stuck on the machine is not practicable; rather, controls and operation must be self-evident and interlocked to prevent damage until the correct procedure is discovered. An analogy would be use of a new programable calculator; pressing the wrong sequence of buttons does not break it, simply the "error" sign comes up till the correct sequence is used. Similarly components like audible ratchet safety clutches are better than silent friction ones.

Apart from mistakes during learning, the operators are careful with their new investments. Tractor engine oil and water are by the large majority inspected daily, all obvious grease points are well lubricated, but often the hidden ones never receive grease at all. All grease points should therefore, be well marked. On the headland, a tractor would never be turned by use of the steering brakes as such a manoeuvre would be considered far too violent a treatment for such a valuable investment. However, when a part starts to wear or partly break, they continue to be used until a complete breakdown occurs, as both spare parts and technical service are difficult to obtain, often being remote and always very expensive. Because of this, a two year written guarantee is of no use to the farmer and not good business for the supplier either. Reliability must be included in the design.

The level of technology; low, intermediate or new, incorporated in the machine design, is of no consequence to the user, it only shows the manufacturer's capability! What matters for the farmer is the machine's reliability, the efficiency and the ease with which he understands how to work it. An example is a complex hydrostatic drive including variable and reverse speed, clutch and overload protection. If the unit is a bolt-on, totally enclosed package, it will be no problem for a farmer in a remote area and may well be the most economical way of providing the required performance and reliability. However, if the hydrostatic drive consists of separate pump, motor, valves and reservoir, all connected by hoses, then it is no longer appropriate as it is too susceptible to damage, tinkering and the ingress of sand.

The over-simplified assumption "only use low technology for export to Third World countries" can be responsible for lack of sales.

2 Design considerations for local technical ability

Research and development is now carried out very professionally in agricultural science, plant breeding, seeding techniques for local conditions such as salt and drought resistance etc but work on machinery is limited to testing and evaluation of both locally made and imported equipment.

Some equipment supply contracts have to contain a percentage of local work in order to be granted an import licence. There are a number of possibilities depending upon the goods, the size and detail of the contract. Industrial development is under greater government control than it is in the UK. Most of the large factories are government owned and supply of raw material also is in their hands, hence, the first priority of supply is given to government factories. Raw materials, outside government control on the open market, are bought at a higher price. There are a few large government engineering works that can make most things such as spare parts for aircraft, giant forgings for rock crushing machines and multitudes of odd parts for other companies' use. Though it is technically possible to have "high tech." work done on location for the stipulated percentage of local content, these factories are so overloaded that permission to have something undertaken in them is difficult to obtain.

Kit assembly factories for a wide variety of goods are quite common, though undertaking new outside work in them is not generally possible, as they are built for the assembly of one permission-granted product supplied by one (very happy!) foreign company. Sometimes a general manager of one of these assembly factories may wish to take on a new "side line", but the difficulties of getting permission and finding spare capacity and extra raw material supply beyond that previously allotted usually prohibit contracts.

Commercial importing companies, though they may not have facilities or staff for part local manufacture, are in a good position to get raw materials and finished parts. They are more flexible than the previous two classes of company, especially in finance. Manufacturing the "local content" of the equipment can be subcontracted to a (usually private) engineering works on behalf of the exporter. Machines should be designed so that after an initial batch is completed in the UK, a good proportion of the manufacture can be undertaken locally out of mild steel with conventional small workshop facilities. The procurement of steel is conducted by the commercial importing company with the assistance of government agencies.

Design calculations should be based on steel having a maximum yield stress of 210 MPa (14 t/in^2). This applies to plate, bar, rod and rolled sections as the only commonly available high tensile steel is concrete reinforcing rods. Grade 5.6 steel is considered high tensile, and greater than 8.8 is not available.

Standard metric sizes should be used for all components, with the possible exception of pipes which are largely inch nominal inside diameter. Nuts and bolts of all sizes are usually available, but even specials like self-locking nuts, are not obtainable.

Dealers in agricultural machinery work as agencies for importing companies and undertake the servicing of imported machines. Locally designed and made machines are sold from the road outside the workshop, not through a dealer. Service is rather different from that experienced in the UK, the main problem being the impossibility of specialisation for the mechanics to get "in depth" product knowledge.

It is often thought that providing product training in the UK for a local mechanic will overcome many servicing difficulties. However, when such a trainee returns home, he tends to consider himself as a foreign educated 'Engineer' who is no longer an artisan.

Ordering spare parts from abroad takes many months, due to shipping and import licence delays, and small quantities are rarely ordered. The most serious spares shortage relates to finding vee belts of the correct size. Vee belt drives may appear a simple low cost system for export to the Third World, but even where a machine is supplied with a good stock of spare belts of the correct size in the packing crate, the importer or dealer will collect these belts, store them and later, sell them to his best customers at an extortionate profit, leaving the remote, less well-off farmers without their requisite spares. Hence, belts and pulley sizes must be designed to industrial (2600 hour) ratings, not agricultural (500 hour) ratings, to reduce the demand for spare belts.

The smaller kind of manufacturing company, of which there are many, is often a private family business and such firms can be a problem for the UK exporter rather than a help. These firms work with mild steel carrying out turning, welding, bending, drilling, rolling, but none have a drawing office as they all work on the principle of "copy", some parts being made from patterns. There may be 20 separate businesses in a town all making the same basic machine with only small individual differences. This situation is accepted as they regard themselves as any other self-employed craftsman, like 20 tailors making a similar suit. The slightly more adventurous of these firms buy foreign made machines (especially of Western make) having reputable performance under local conditions. They then dismantle them to enable a direct copy to be made, even the colour and trademark may be included. One family business in a remote area making a very limited production of a direct copy is both rather insignificant and very expensive legally for a manufacturer to suppress, but 20 such businesses in one town copying another firm's goods are no longer insignificant but is still very expensive to suppress. The same problem faces any local engineer who wants to develop his own idea for a new machine.

Though this copying is technically illegal, it is difficult to control. The government seems more sympathetic to giving the farmer equipment at the lowest possible price, which the local family businesses can do with their minimal overheads and wage bills. Perhaps the commercial answer to the copying problem is for the exporter to design it in! UK manufacturers could design their machines using both low and advanced technology. Spares would then only consist of supplying the new technology in "black box" form and local industry could supply the rest.

3 Design considerations for an import licence

In Iran, agricultural development is under the Ministry of Agriculture who require machines and

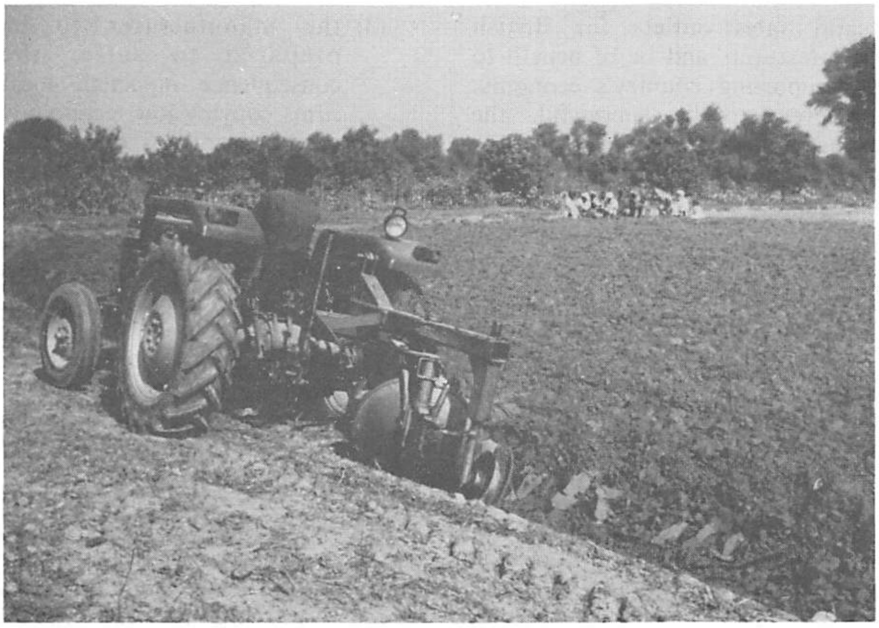


Fig 1 Disc ploughing in Pakistan (AFRC:IER photograph)

techniques that are the best and most reliable for agricultural development; whereas industrial development is under the Ministry of Industries who wish to promote domestic manufacture where the emphasis is on "manufacture" rather than design or quality control. The two Ministries work separately so there is always friction over agricultural machinery because the Ministry of Agriculture prefers to import the best performing and the most reliable equipment wherever it is made. From the agricultural view this way is seen to be more cost-effective than designing and developing their own machines. One of the stages of obtaining an import licence is having the machine tested for performance and reliability in comparison with competitors' machines.

The Ministry of Industries, however, takes an opposite view; if a machine with the same function can be made domestically, regardless of quality control, they block the import licence to save foreign currency. On the other hand, the import of a small trial batch would not be stopped. This could lead to obtaining an import licence for a large order, whereby part of the machine is made domestically and the more sophisticated components are imported. A mixture of low and new technology is admirable for acceptance by both Ministries of Agriculture and Industries.

Many exporting countries such as Turkey, Spain, Romania, India and China, produce conventional machinery at a price that just cannot be matched by UK producers no matter how efficient they are. So why and when do the import agencies buy from the more expensive UK? There are two distinct sorts of goods ordered from the UK, viz:

(1) traditional, extensively proven products with excellent reliability records and stocks of spare parts in every town. Such an example is the Lister Blackstone slow speed (700 rev/min) single cylinder diesel engine with a large open flywheel. There are considerably cheaper engines on the market, but these do not have the proven reliability for pumping water 24 hours a day for eight months of the year, year in year out. Such reliability is a necessity where the crops of a village will die in a matter of days, if irrigation water is unavailable due to breakdown of the pump engine.

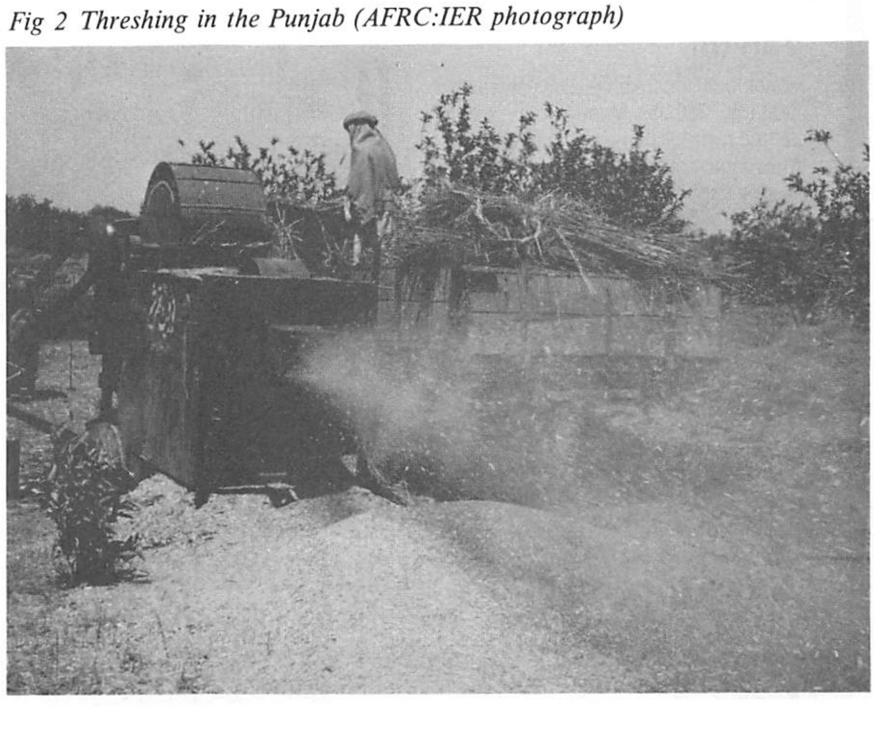
(2) high performance machinery of new design, advanced in specification and work. High technical content will sell a machine providing that it is not susceptible to meddling, knocks or sand.

Although equipment offered for sale in Middle East countries is often promoted by the usual methods of advertising, exhibitions, pamphlets, photos, videos, sales trips etc, to generate awareness of the product to potential buyers, the actual decision "to buy" has to be made through government order.

As stated previously, all imported equipment has to undergo a test to obtain a favourable report in order to receive an import licence. As these tests are comparative with existing machinery in the country, it is important to ensure that new types of equipment are correctly described so that their test performance is equated with that of machinery within the same generic type.

It is rather surprising that commercial agencies buying and

Fig 2 Threshing in the Punjab (AFRC:IER photograph)



importing equipment, make many machinery selections based upon "Telex" specifications of the equipment, therefore, the Telex specification must be well written and the use of an extensive vocabulary avoided, as English is the second language for the buyers. Abbreviations should never be used, particularly as Persian and Arabic languages do not use them because the capital letter function is different and is at the end of the word. For example, if a manufacturer has a machine with a variable transmission described on the Telex, it may not be fully understood; but if the design is adjusted so that the control lever of the variable speed device has 12 notches, the Telex can be made to read "12 speeds" which can be fully understood and sounds impressive.

4 Conclusions

Exporting agricultural machinery to Middle East countries can provide useful sales outlets for British manufacturers and be of benefit to the importing country's economy. However, to be successful, the exporter must fully understand the market needs and recognise the requirements of "official" import procedures of the country concerned.

These market needs and official procedures are for:

(1) simple and reliable machines of low technological input or more complicated high technology machinery provided it is reliable, robust and resistant to amateur tinkering;

(2) the capital cost of the machine to be such that the purchaser can pay the value back within two years of use, (the borrowing of capital and paying interest on the loan is not acceptable in the Middle East);

(3) the manufacturer to be prepared to suffer the consequence of small local firms copying low technology machines or items, (in the long run it may be preferable to have such items manufactured locally);

(4) the exporter to be prepared to have his machine tested in order to obtain an import licence. For such licence to be granted, his machine must fulfil a need that cannot be met by local manufacture in cost or performance;

(5) instructions and sales descriptions to be preferably written in the language of the importing nation, but if English is used, it should be simple, unambiguous and having a restricted vocabulary (particularly for Telex descriptions).

Research and development facilities in Europe

I J Duncan

COMPANIES in the United Kingdom, in general, spend significantly less on research and development than their overseas competitors. Obviously, it should help to change this situation if money is available to augment companies funds, but the next problem is to locate this money and find out on what terms it is available. For some time, the Commission of the European Economic Community has been concerned that Europe may be left behind in matters of research and development, and to try to avoid this, a number of European schemes have been launched. Statements were made originally that sums of up to £150 million were available, but now no specific sums are mentioned as the budget alters from year to year.

The main pressure for European collaboration has been the mounting cost of individual projects, often far greater than any one country can afford. Faced with aggressive competition from groups of companies elsewhere that are able to afford to develop rival products, in many industries it is now a case of collaboration or die.

Collaboration involves both Governments and industries, and often, academic expertise as well. Military weapons systems and civilian programmes figure in the growing list of joint projects, some of the better known of which are "Concorde", "Jaguar", "Tornado", "Airbus" and "Ariane". While we have learned many lessons in trying to organised collaboration in Europe, it is evident that we have some way to go before we become adept in this area.

Some of the schemes are unlikely to apply to agriculture and RACE (R and D in Advanced Communications Technologies in Europe) is one of these, ESPRIT is another, (European Strategic Programme for R & D in Information Technology) although it may be possible to obtain funds for the development of farm computer control systems from this source.

We have R and D in Non-nuclear Energy where projects in biomass conversion technologies are underway, dealing with the conversion of crops to fuels, projects in solar energy generation, projects in generating wind energy and in the production and management of geothermal reservoirs. Two typical projects are as follows:

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Republic of Ireland — the application of an internal combustion engine driven heat pump for grain drying combined with refrigerated storage.

Holland — energy saving in soyabean extraction industry by reducing the steam consumption for desolventizing, toasting and drying beans.

For these projects, the Commission especially favours joint proposals involving organisations in two or more member countries, and the work should not be planned to extend beyond the end of the programme (i.e. 31-12-88). Support will not normally exceed 50% of the total project costs, but may, for Universities and other higher education establishments, be 100% of "marginal costs".

The scheme that seems to offer us the most scope is EUREKA which is a framework for promoting collaborative projects in advanced technology. This scheme was set up by agreement between 18 European countries and the European Commission on 6th November 1985, and the aim is to improve European competitiveness in world markets in civil applications of new technologies, by encouraging industrial and technological collaboration within Europe.

Through EUREKA, governments and the European Commission can assist the development and commercial success of collaborative projects in the following ways:

1) *Information and contacts*
EUREKA provides for a process of information exchange on potential areas for collaboration between firms or organisations in different countries who are either seeking partners for specific projects or expressing an interest in collaboration in certain fields.
EUREKA project proposals or expressions of interest are circulated to the member countries for distribution to companies who may wish to participate. EUREKA will ultimately have a secretariat with a database on projects, but until it is in place UK firms should approach the UK government contact point for information on a particular sector, or to submit a proposal for circulation to interested parties in other EUREKA countries. Details of EUREKA projects will also appear in the Department of Trade and Industry's weekly news magazine 'British Business'.

2) *Market opening measures*
The point has often been made by industrialists that an integrated European market can be crucial to the success of the exploitation of technological developments. EUREKA can act as a powerful lobby to help set priorities for action by focusing on market barriers encountered by specific projects.
Where a number of firms have agreed upon a EUREKA project, but anticipate a particular barrier to market penetration (e.g. incompatible standards in different EUREKA countries or public purchasing restrictions) their governments can on request apply pressure in the appropriate fora for action to resolve the problem.

3) *Public funding*
UK participants in EUREKA projects will be eligible to apply for financial support under existing UK schemes.

Under the Department of Trade and Industry's Support for Innovation (SFI), UK firms participating in EUREKA are eligible for support of up to 50 per cent of their share of applied research costs, and up to 25 per cent of their share of development costs. Only one UK firm need be involved in a project to qualify for assistance at the higher level. In other respects, the terms of assistance in each case will be determined under the normal SFI criteria.

However EUREKA is not primarily a programme for funding R & D and EUREKA status of itself does not guarantee financial assistance. It is expected that EUREKA projects, having a commercial purpose, should rely mainly on finance from the capital markets or commercial sources.

In order to define a EUREKA project, to achieve EUREKA status and be eligible for the benefits listed above, projects should have the following attributes:

- co-operation between participants in more than one EUREKA country;
- an identified benefit from pursuing the project on a co-operative basis;
- the use of advanced technologies;
- the aim of securing a significant technological advance;
- appropriately qualified participants, technically and managerially;
- adequate financial commitment by the participants;
- development work carried out in EUREKA countries and its results exploited to the benefit of EUREKA members.

EUREKA status is granted by agreement between governments of all the firms taking part in a project and notification of the project to the conference of EUREKA ministers. EUREKA projects are circulated to the EUREKA members in a standard format (at the end of this paper) in two stages:-

(i) when the project is first proposed;
(ii) when EUREKA status has been granted to an agreed project in order to inform the other EUREKA members

Forty-five days must elapse between the first circulation of a proposed project and granting of EUREKA status, to allow for expressions of interest from potential partners in EUREKA countries. However it is entirely up to the participants to decide whether to accept further partners.

In addition to information on specific projects and project proposals, expressions of interest from firms who wish to collaborate in a particular field are also circulated. In some cases the best approach may be for a number of firms interested in the same field to set up a forum to discuss a particular sector or market area with a view to identifying areas for collaboration.

All project information is circulated to all EUREKA countries and if any information is not to be circulated, then this point must be made. Once the project is under way, the Department of Trade and Industry needs to keep in touch with progress made, as Governments are asked to give annual progress reports at the meetings of the 19 EUREKA members on projects involving firms from their countries. Any organisation that has a proposal for a EUREKA project, should approach their usual contact in the Department of Trade and Industry or contact:

The EUREKA Projects Office
Department of Trade and Industry
Room 210
Ashdown House
123 Victoria Street
London. SW1E 6RB.
Tel: 01 212 0249 or 212 6770
Tlx: 8813148 Fax: 01 821 1298

By the end of 1985, 26 projects had been announced, of which France was involved in 22, the UK 9 and a further 62 were announced on 30 June 1986 at the Ministerial Conference held in London. Thirty nine proposals and projects are currently under discussion. While most of these projects and proposals are outside agriculture, some of them can have agricultural applications and examples are shown. Altogether some 113 projects are under consideration, and it should be emphasised that there is no set upper or lower limit of expenditure, the scheme being entirely flexible in this respect. Projects can be accepted where there is no end product, such as research projects, but acceptance of these is not easy. The scheme applies only to EEC countries and partners outside EEC are not accepted. It is emphasised that no work on any project should be started before approval is given and the target time for approval is 45 days from receipt by Department of Trade and Industry. Where appropriate, patent applications should be made before submission of a project. Initially, the UK has been slower than other European countries to become involved with these schemes, possibly because instinctively we are not yet Europeanised. If we are to compete on equal terms with our European partners, we must seize every opportunity to benefit in future by Community schemes.

Table 1 EUREKA Project/Proposals

Part I Project Information

1) *Project title*
2) *Project description or technological area of interest*
   In the case of expressions of interest at an early stage, a specific project may not yet be envisaged. If this is the case, the technological area of interest should be identified.
3) *Participants*
   Name of enterprise/institute or other body acting as contact point for EUREKA purposes to be underlined. Country of location for all participants to be specified.
4) *Contact(s)*
   Should include name and address of participant acting as contact point to EUREKA purposes.
5) *Financial or other contribution of each participant to project*
   Should specify each participant's share in the project.
6) *Technological developments envisaged*
   Description of technological objectives and how these differ from, and improve on, existing products/processes/services.
7) *Relationship to other European technological co-operation programmes*
   Should state whether any relationship exists or should exist, with Community or other European technological co-operation programmes.
8) *Relevant qualifications of participants*
9) *Status of agreement between participants*
   Should state whether Memorandum of Understanding or other formal agreement exists; what conditions, if any, are attached.

Part II Additional measures requested

10) *Additional measures requested*
    Should specify what type of measure and time-scale are requested, e.g. agreement on common standard.
11) *Competent authorities*
    Competent authorities for the requested measure(s) differentiating between measures by governments of countries of participants and measures involving others (third parties).
12) *Authorities responsible for progress report to High Level Group*

Part III Optional Supplementary Information

13) *Estimated costs*
    For definition phase and full project.
14) *Application/market*
    Should specify the international market at which the product, process or service is aimed.
15) *Time-scale*
    Where appropriate, broken down into phases (e.g. definition phase, completion of project, date product/process/service on market).
16) *Location of development work*
17) *Where and by whom is development to be exploited initially*
18) *Partners sought*
    This will apply particularly to proposals in the early stages. The answer may be simply 'yes' or may specify, for example, areas of expertise.

Table 2 EUREKA projects pertaining to agriculture

Destruction and detection of chemicals by laser beam

Use of high powered lasers for the detection and destruction of impurities in finished products and in waste products.

Cost	:	9 million European Currency Units (MECU)
Time-scale	:	5 years
Participants	:	Belgium, France, Netherlands and interest expressed by Germany, Italy and Switzerland
Ref	:	EU23

Chrome tanning salts substitutes

Developments of techniques to treat leather replacing chrome by aluminium.

Cost	:	2.5 MECU
Time-scale	:	3 years
Participants	:	Austria, Greece, Spain and interest expressed by Turkey
Ref	:	EU25

Mass production from animal cells culture by a continuous process

Animal cell culture applications by implementing processes at industrial scale, permitting:

- either a mass production of one specific chemical by a process during a large period:
- or versatile and adaptable production of small quantities of a large spectrum of products, like monoclonal anti-bodies to be used in diagnostic activities.

Cost	:	25.5 MECU
Time-scale	:	3 years
Participants	:	Austria, France, Italy and interest expressed by Germany.
Ref	:	EU104

Crop management expert system

Development of a range of expert systems, software and ancillary hardware for use in crop management on farms.

Cost	:	0.6 MECU
Time-scale	:	3 years
Participants	:	Netherlands and UK
Ref	:	EU63

Sunflower seeds

Production of new commercial varieties of sunflower with high oil content, suitable for arid zone conditions.

Cost	:	4 MECU
Time-scale	:	10 years
Participants	:	France, Spain and interest expressed by Turkey
Ref	:	EU57

Eau claire

To develop a systematic approach to further reduce pollution levels with the River Rhine Basin as a model example.

Cost	:	0.4 MECU for definition phase
Time-scale	:	4 years
Participants	:	Belgium, Netherlands and interest expressed by UK
Ref	:	EU53

Ceramics for diesel engines

Development of new, efficient fibre reinforced ceramics, for diesel engines for commercial vehicles.

Cost	:	14 MECU
Time-scale	:	5 years
Participants	:	France, Germany and interest expressed by Spain
Ref	:	EU47

Protein design

Development of a complete and integrated system of instrumentation and computer analysis capable of solving 3D structures of small and medium sized proteins.

Cost	:	16 MECU
Time-scale	:	5–10 years
Participants	:	Denmark, Germany and interest expressed by Italy
Ref	:	EU41

Light materials for transport systems

Development of technology for welding aluminium alloys by electron and laser beams; and development of multi-layer composite materials.

Cost	:	15 MECU
Time-scale	:	4 years
Participants	:	France, Germany and interest expressed by Spain
Ref	:	EU42

Table 3 Projects under discussion in 1986

Beet, maize, soya and cereal seeds development

Development of inoculent bacteria to be used in improving plant growth and yields and in the biological control of pathogenic organisms, "in-vitro" culture, and encapsulation and coating techniques (for normal and artificial seeds).

Cost	:	Not yet determined
Time-scale	:	Not yet determined
Participants	:	Belgium, Italy and Spain
Ref	:	EU78

New process for obtaining polymers

Development of acrylic monomers from lactic acid derivatives (by fermentation), with the aim of obtaining polymers

Cost	:	Not yet determined
Time-scale	:	Not yet determined
Participants	:	Spain
Ref	:	EU74

Chemical and biochemical sensors for meteorological monitoring

Development of sensors for measuring gases of meteorological importance — notably oxides of nitrogen and ozone.

Cost	:	0.8 MECU
Time-scale	:	12–18 months
Participants	:	Finland, UK and interest expressed by Spain
Ref	:	EU46

Production of artificial seeds

Development and production of artificial tomato seeds.

Cost	:	3.3 MECU
Time-scale	:	5 years
Participants	:	France, Switzerland and interest expressed by UK
Ref	:	EU100

Microbiological supplements

Microbiological replacements for growth promoters in animal feed.

Cost	:	Not yet determined
Time-scale	:	3 years
Participants	:	Sweden
Ref	:	EU70

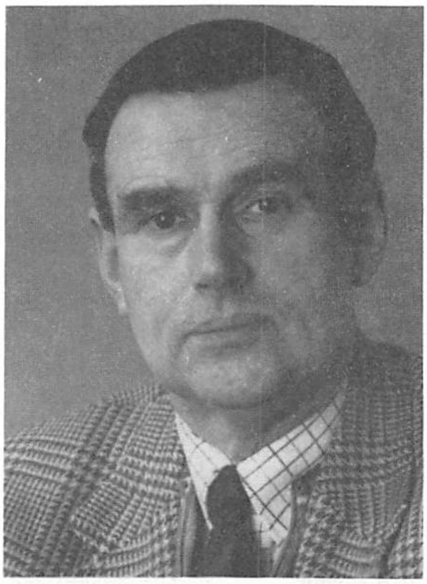
Use of new materials in the construction of semi-trailers

Development of maxi-code semi-trailers constructed of composite materials.

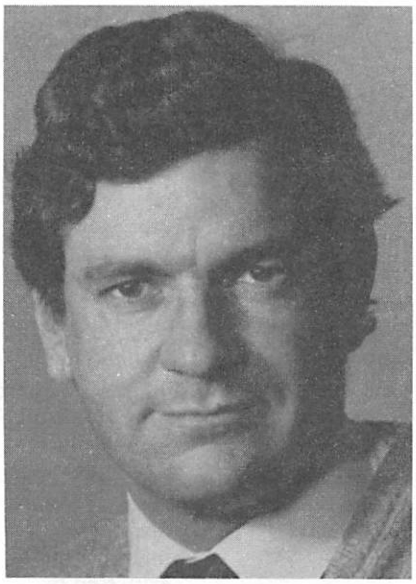
Cost	:	26 MECU
Time-scale	:	3 years
Participants	:	Belgium, France and UK
Ref	:	EU80

Rotary Implement (the "Sturplow")

D MacIntyre, M J Sharp and A G Gray



Duncan MacIntyre



Malcolm Sharp

1 Introduction

FOLLOWING public concern on straw burning in 1983–4, development work was undertaken on the design of an implement to incorporate straw and trash, as well as to act as a general purpose tillage tool with a low power requirement and to have the ability to produce a good tilth.

The design was different from the straw incorporation implement produced by the AFRC Institute of Engineering Research (Patterson 1985) because the SIAE design was developed to provide a more general purpose cultivation capability (it is a pto driven rather than a draft tool) and also there were rather different soil and weather conditions in Northern Britain compared with the South (Pascal *et al* 1985).

2 Description of SIAE prototype cultivator

The implement (fig 1) consisted of three or four tined rotors, axially angled at 13° to the direction of travel. These cultivated the soil, simultaneously mixing chopped straw throughout the cultivated depth (20–25 cm). Each rotor was only slightly staggered behind the adjacent one working in front of it and each covered a working width of 53 cm. Thus the rearward overhang of this mounted implement when lifted, was much reduced compared with a mouldboard plough of the same working width. An 'A' blade share was mounted in front of each rotor to initially "bust" the soil. Subsequent to its initial trials the implement is now being manufactured and marketed by Falcon Farm Machinery Ltd of Stafford under the trade name of the "Sturplow" (fig 2).

Duncan MacIntyre recently retired from the Scottish Institute of Agricultural Engineering, Penicuik, Midlothian; Malcolm Sharp is in the Marketing Dept of the Scottish Centre of Agricultural Engineering, East of Scotland College of Agriculture, Edinburgh, and Alistair Gray is a financial adviser with Abbey Life, Edinburgh.

3 Details of tests to evaluate performance of straw incorporation methods

The performance of the new implement was compared with six other cultivation implements (table 1) at two sites near SIAE. At Site 1, winter barley was grown on a sandy loam (Darvel series) and at Site 2, winter wheat was grown on a clay loam (Winton series).

An attempt was made to evaluate quantitatively the degree of straw/soil mixing obtained with the different tillage treatments.

Numerous soil profiles were exposed in the field and were photographed. Subsequently a video camera was used in the laboratory to scan the photographs. A program developed for a microcomputer enabled the recorded information to be digitised and a scoring system was then applied to assess both the quantity and the distribution of straw within the soil profile down to cultivation depth (Rackham and Sharp 1986). However, results were very variable, even between replicates of the same treatment, so no figures have been quoted. However, visual comparison of the profiles and the photographs provided information on the effectiveness of the treatments.

Table 1 Details of treatments

Treatment No.	*Straw disposal method*	*Implement*
1	Removed	Mouldboard plough with skims (control)
2	Chopped and spread	Mouldboard plough with skims
3*	Chopped and spread	Mouldboard plough with trash boards
4	Chopped and spread	Tine/disc cultivator
5	Chopped and spread	Spike tine rotary cultivator
6	Chopped and spread	Rotadigger
7	Chopped and spread	SIAE prototype implement

* *Treatment 3 omitted at Site 1*

Fig 1 SIAE prototype in work

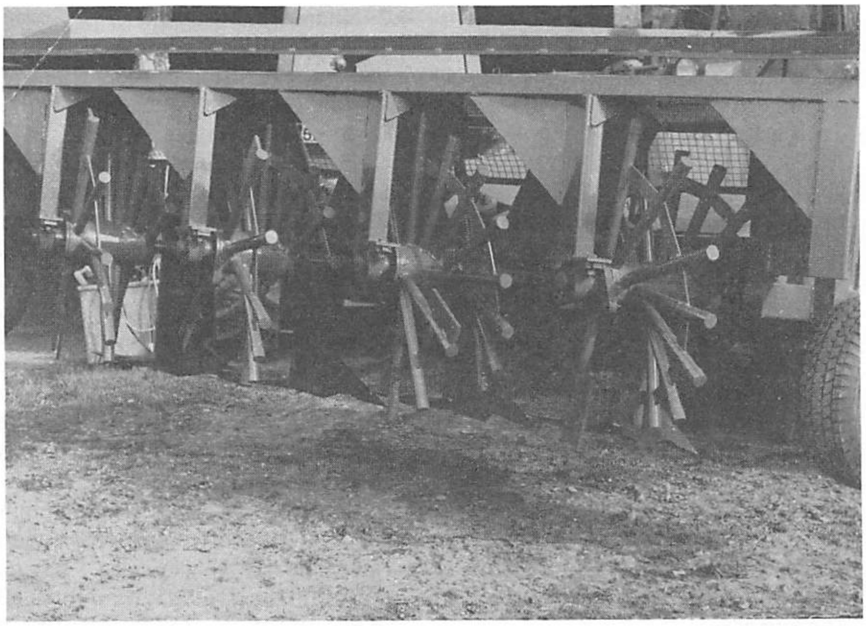


Fig 2 Pre-production prototype manufactured by Falcon Farm Machinery Ltd with rear guard removed to show tines and rear rotors

4 Results of trials

4.1 Observations on cultivation and straw incorporation

The cultivation and straw incorporation effects were similar at both sites:

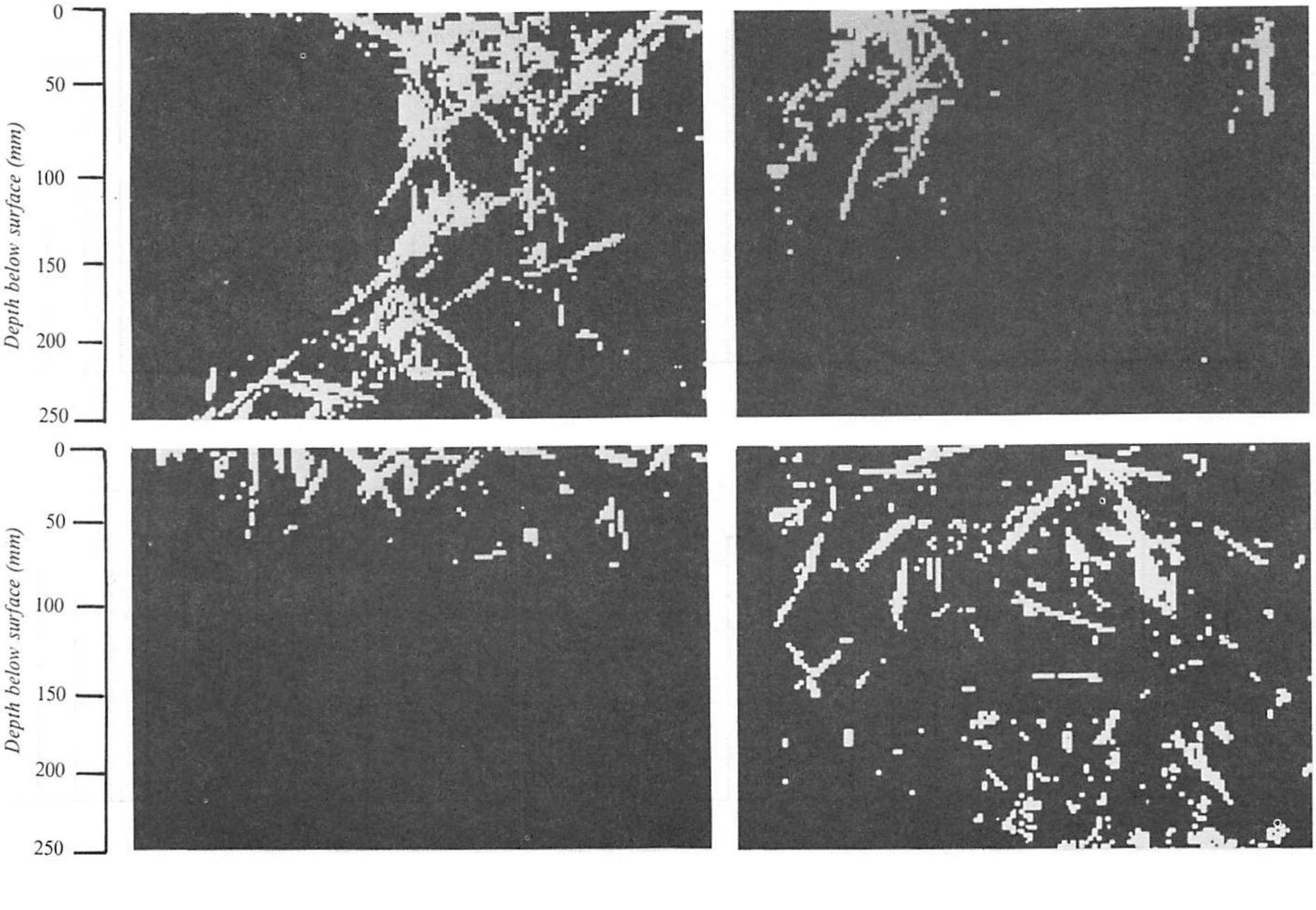
Treatment 1 (plough, straw removed). There was little straw to bury and a broken furrow with a clean soil surface was left.

Treatment 2 (plough with skims). The straw was buried to the depth of ploughing and between the furrow slices. A broken furrow with a clean soil surface was left.

Treatment 3 (plough and trash boards). The straw was buried to the depth of ploughing and partially between furrow slices. A broken furrow was left with a few wisps of straw visible on the surface.

Treatment 4 (tine/disc cultivator). Some straw was buried and some mixed in the top layers of soil but about 25% was still visible. The

Fig 3 Computer printout of digitised data on distribution of straw after incorporation by mouldboard plough with skims (top left), disc/tine cultivator (top right), spike tine rotary cultivator (bottom left) and SIAE prototype implement (bottom right)



land was left in a series of small ridges comprising a mixture of straw and soil. Some seedbed tilth was made.

Treatment 5 (rotary cultivator). About 50% of the straw was still visible after cultivation. The straw that had been incorporated was only mixed in the topmost layer of soil. A shallow tilth was prepared.

Treatment 6 (Rotadigger) The straw was well mixed with the soil down to the cultivation depth. A coarse tilth was produced with a little straw still visible on the surface.

Treatment 7 (SIAE prototype). The straw was well mixed with the soil down to plough depth. A medium tilth was produced with only a little straw still visible on the surface.

The distribution of straw within the cultivated layer following incorporation by the mouldboard plough with skims (treatment 2), the disc/tine cultivator (treatment 4), the spike tine rotary cultivator (treatment 5) and the SIAE prototype (treatment 7) is shown in fig 3.

4.2 Plant establishment

The establishment data for winter barley at Site 1 and winter wheat at Site 2 are shown in figures 4 (top) and 5 (top) respectively.

The highest plant establishment was obtained on the plots cultivated with the SIAE prototype implement at Site 1, although the differences between the treatments were not significant. However, at Site 2, statistically greater plant establishments ($P \leqslant 0.05$) were obtained from the plots of the Rotadigger compared with those of the mouldboard plough with skims and with trash boards; both the plots of the SIAE prototype implement and the tine/disc cultivator had significantly greater plant establishment ($P \leqslant 0.05$) than those of the mouldboard plough with trash boards.

4.3 Crop yields

The grain yields at Sites 1 and 2 are shown in figures 4 (bottom) and 5 (bottom) respectively.

Crop yields from the treatments at both sites were not statistically different ($P \leqslant 0.05$) and bore no correlation with plant establishment. At Site 1 the highest yields were from two of the mouldboard ploughing treatments, one with the straw removed. These yields were closely followed by the plots of the tine/disc implement and the SIAE prototype implement. At Site 2, the highest yield was from the rotary dug plots closely followed by those cultivated by the SIAE prototype implement.

Power requirements and work rates

Power consumption measurements were made of draft and pto requirement of the SIAE prototype implement working in a loam and in a sandy clay loam. Draft measurements were also made of a conventional 6-furrow mouldboard shallow plough in loam (the working width of the plough was similar to that of the SIAE prototype implement). Results of this work are given in table 2.

There was a slight reduction in draft of the SIAE prototype over a mouldboard plough at roughly the same work rate, but overall power

Fig 4 Effects of applied treatments on the establishment (top) and grain yield (bottom) of winter barley at Site 1

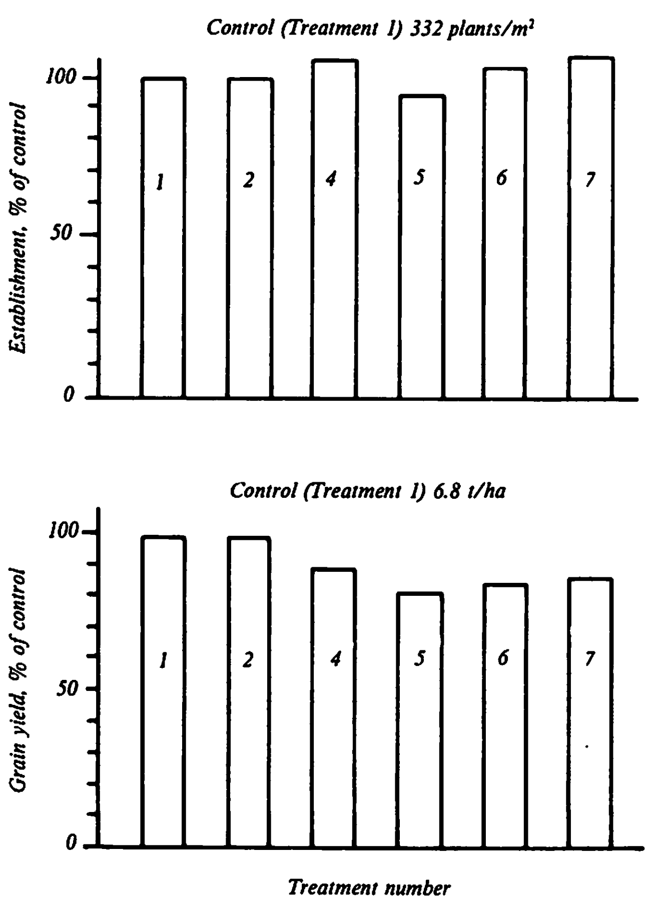


Fig 5 Effects of applied treatments on the establishment (top) and grain yield (bottom) of winter wheat at Site 2

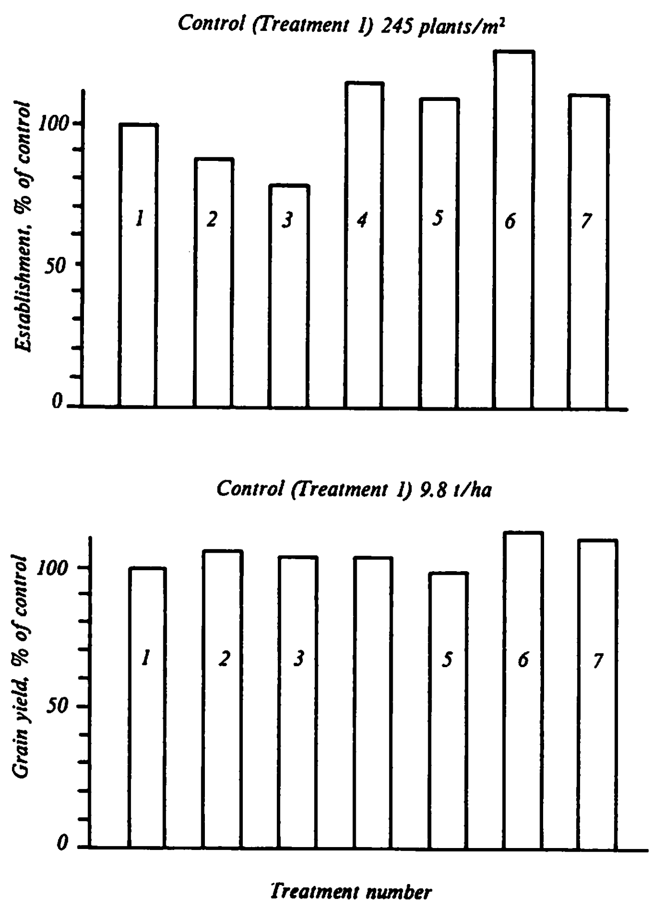


Table 2 Power consumption of SIAE prototype implement compared with mouldboard ploughing

Implement	*Soil type*	*Working width, m*	*Work rate, ha/h*	*Power consumption, kW*		
				draft	*pto*	*total*
M'board plough	Loam	2.40	0.83	28	nil	28
SIAE prototype	Loam	2.40	0.80	26	18	44
SIAE prototype	Sandy clay loam	2.40	0.75	28	20	48

was appreciably increased through the pto requirement. However, the work done to the soil was much greater than was the case with a plough and this was shown by the overall reduction in tractor fuel consumption of a cultivation system using the SIAE prototype implement for primary cultivation rather than a conventional plough or even tine/discing a burnt stubble, as shown in table 3 (Patterson 1987).

Discussion of results

Land preparation for cereal sowing by different cultivation treatments incorporating chopped straw, when assessed by crop yield results, cannot be conclusive with results from only one year. However, there are slight indications that in heavy land higher plant establishment is obtained by rotary digging, by the use of the SIAE prototype implement or by using a tine/disc implement. These experiments have not been running for sufficient time to suggest the long-term effects of different methods of straw incorporation. However, observations of the soil profiles from the different cultivation treatments do suggest that there is a much greater intimate mix of straw and soil from the SIAE prototype implement compared with mouldboard ploughs which bury straw in one position in the profile, and with shallow working implements that only incorporate the straw in the surface layers.

Although the power measurements of the machine indicate that it has a slightly reduced draft compared with a plough, overall power consumption is higher with the additional pto requirement. However, the greater amount of work done to the soil results in less fuel being required (i.e. less power) for an overall cultivation and sowing system using the SIAE prototype implement compared with operating a more traditional primary cultivation system.

Table 3 Tractor fuel consumption in tillage experiments for winter wheat on clay, 1986–7 (Patterson 1987)

Cultivation system	*Straw disposal method*	*Fuel consumption, l/ha*	
		Individual operations	*Total for system*
Plough	chopped	24.4	
Secondary cultivator (3)		16.0	
Drill, roll		6.9	47.3
Shallow plough	chopped	14.9	
Secondary cultivator (3)		15.7	
Drill, roll		6.5	37.1
Disc/tine (2)	carted	20.6	
Secondary cultivator (2)	burnt stubble	9.2	
Drill, roll		6.4	36.2
SIAE prototype	chopped	18.2	
Secondary cultivator (2)		10.6	
Drill, harrow		6.6	35.4

NB Bracketed figures refer to number of passes of the implement when greater than one

Acknowledgement

The help of the Scottish Crop Research Institute in providing land for the trials is gratefully acknowledged.

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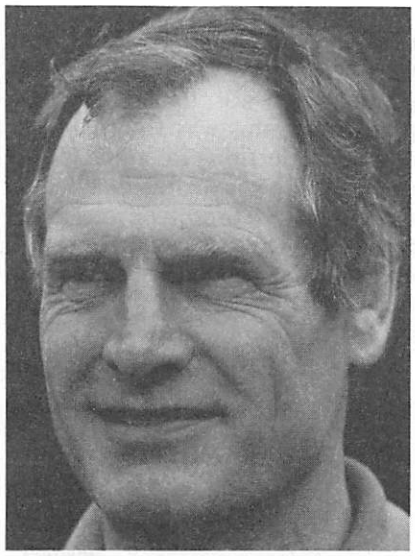
Trailed equipment stability on slopes: problems and solutions

G M Owen

Summary

THE stability of trailed equipment on slopes is often considerably less than that of the tractor. A trailer or spreader, for instance, can overturn and then pull the tractor over. This paper discusses and demonstrates methods of preventing the tractor overturning by simple changes in the design of trailed equipment.



1 Introduction

Many tractor overturning accidents are caused by the equipment trailed behind the tractor first overturning and then pulling the tractor over. Typical examples are loaded silage trailers, fertiliser spreaders and sprayers. A tractor alone can have improved stability by extending the wheel track or using dual wheels but trailers have fixed tracks and load generally increases the height of the centre of gravity and hence, reduces stability.

In a full scale study of the problem using a radio-controlled tractor and a trailer with a simulated load, the trailer stability limit working across the slope was 19°, and the tractor stability limit was 28° (Owen and Spencer 1981). It was found that the trailer caused the tractor to overturn even when the tractor track width was set to maximum. This was due to the overturning trailer transmitting both twist and lift to the rear of the tractor. If this twist and lift could be eliminated the trailer could overturn without overturning the tractor, and danger to the driver would be considerably reduced.

In a serious accident case, a loaded lime spreader overturned and started the tractor into a multiple roll even though the tractor was fitted with dual wheels (fig 1).

It was decided to investigate these problems, first using physical models of a trailed spreader and a four wheel trailer, and then using full scale equipment (Owen 1982).

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2 Tractor and trailer stability

Most types of trailer have a wide body such that, if the trailer overturns onto its side, the drawbar and hence the tractor hitch are lifted well clear of the ground. In addition, both the clevis and the ring types of hitch will twist the tractor. Even tractors with dual rear wheels or wide track settings can be pulled over and in such cases the probability of a multiple rollover is increased. A model tractor (fig 2) shown with and without dual wheels, demonstrates that dual or extended wheels can cause the tractor to continue to roll rather than stop on its side because the tractor with dual wheels is less stable on its side than that with the narrower wheel setting. Multiple roll overturning accidents are likely to be expensive and possibly fatal.

There are three ways in which the problem can be reduced:

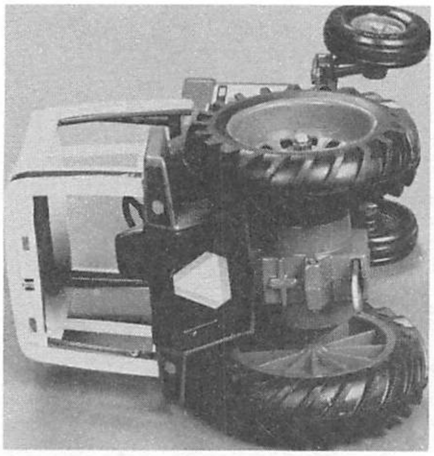
(a) increase the trailer wheel track,

(b) allow the trailer to overturn without pulling the tractor over,

or

(c) determine a safe operating slope limit for the equipment and observe the limit.

Fig 1 An actual multi-roll accident on a 25° cross slope where the spreader overturned and pulled the tractor over even though the tractor was fitted with dual wheels



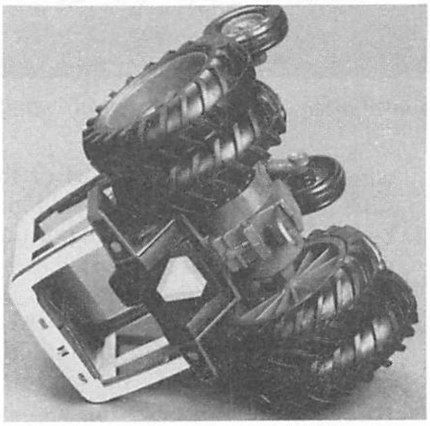


Fig 2 Tractor fitted with dual wheels will have greater tendency to multiple roll than that without dual wheels

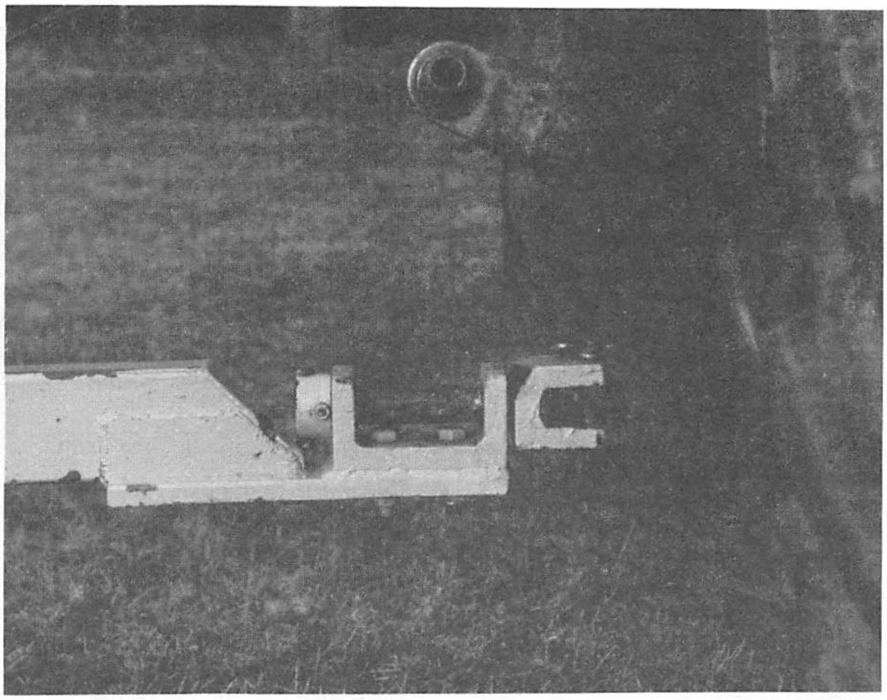


Fig 3 A swivel hitch

Increasing the trailer wheel track or making the wheel track adjustable is a practical proposition which manufacturers could implement; the new safe operating slope would still need to be determined. It is always good practice to measure rather than to guess the severity of a slope. Field slope values, once measured, are easy to remember and give the driver a sound objective comparison base for different situations. On the other hand, little is known about safe slopes for actual vehicles in working conditions. Current work at the Scottish Centre of Agricultural Engineering is beginning to show that the dynamic stability limit for some vehicles operating on slopes may be as little as half of the static stability limit.

It was decided to redesign the body shape and the hitch of a trailed fertiliser spreader in such a way that the spreader could not pull the tractor over when it overturned. In addition, the safe slope static limit for stability was measured using the weighpad method (Spencer *et al* 1985) for all load conditions prior to testing in previously measured side slopes. Thus, the driver had prior knowledge of the slope limit for his machine but, should that limit be exceeded, a serious overturn of the tractor would be avoided.

3 The modified spreader and hitch

3.1 The hitch

The clevis and the hook hitch are the commonest types in use with trailed equipment. Both types allow some free rotation of a spreader during normal working but only to a limited degree before locking and applying a rotational force to the rear of the tractor. A rotational force from this source was eliminated by fitting a swivel hitch (fig 3).

3.2 Spreader body shape

The tractor hitch height is typically 0.33m above the ground but the half-width of the spreader was 0.8 m; therefore when the spreader rolled onto its side, the spreader drawbar lifted and forced the rear of the tractor up, shown with models in fig 4, and the tractor overturns. The spreader body was modified (fig 5), the sides were trimmed at an angle formed by the line from the drawbar pin to the outside leading edge of the spreader wheel. This gave the

Fig 4 Spreader overturns, and lifts the rear of the tractor

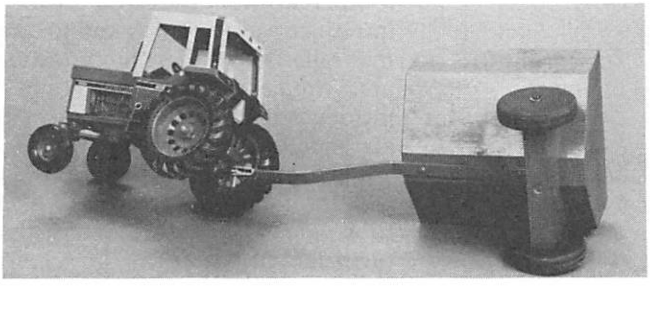
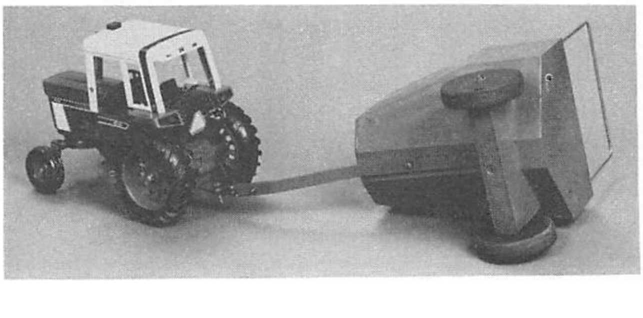


Fig 5 Modified spreader fitted with a swivel hitch overturned without pulling the tractor over



spreader a slightly conical appearance but enabled the spreader drawbar to remain at the same height irrespective of spreader attitude. The loss in spreader capacity could be made up by elongating the full-size body approximately 40 cm. To ensure that the spreader overturn is limited to 90° (on its side), an anti-roll bar could be fitted to the rear of the spreader.

3.3 Full-scale trials
Similar modifications to the full-size spreader allowed it to be overturned without affecting the tractor (fig 6). The modified spreader has been used on many occasions both in research work and at demonstrations (fig 7). During an overturn the load is lost, stability is improved and the tractor may be unhitched and used to recover the spreader. The technique may be applied to any trailed equipment but it is important to realise that both the rotating hitch and the modified shape must be introduced to eliminate first the twist and then the lift imparted to the tractor by the less stable trailer.

However, if an operator wishes to be certain that his equipment and working method are safe by preventing an overturn of all or part of his equipment, he must know the working stability limits and the slope of the land on which he happens to be driving.

4 Four wheel trailer stability

During the summer of 1981, a large four wheel trailer with a load of 280 bales of hay overturned on a 14° side slope. In this accident the tractor was not pulled over by the trailer, no one was injured and there was little damage. The trailer load remained intact, even after the overturn and thus helped to prevent the trailer overturning further than through 90°. It appeared, therefore, that this was an alternative design of trailer which could overturn without affecting the tractor.

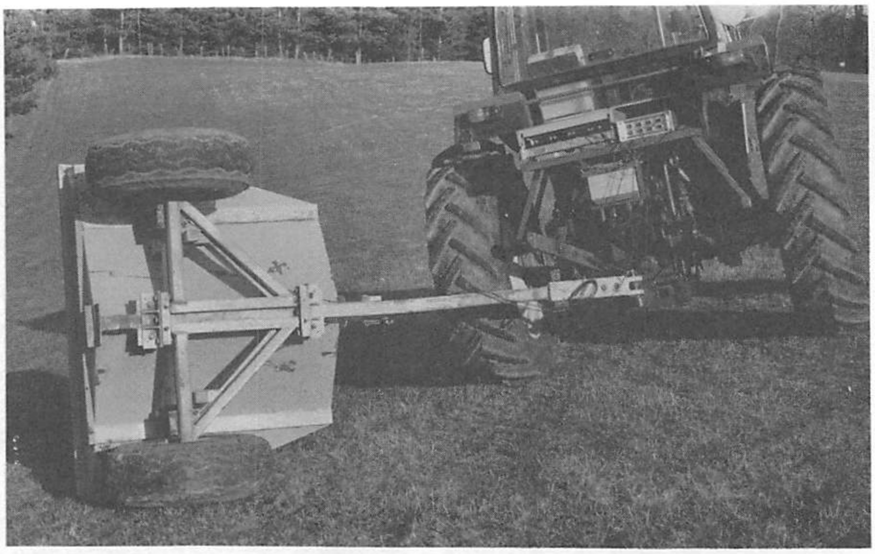


Fig 6 Full size modified spreader with a swivel hitch overturns without affecting the tractor

The trailer had been constructed by the workshop staff of a farm and was a close copy of a commercially available trailer. The front axle and turntable were arranged to give some weight transfer on to the tractor drawbar and the front wheel had a narrower track than the rear wheels; the model illustrates these features in figures 8 and 9. Thus, the front wheels were always inboard of the sides of the trailer and could not become trapped in any fixed position when the trailer overturned.

The trailer was examined after the accident and the driver interviewed. The driver maintained that as the trailer overturned the tractor remained stable and the only damage incurred was a slight twist of the trailer drawbar. The trailer was attached to the tractor by a clevis hitch but one bolt was missing from the clevis bracket allowing more rotational freedom than normal (a feature recommended by the tractor driver to increase the flexibility of a clevis hitch). This factor did allow the trailer to overturn without imparting sufficient twist to cause overturning problems to the tractor. Not only was there insufficient twist to cause problems but, because of the freedom allowed by the trailer turntable, no lift was imparted to the rear of the tractor, a very desirable feature in the design of such trailers for safer use on slopes.

Fig 7 The reshaped spreader with swivel hitch about to overturn but the tractor and driver are safe

5 Conclusions

Single axle or twin axle unbalanced trailed equipment such as spreaders, sprayers and trailers can be designed so that if they overturn they do so without pulling the tractor over. The modifications required are to introduce a swivel hitch and to taper the trailer body; these modifications are simple, cheap and can be introduced into new equipment by any manufacturer.

The four wheel balanced trailer with turntable is inherently less likely to cause a tractor to overturn than the balanced type.

It is recommended that manufacturers should design their equipment for safe use on slopes and to have the stability limit marked clearly on each machine for both loaded and unloaded conditions. All users of equipment on slopes should measure the slopes on their land.

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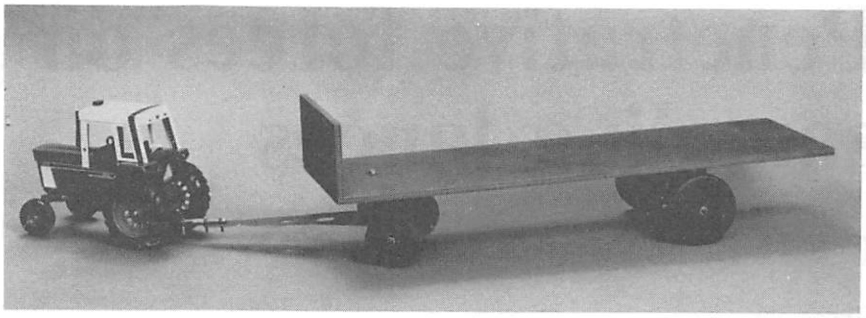
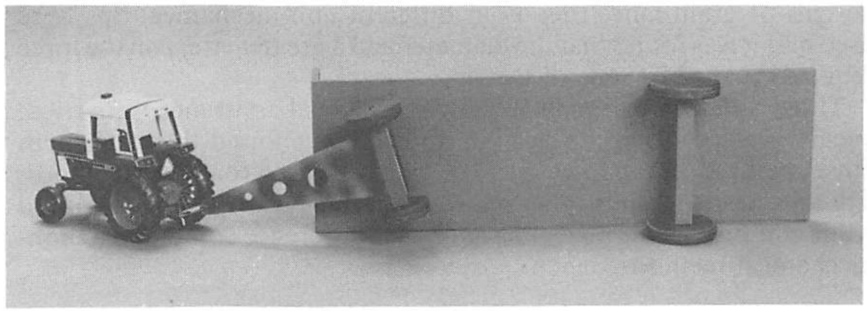


Fig 8 The four wheel trailer with weight transfer and swivel hitch

Fig 9 The four wheel trailer overturned without pulling the tractor over



Penetrative forces on grain sampling lances

C F H Bishop and D N Hardwick

Summary

MEASUREMENTS were carried out on the force required to penetrate bulk wheat to a depth of approximately 2 m using various designs of grain lance tips. Four different non-mechanical tips were used and it was found that the diameter had a greater effect on the force required than the shape of the tip.

Three different methods of using mechanical assistance were tried; vacuum, compressed air and vibration. It was found that a vacuum lance required less than 10% of the force required for other methods. The vibratory method also reduced the penetrative force required while compressed air made no significant difference compared to non-mechanical methods.

David Hardwick

Chris Bishop

1 Introduction

Grain sampling lances are used extensively for grain store management as they are the most effective way of obtaining representative samples of grain from throughout the depth of crop in store without having to disturb the grain bulk.

There are huge quantities of grain stored throughout the world and frequent checking is of the utmost importance if the maximum value of the stored crop is to be obtained. Lances are used to take samples by grain dealers to analyse the quality of the crop and by store managers to monitor the effect that drying is having through the depth of the crop.

The effort required to force a lance into the grain is often one of the main factors limiting the number of samples taken, which in turn restricts the efficiency of management of grain store.

Little work has been carried out on the forces acting on a grain lance. The objectives of this investigation were to measure the tip forces and to evaluate the various ways of reducing the force required for penetration by the use of various forms of power assistance. Nine different tips, some with power assistance, were evaluated.

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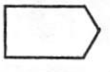
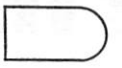
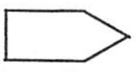
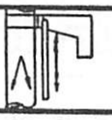
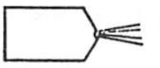
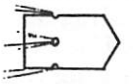
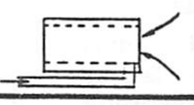
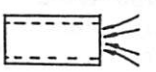
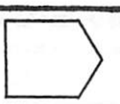
2 Test Method

The types of points used are shown in fig. 1 together with their diameters and tip angles where relevant.

The probe was manually or mechanically pushed to the depth for measurement. A downward force was then applied to the lance and was measured by means of a spring balance on a sliding arm. The equipment used is illustrated in fig. 2. The test was repeated 14 times between depths of 0.4 m and 1.6 m at 0.2 m steps for each tip and to a greater depth for the vacuum, sharp and blunt tips.

Fig 1 Summary of lance tip characteristics

			Tip Diameter (mm)
TIP 1		BLUNT TIP (30°)	27
TIP 2		ROUNDED TIP	27
TIP 3		SHARP TIP (60°)	27
TIP 4		JIG SAW (VIBRATION)	27
TIP 5		SINGLE HOLE COMPRESSED AIR	27 (1 Hole 2 mm)
TIP 6		MULTI HOLE COMPRESSED AIR	27 (4 Holes 2 mm)
TIP 7		VACUUM TIP PLUS AIR SUPPLY	27 (Hole 13 mm)
TIP 8		VACUUM TIP NO AIR SUPPLY	27 (Hole 13 mm)
TIP 9		ENLARGED TIP (30°)	34

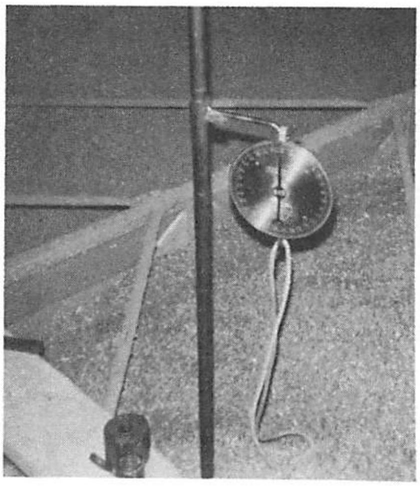


Fig 2 General view of the equipment used for testing lances

Table 1 Mean penetrative force (N) required for non-mechanical tips

	Depth, m										
Tip type	0.4	0.6	0.8	1.0	1.2	1.4	1.6	2.0	2.4	2.6	3.0
Blunt tip	39	77	102	128	162	196	234	330	430	488	570
Round tip	27	73	106	140	184	216	267	—	—	—	—
Sharp tip	28	69	103	131	170	203	247	370	440	520	650
Enlarged tip	63	133	178	223	272	—	—	—	—	—	—

Table 2 Mean penetrative force (N) required for mechanical tips

	Depth, m									
Tip type	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2
Jig saw	7	44	70	94	113	139	168	—	—	—
Single hole compressed air	45	83	104	134	163	198	243	—	—	—
Multi hole compressed air	36	79	98	125	156	192	237	—	—	—
Vacuum plus air supply	0	0	0	0	0	8	22	41	54	68
Vacuum without air supply	0	0	0	0	0	10	22	36	49	62

The three mechanical systems used were as follows:

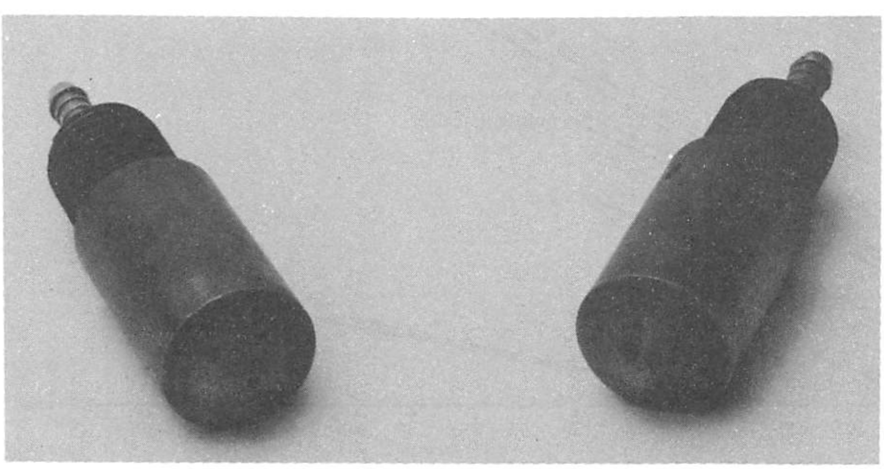
(i) Vacuum tip
The vacuum tip works by sucking the grain from the lance tip in a continuous stream. A hollow tip was made with an entry point tapped into it to allow a comparison of using air extracted locally from within the grain and that supplied from the surface. The equipment was operated with a domestic vacuum cleaner. A commercially available vacuum lance is available at a cost in excess of £1000.

(ii) Compressed air tip
To try and reduce the force between the lance tip and the grain a cushion of compressed air was used. Two tips shown in fig 3 were tried: one with a single hole blowing air downward and the second with four holes equally spaced around the diameter which directed air back along the lance towards the surface.

(iii) Jig saw
One method of force reduction considered was the vibration of the lance as it was penetrating the grain heap. A standard Black and Decker jig saw was used with the blade replaced by a 200 mm length of 6 mm thick bar. The jig saw produced a vibration with an amplitude of 7.5 mm and a frequency of 40 Hz. It was attached to the top of the lance by the method shown in fig 1.

The trials were all carried out in the same grain bin of winter wheat (var Avalon) which had a 14.25% moisture content (wet basis). The grain was not disturbed during the course of the experiments. The same lance/rod was used for all the trials with only the tips being changed.

Fig 3 Tips designed for use with compressed air



3 Results of trial

The results for the non-mechanical and mechanical tips are given in tables 1 and 2 respectively (Hardwick 1987). A force of 300 N was found to be the maximum that reasonably could be applied by one person manually; for greater forces than this two people were needed.

A graph of the results is given in fig 5 which shows a linear relationship between depth and force required.

3.1 Non-mechanical tips

For the non-mechanical tips as shown in fig 6, the tip shape does effect the force required for penetration. However this difference, although statistically significant, was relatively small in comparison with the total force measured.

At shallow depths the rounded and sharp tips required less force than the blunt tip, the most commonly used. However, as the sampling depth increased, the blunt tip required least force. It is thought that as the blunt shape approximated to the angle of repose of wheat, the shearing force required to pass through the bulk grain was minimised.

As the penetration forces needed for the various tip shapes were similar, differences in the cross sectional area were investigated. A tip was made with the same angle (30°) but with twice the cross sectional area. A much greater force was then required for penetration

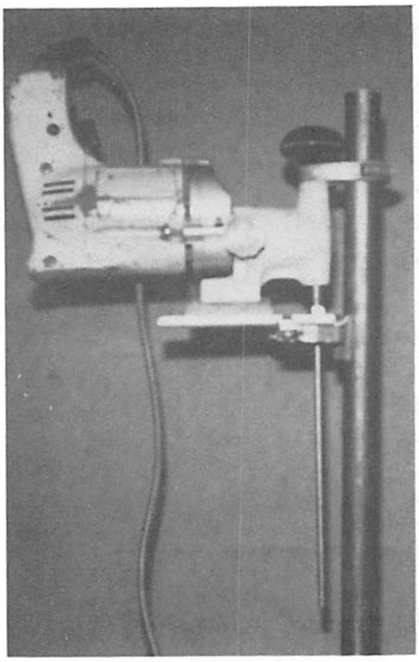


Fig 4 Jig saw attachment to cause vibration of lance tip

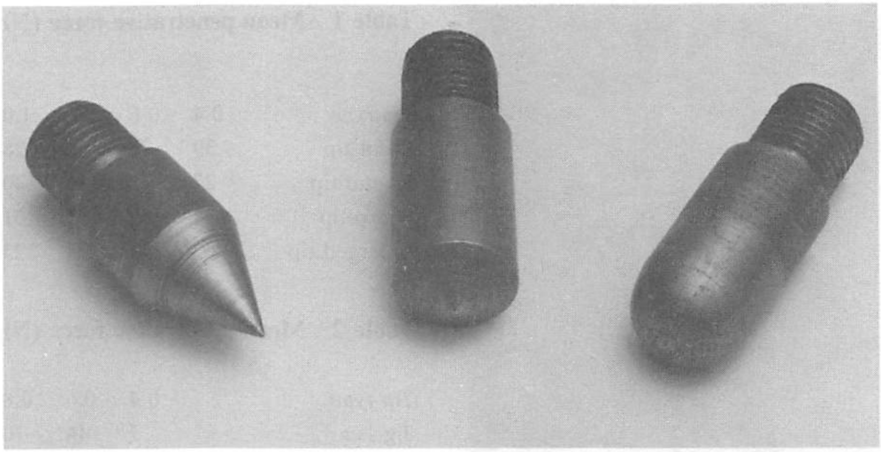


Fig 6 Sharp, blunt and rounded tips for non-mechanical lance

because the individual grains immediately below the tip at any depth require more lateral movement and there are more of them under a wider tip. The results show that the size of the cross section of the tip has a much greater influence on the force required to pentrate the grain than the angle of the tip.

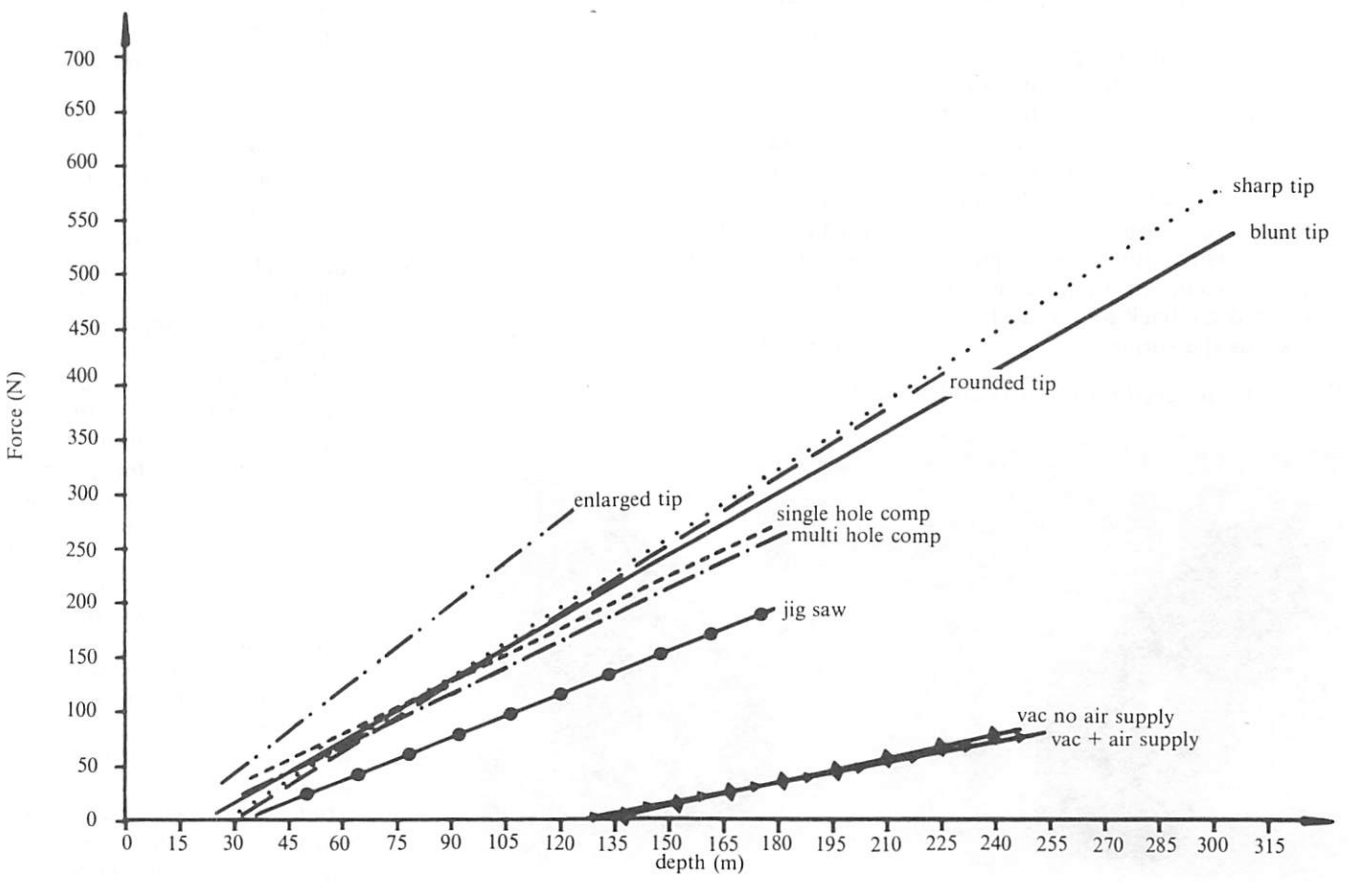
3.2 Mechanical tips

The vacuum tip required considerably less force than any of the other tips which were considered. There was no significant difference at any depth between the two methods used whereby the air was either extracted from the surrounding interstitial gaps to the lance tip or where supplementary air was provided from the surface through a separate pipe. The vacuum method takes a continuous sample from all depths, providing a core of grain. In some cases this could be useful but it is difficult to identify a problem at a specific depth such as over- or under-drying. Moreover the vacuum method needs a vacuum pump which is not always available.

Compressed air tips did not give very promising results and required similar if not slightly more force than the non-mechanical methods.

A jig saw fitted to the lance to give a vibratory effect reduced the penetrating force required by

Fig 5 Mean penetration force in relation to depth of grain



10–18%. This device gave the lowest figures for a discrete sampling method and would seem to be a good "add on" to a lance for shallow bin sampling. It is assumed that the advantage of the force reduction would decrease with depth as the vibration exciter became more distant from the lance tip, but this was not shown to occur at depths down to 1.6 m.

3.3 Statistical results

For each tip tested, a total of 98 readings were taken to obtain representative mean forces. To make full use of the data it was decided that an analysis of variance (ANOVA) should be carried out to evaluate significant differences between;

a) the different tips

b) each test for that tip (ie variations in bulk)

Two ANOVA tests were conducted, one on the two vacuum tips (which had much lower force requirement than the others) and the second one on the remaining tips excluding the enlarged one.

A computer program was designed specifically to handle this data and was based on an ANOVA method by Chatfield (1985).

The results from the ANOVA in addition to showing the degree of significance between different tips, also indicated that the precautions taken when positioning the lance in the bin were adequate. There was a significant difference ($P \leqslant 0.05$) between all treatments at all depths except between the two vacuum methods.

4. Conclusions

4.1 The most significant factor affecting the force on and the penetration of a lance in grain is the tip diameter or cross-sectional area and the actual shape is of secondary importance.

4.2 The vacuum lance provided a major reduction in the force needed for penetration and was the only one which could be easily used at depths of more than 2 m, although its cost is significantly more than other methods.

4.3 The use of compressed air did not reduce the force of penetration.

4.4 Vibration of the lance reduces the force required for penetration. Further work is necessary to investigate the optimum amplitude and frequency of vibration and the maximum depth to which force reduction can be obtained.

4.4 As only the penetrative forces required were considered in this investigation, further work should be carried out on side and frictional forces acting on the lance.

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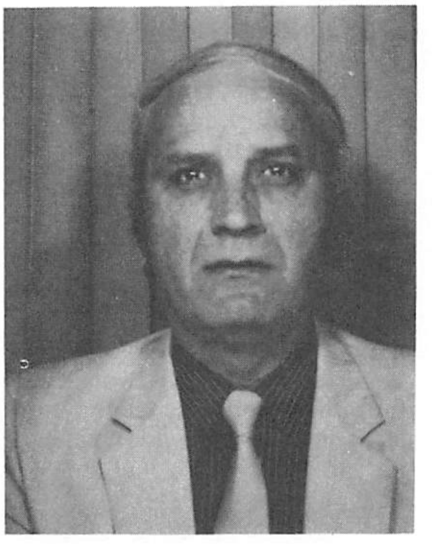
Grain drier fires — their cause and prevention

J-C Lasseran

Summary

THE causes and prevention of fires in grain driers are discussed with particular reference to large continuous-flow driers used for drying maize and sunflower seeds. The main cause of fires appears to be the ignition of accumulated grain and trash by incandescent particles from the burners. Spontaneous combustion is not a prime cause of fires but may occur in dry material subjected to heat from an existing fire. Outbreaks can be minimised by pre-cleaning the wet grain, by regular cleaning of the drier, and by the fitting of fire detection alarms. Measures for dealing with a fire are described.



Introduction

Every year outbreaks of fire in drying installations occur in consistently high numbers. Material damage to the drier column is considerable and the grain is often lost. Furthermore, shut-down or disorganisation of the drying process involves operating losses, particularly when fire occurs at the start of the season.

In France during the 1984 drying season, the head office of one insurance friendly society recorded 20 serious outbreaks, in 10 of which the damages exceeded one million francs. It is expected that in the near future, the insurance companies (friendly societies or private companies) will be obliged to adjust premiums as a function of fire detection and protection systems installed for driers, and to incorporate exemptions which could represent up to 20% of the compensation.

Sunflower seeds, production of which continues to increase, and maize are the two materials which, in equal proportions, have incurred the heaviest losses.

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The purpose of this article is to give practical advice on fire protection systems to drier operators, to indicate the types of equipment which appear most suitable, and to recommend the procedure to be followed in the event of fire.

No particular brand of drier can be implicated more than any other. Fires have occurred in all makes. Driers with direct heating appear to be the most vulnerable: however, fires have also occurred in driers equipped with heat exchangers. The type of fuel used also cannot be implicated. Recorded fires apply equally to oil and gas-fired driers. Recently installed driers are just as vulnerable as older equipment. Sunflower seed and sorghum are without doubt the most dangerous materials subjected to the drying process. Oil seeds constitute a hazard because of the gases released during drying (volatile fatty acids). Maize, however, is responsible for most damage because of the tonnage handled. Most fires occur in the period from October to December, ie the maize drying season. Outbreaks with serious consequences often occur at night, or at the end of the day between 8 pm and 10 pm. Frequency of fires is related to harvesting conditions; paradoxically, the number of fires is much greater in a wet year than in an average year. Wet crops contain more of the heavier trash (stalks, stems, cobs), which should be removed by the appropriate equipment before drying, but which is often loaded into the drier columns with the consequent risk of blockages.

2 Cause, spread and factors conducive to fires

The cause of fire, the point where the outbreak starts, generally appears to be incandescent vegetable or metallic particles from the hot air generator(s) coming into contact with a mass of over-dried grain or trash in a zone where the column is over-heated or where there is a blockage.

Generally the fire starts inside the column and less frequently in the dust filtration system, down-line from the drier.

Fire spreads very quickly because of the presence of a large quantity of more or less dry vegetable matter mixed with dust and trash and a considerable air flow (supply of oxygen). The metal sheets and air ducts comprising the column become distorted as a result of the heat given off.

Functional defects which seem to precede and propogate fires more often than not are as follows:

(a) Blockage of grain and dust at some locations in the column by heavier trash or foreign bodies; these deposits are exposed for a long time to the ambient heat and becoming completely dehydrated, can readily burst into flame on contact with an incandescent particle. Blockages can also occur when driers are operated in "static mode", or when they are shut down for too long (more than 24 hours), with the column not emptied.

(b) Faulty burner functioning, for example running the burner with ineffective atomisation, and sudden outbreak of fire in the burner. Overheating because of failure of temperature regulation or faulty setting by the operator (eg 200°C instead of 120°C).

(c) Excessive variation in temperature of the hot air flow through the grain, as a result of unsatisfactory mixing of the air flows, or an incorrectly located temperature probe; variations of 30 to 50°C relative to a threshold setting of 150°C have frequently been found.

(d) Aspirations through the air intakes of dust or dry trash which may burst into flame on contact with the heat exchanger walls, or on contact with the burner flame in direct heating mode.

(e) Molten metallic debris can ignite dust and trash (hence the requirement of regular burner maintenance, particularly for direct heating). Such debris may arise from the deterioration of the drier combustion chamber or gas burners through excessive rusting. With indirect heating, if the heat exchanger is holed, there may be direct contact between the aspirated air and the burner flame. The incandescent particles from the combustion chamber or the damaged heat exchanger are then introduced into the column.

(f) Drying grain which is fermenting and giving off readily inflammable alcohol or volatile fatty acids (hence the advice to dry crops freshly harvested and to avoid any procedure involving unsuitable preliminary storage over a long period).

(g) Carrying out welding operations without shutting off the installation.

(h) Grain feed failure, leading to the emptying of the drying chamber.

3 Spontaneous combustion — fact or fiction

Some unexplained fires have been attributed to spontaneous combustion of the grain during drying. Laboratory tests have been undertaken by ITCF to try and prove the existence of this phenomenon. As a preliminary test, a mixture of maize grains and trash (pieces of stalk and stems) was placed in an airtight metal box of 1 dm^3, which in turn was placed in an oven with temperature adjustable to within 1°C. A copper pipe was used to remove the pyrolysis gases, which were trapped first in water, then in hexane. The presence and analysis of the results of decomposition was effected by chromatography in the gas phase. The threshold temperature for pyrolysis to commence is 155°C. At 200°C, separation is intense. The constituents produced are very numerous; methanol, ethanol, acetic acide, butanol and many other organic compounds, all readily inflammable, were found, but ignition did not take place in the test container.

A second test using a mineral furnace revealed that the grain ignition point was of the order of 750°C, but it is probable that this is much lower for some trash mixed with the maize (pink follicles particularly). From these tests, admittedly incomplete, and other surveys that have been conducted, we draw the following conclusions:

The grain being dried, even at high temperature, does not overheat seriously until it reaches a dryness verging on an anhydrous condition; such conditions occur in the drier at points of blockage or clogging. Hence the importance of pre-cleaning the damp grain before loading it into the drier.

Pyrolytic decomposition releasing combustible substances occurs only above 155°C; consequently, driers operating at temperatures from 140–150°C should be designed to supply hot air at a perfectly uniform temperature.

Spontaneous combustion of the grain does not need to be considered as a prime cause of fires, but rather as the consequence of a thermal decomposition condition of the grain in the presence of a source of fire.

The source of fire is latent, or quasi permanent, in hot air generators with direct heating, of the "mixer" type; it may become so in heat exchanger generators in poor condition or if fouled. Only indirect heating by steam batteries or thermal fluid system (a quite rare heating method) can eliminate this source. Consequently, fires can only be avoided by using a good protection system.

4 Fire precautions

Fire precautions for driers are based on three principles; action to be taken before and during the drying season to render installations less vulnerable to sources of fire, detection equipment to be installed, and procedure to be followed in the event of fire to restrict damage to the drier columns and the grain.

4.1 Measures to take before and during the drying season

4.1.1 Equipment cleaning and maintenance

Thoroughly clean the driers, ie remove all dust, trash and accumulations of grain remaining in the columns.

Clean the air intake and circulation ducting. To perform these operations correctly, it is sometimes necessary to carry out work or modifications to improve accessibility to the various parts of the driers, particularly on some old models. Make provision for an access door at each level; an operator should be able to reach the presumed area of the fire outbreak in less than two minutes.

Pay particular attention to the air filtering system, the filters and the dust collection chambers.

Arrange for a specialist to check the drier's overall functioning, burner tuning and the fan system.

If necessary, increase the number of threshold temperature probes in the drier, particularly on the moist air exhaust face and between the two air ducts for economiser driers operating in air recycling mode.

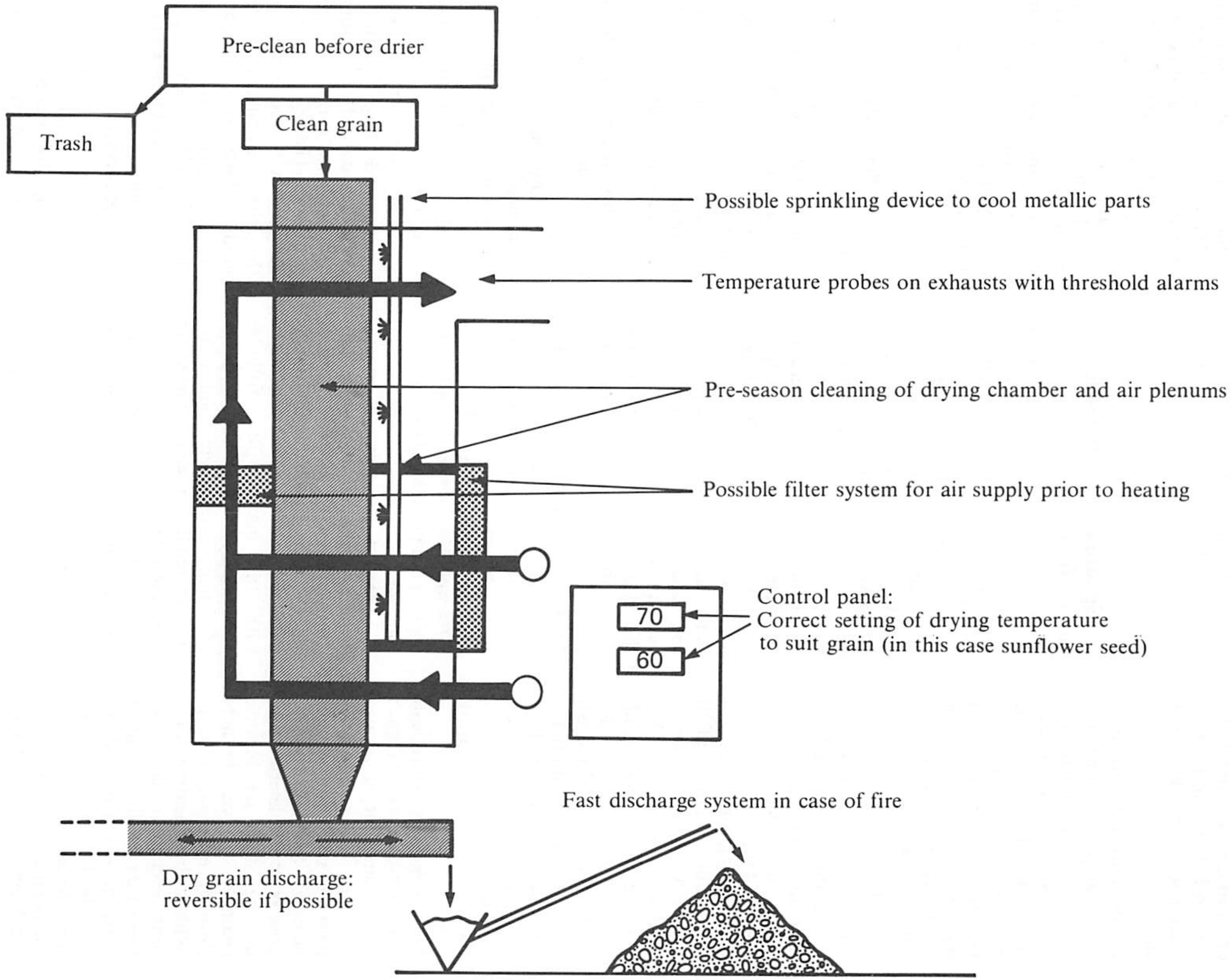

Fig 1 Fire safety on a grain drier

Connect the threshold probes to luminous indicators or audible alarms, setting them at 15°C above the normal operating temperature.

Check the condition of metal components for corrosion, particularly the condition of the combustion chamber of the heat exchanger in indirect heater systems, the burner walls and the burner itself in direct heaters. Brush clean the burner and combustion chamber walls and remove the dust resulting from this operation.

Every year check the electrical installations and ensure that they are fully protected.

If not already present, install equipment (shutters, doors, plastic bags) which allows blanking off of the fan air intakes and the drier column to avoid the "chimney effect" which assists the spread of fire.

4.1.2 Installation of equipment for pre-cleaning undried grain

Cleanness of the grain at the drier intake is very important. A pre-cleaner with a capacity considerably in excess of the grain throughput in the drier must be installed upstream of the drier(s), to avoid blockages in the latter. Provision should be made for trash discharge using pipework of adequate dimensions.

4.1.3 Safety precautions during the season

Constant surveillance during operation; never allow an installation to function without an operator in charge.

As far as possible, avoid overloading the drier and handling equipment, above all with fermented material.

Check that protection equipment such as thermostats, photo-electric cells and level switches are in good order.

In the event of work involving the use of torches, grinders and welding sets, shut down the drier and comply with any supplied fire precaution instructions.

Empty the dust collection equipment regularly. Do not wait until it is full before doing this.

4.2 Fire detection equipment

Apart from the afore-mentioned installation of thermal probes with threshold setting and alarm, driers can be fitted with various specific fire detection equipment.

4.2.1 Smoke detectors

These comprise a stannic dioxide semi-conductor sensor, sensitive to gaseous compounds containing carbon (CO, CO_2 in particular) located in an exhaust air duct and connected to an electronic control panel. They trip the luminous indicators and audible warnings in the event of fire. Sensors must be located in an area which is not too humid, as functioning can be hampered by condensation.

4.2.2 Thermal detectors

These detectors are sensitive to a rise in temperature of the air close to the fire zone. Two models use an electric signal:

The first detects the variation in impedence of a cable placed on the exhaust air outlet face. The second detects the short circuit between metal conductors in a twisted plastic cable upon melting at 80°C.

There is also a system in which a nylon thread is stretched across the zone to be protected and which breaks and triggers an alarm when temperature exceeds 80 or 120°C.

Smoke detectors seem better suited for the protection of driers, and have been widely adopted fairly quickly on new or modified installations. However, in some circumstances these detectors can cause false alarms which inconvenience the operator; for example, due to incorrect burner setting, or when drying fermented grain (where both cases, carbon molecules are given off). It is therefore essential to check the "false" alarm by a rise in temperature signalled by a threshold probe, particularly that located in the exhaust air duct.

4.3 Procedure to be followed in case of fire

As soon as fire is detected in a drier (smell of burnt material, tripping of audible and visual alarms) prompt action is essential to prevent the fire spreading.

Shut off upstream and downstream handling systems, hot air generators and fans; *never leave the ventilation system running, thinking that this will help to cool the drier.*

Blank off all air intakes, load undried grain into the handling system upstream of the drier to restrict the flow of oxygen to the outbreak. If the handling systems and site layout permit, quickly empty the column by *discharging the grain outside,* preferably to an empty silo, using the available means (extinguishers and fire hoses) to extinguish the glowing material during this process. If this facility does not exist, it should be installed on large drying plants. Prompt action is vital for saving the equipment and personnel should be trained to this effect. If such action is unsucessful, the fire brigade will have to be called in, but this will result in major damage and a protracted shut down of the installation with consequent operating losses.

Semi-automatic extinguisher systems injecting extinguishing products such as nitrogen, carbon dioxide or water into the column or lateral plenums, are already available. The "sprinkler" system, in particular, comprising a water feed system with spray nozzles, from a "dry column" is located in the exhaust air plenum, to cool the column structure and walls. In this case, a compressor (4 bars), or a water tank at the top of the silo is required.

To sum up, fire protection and fire fighting systems are shown in fig 1.

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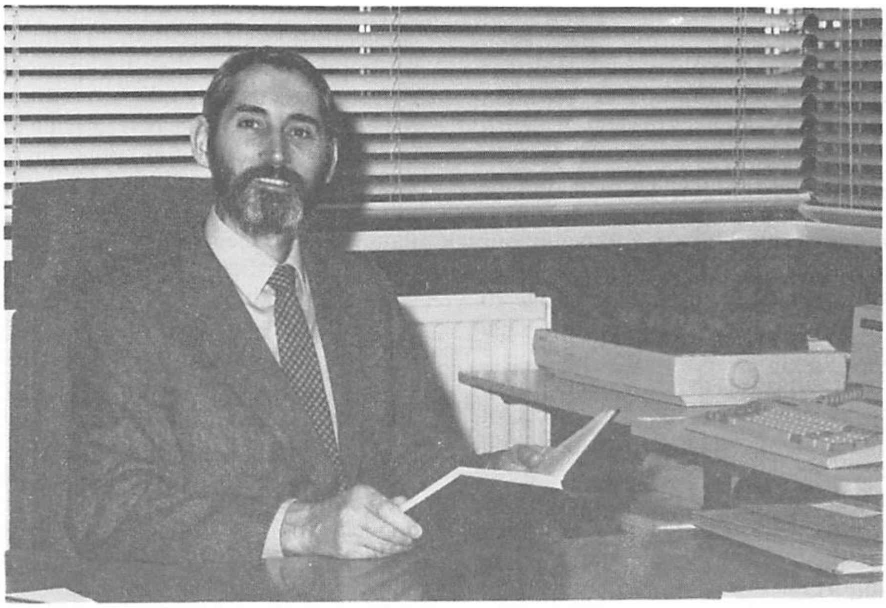
The environmental requirements of livestock

J M Bruce

1 Introduction

THE main reason for providing livestock with buildings is to create an environment so as to make efficient use of their biological potential for productivity. In this paper I have discussed some important aspects of the environmental requirements of livestock. This is not a strongly technical paper; I have avoided, where possible, mathematical development and formulae. Instead, I have used words to try to describe and discuss certain key areas. Following this line, and to enhance readability, I have not quoted references which are legion in this field. A bibliography, however, is given which will provide a sound introduction to the environmental requirements of livestock.

I have not seen it as within the scope of this paper to reproduce tables and graphs of data, and recommendations which exist in print already. The tenacious devotee will discover, for himself, an endless mosaic of published information.



2 Climatic environment

The understanding of the responses of livestock to the climatic environment has accelerated in the past decade. Mainly work has been aimed at the response in productivity. For the major types of livestock it is possible to estimate the effects of climate on the energetic efficiency of production. But much less is known about how climate affects protein deposition, carcase composition and the nutritional and eating quality of the product. If we consider the farm animal as a means of converting animal feed into food for humans and recognise that the process is affected by the climate to which the animal is exposed, then we see that there is still a long way to go before we can design and manage livestock buildings to achieve a desired response expressed in the context of human nutrition.

Much less is known about the health response of livestock to climatic factors. This area of research appears so difficult and expensive to work in that I suspect it has been deliberately avoided. Many people, however, remain convinced that climate and other environmental factors are powerful mediators in disease. The importance of ventilation rate, temperature (both high and low), humidity, noxious gases and dust are all believed to be important but there is little scientific substance to which we can point in order to claim understanding. The result, of course, is that farm building designers, rightly, have to fall back on anecdotal and traditional views. Business never waits for technology and technology never waits for science. It is a matter of history that understanding often succeeds rather than precedes action.

The effects of climatic factors on the welfare of livestock are also obscure. In passing we can recognise that health may be viewed as a subset of welfare but that the detection of disease has, in general, developed much more than the detection of other aspects of poor welfare. In the welfare code for pigs ranges of temperatures are offered as "appropriate" but the values quoted are derived from bioenergetic analysis of productivity and not from measures of welfare. I am not sniping at an easy target. I am illustrating the lack of a genuine understanding of the welfare response, of a well-studied species, to the simple climatic variable, temperature. We are learning not to equate, necessarily, good productivity with good welfare so it would appear that there is no reason to suppose that conditions for good productivity will necessarily promote good welfare.

When other aspects of the climatic environment are considered such as humidity, air velocity and radiation, it becomes clear that, although we can estimate the effects of these variables on the energy balance of some animals, we have very little idea of their effects on health and welfare.

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Even at the anecdotal or experiential level, high humidity is praised and damned. Certainly we cannot treat each variable in isolation; there is always an interactive effect on productivity so we can at least expect the same to apply to health and welfare.

3 Other environmental variables

The biological world has been exposed to night-day and seasonal variations of photoperiod (which, incidentally, is correlated with temperature) so we can expect to observe profound changes in animals in different lighting regimes. Productivity, puberty and behaviour (notably reproductive behaviour) are all affected by light. Knowledge in this area is already used in the design and management of farm buildings. I think, however, that much remains to be discovered about the effects of light on production, health and welfare.

The effects of noise do not appear to have been investigated to any great extent. Where vocalization is an important means of communication between animals we might expect some interference. For example the noise of fans tends to disrupt the communication between sow and piglets at suckling.

Some attention has been given to the measurement of dust and gases in livestock buildings and their resulting effects on the animals. Dust is a particularly difficult thing to measure and characterise. A gravimetric measure of dust concentration would seem to be insufficient unless accompanied by a description of the distribution particle sizes. Even here particle size is not an easy thing to measure as the shape of the particles is also important. The constituents of the dust is not less important; various problems, allergens, moulds and organisms can be present. Dust is also known to be associated with humidity, air velocity; stocking rate and feeding system among other things. However, we are not much beyond the stage of saying intuitively that low dust levels are desirable in livestock buildings; certainly dust is despised by stockpersons.

Gases, on the other hand, are much easier to measure than dust and the significance is a little better understood. Hydrogen sulphide, for example, is a deadly poison and must be avoided by animals and men at all costs; deaths are recorded each year. Ammonia is claimed as an irritant and short exposure, especially at high concentrations, can have serious effects, even fatal, on both animals and men. At the concentrations normally experienced in livestock houses there does not appear to be strong evidence that productivity, health or welfare are affected. The presence of ammonia at a concentration greater than 20 ppm is so unpleasant for the stockperson that steps are usually taken to reduce the concentration. Carbon dioxide is an asphixiant and at very high concentration causes unconsciousness followed by death. However, dangerous concentrations would be extremely difficult to achieve in livestock buildings.

Apart from carbon dioxide it is not possible to estimate the concentrations of gases in livestock buildings since the rates of production cannot be estimated with useful accuracy. Carbon dioxide is a product of the metabolism of animals and the concentration is capable of being estimated. For this reason it is enjoying a resurgence as a general indicator of air quality and as a criterion for ventilation design in livestock buildings.

4 Relevance of critical temperatures

Air temperature is readily measured and understood. It is also of primary importance to the energy balance of livestock. For these reasons it is used, almost without exception, as the controlled climatic variable in intensive livestock housing. However, it is vital to realise that other components of the thermal environment affect the heat loss from animals. A given temperature must, therefore, be expressed in relation to those other components. For example growing pigs kept on straw bedding require a temperature about 6°C, less than if they were kept on bare concrete.

Depending on the feed intake and metabolic processes, an animal will produce waste heat which is available to maintain its deep-body temperature within the necessary close limits. This normal waste heat is known as the thermoneutral heat production and is available, at no cost to productivity, to keep the animal in thermal comfort. If, however, the heat demanded by the thermal environment is greater than the thermoneutral heat production then the animal must increase its heat production by thermogenesis. As the air temperature decreases the heat demand increases. The temperature at which the heat demand equals the thermoneutral heat production is known as the lower critical temperature (LCT). If the temperature continues to fall below the LCT, then excess heat must be generated by the animal and this will be at the expense of productivity. It is therefore highly desirable that air temperature is controlled to be at or above the LCT.

If we consider growing pigs kept on concrete slats in groups of fifteen fed a diet containing 12.5 MJ/kg, then the amount of extra food required by each pig of live weight 20, 40, 60, 80 and 100 kg would be about 22, 31, 37, 43 and 48 g per day respectively for every degree below their LCT. This extra food would ensure that the pigs grew at the same rate as if they were at their LCT but the food conversion ratio (FCR) would be greater of course; the economies of production would, therefore, be worse. The relevance of LCT is evident. However, we would not necessarily expect either the health or welfare of animals to be affected by moderate excursions below their LCT. On the other hand — if the excursion were great and prolonged then death could occur.

Heat is lost from an animal in two forms — sensible heat and latent or evaporative heat. At and below the LCT the latent heat is usually assumed to be more or less constant. As the temperature rises above the LCT then the sensible heat loss decreases, because it is controlled by temperature, and the latent heat increases in such a way that the total of latent and sensible heat remains equal to the thermoneutral heat production. Some animals pant and some sweat to increase the vapour loss. The pig, for example, does neither well so it prefers to wallow in liquid.

However, there is a limit to the amount of latent heat that can be generated. When this limit is reached and the temperature continues to rise then the animal will become hyperthermic with a consequent, and possibly fatal, rise in deep-body temperature. This point is termed the upper critical temperature. Given the opportunity an animal will adjust its behaviour and reduce its feed intake before a dangerous situation arises. It is for this reason that animals should not be kept unecessarily warm; they will reduce their feed intake with the result that productivity and the efficiency of production will decrease. In the United Kingdom we have, quite properly, given a lot of attention to environmental design and management for cold conditions. More and more, however, the problems associated with higher temperatures are being addressed.

Our understanding of the thermoneutral zone and the upper and lower critical temperatures have led to better environmental design. It is not long ago that the control of temperature to a high degree of accuracy was thought to be necessary for most livestock. We now know that most livestock can be healthy and productive over a range of temperature. Fluctuations in temperature have been abhorred yet evidence now suggests that moderately fluctuating temperatures do not cause a detectable effect on production. Livestock are, of course, biologically equipped to cope with fluctuating temperatures diurnally and seasonally so we would not expect moderate fluctuation to impair health or welfare.

5 Space

When we discussed environment it was the quality and properties of the space within a building that received our attention. However, it is no accident that the price of buildings is often expressed as £/m^2 and stocking densities as kg/m^2. The quantity of space defined by a building is a precious commodity. It is therefore, all the more important that we understand the spatial requirements of livestock.

The physical space occupied by an animal is obviously a minimum requirement which can be determined by direct measurement of the animal. The floor area (A) occupied by a standing animal is simply the area of the animal viewed from directly above. For pigs this has been estimated at the SFBIU by the equation $A = 0.019W^{2/3}$ where W = weight of the animal. The area required to lie in a fully recumbent posture, on a side with legs extended, is estimated from $A = 0.048\ W^{2/3}$. In cold weather pigs huddle for warmth and so the lying area occupied tends to be a minimum whereas in hot weather they spread out as individuals, avoiding contact, so the lying area tends to a maximum. This latter effect combined with the seeking of surface moisture leads to pigs occupying the dunging area in some pen designs; it is a natural consequence of the space provided and thermoregulation.

In cold conditions, when pigs also lie on each other, the lying area is minimised but other factors come into play. The mechanical stress imposed on a pig where its body touches a solid floor appears to affect the posture of pigs. This stress would be increased by overlying and it would be more severe for larger pigs. It has been suggested, and this is supported by experimental evidence, that the intensity of huddling and the degree of induced mechanical stress is related to the thermal stress defined as the difference between the LCT and the ambient temperature. What this means is that, even for something as simple as lying space, we must consider the size and geometry of the animal as well as the thermal environment and nutrition.

Space for feeding is also complicated by, what has been called "behavioural forces". There appears to be a great deal of competition between some feeding animals which brings out aggressive behaviour. Allocating space at a feed trough using shoulder width alone can be insufficient. The picture is also different for ad-lib and rationed feeding. For pigs, vertical solid barriers, screening the head or head and shoulders and dividing the feed trough have been shown to reduce greatly both aggressive acts between pigs and feed wastage from the trough.

Space in livestock buildings, far from being a simple concept, is difficult to understand and design. In addition to physical space we have behavioural, sociological and psychological space. This is further complicated by the fact that the same space can be used to accommodate different activities, drinking and dunging space can be combined, and that time-sharing can be practised by the animals. It is a major task for the future to create understanding of this difficult area; it is agriculture's own space project.

Welfare

We have measures of productivity and we have ways of detecting, and sometimes measuring, the state of health or at least the state of ill-health but do we have detection techniques and measures of welfare? To some extent we do; we have behavioural and physiological measures. Despite the difficulties of interpreting behavioural and physiological data in the context of welfare it would be thoroughly intransigent and short-sighted to maintain that we have no precise way of assessing welfare and therefore we should ignore or refuse to act on welfare matters. We do have a right, however, to expect information relating to animal welfare to be expressed in such a way as to be applicable in practice, and in such a way as not to be unnecessarily restrictive, I believe that welfare requirements should be expressed as objectives or dynamic performance specifications rather than fixed solutions. Fixed solutions stifle invention. The Animal Welfare Codes do, in general, allow flexibility as to how to achieve the standards they set. The difficulty with the Animal Welfare Codes is that the standards are not always expressed with sufficient rigour so that subjective interpretation is still required.

The Animal Welfare Codes appear to be based mainly on biological requirements, that is their aim is to avoid animals suffering. However, we must be clear that there is a human psychological and sociological aspect and anyone who ignores this will possess an impoverished view of 'animal welfare'. There are members of our society who suffer distress over some aspects of animal production. This has been, and is, a potent force for change.

Change is with us now. The battle, if that is what it was, is over; the animal welfare lobby has won. The important thing now is to accept this and to influence the negotiation of the terms of the peace treaty. I see no logical contradiction between high productivity and high welfare but it may not be easy to find the key to both.

Conclusion

If we wish to design and construct effective buildings we must understand the response of livestock to the various components of the built environment. However, the response of livestock has more than one dimension. Currently, we are greatly concerned with the response in three main areas: productivity, health and welfare. Although there are many instances when the enhancement of all three are simultaneously achieved within an agricultural system there are instances of conflict. Often farm buildings are central to this conflict since it is they that define the environment to which the animals are exposed. For this reason farm buildings will continue to occupy a salient role within livestock production. The resolution of many problems of productivity, health and welfare will require a better understanding of the effects of the built environment and a translation of this into design and management of farm buildings. Translation cannot occur without understanding and understanding will remain as potential only without effective translation. The quality of the people involved will remain a crucial element.

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Book Review

Handbook of Dehumidification Technology

G W Brundrett

Publisher: Butterworth Scientific Ltd, Westbury House, Bury Street, Guildford GU2 5BH. 1987. ISBN 0 408-02520-4. £30.

THIS book presents a good introduction to the technology and applications of dehumidification. The principles of the major methods of dehumidifying are outlined, and refrigerant dehumidifiers are described in detail. The influence of the refrigerant, and design of evaporator, compressor, condensor, expansion devices, fans, electric motors and methods of control on overall performance and noise level are considered. A very wide range of applications is reviewed including, domestic housing, swimming pools, industrial uses and the drying of compressed gases and air. Applications of particular interest to the agricultural engineer include humidity controlled stores, the drying of agricultural materials, food processing and greenhouse dehumidifying. The design of refrigerative dehumidifiers, including CAD, is touched on and a chapter is devoted to economic aspects. Likely future develpments in refrigerative dehumidifiers are outlined.

The text is very readable and should prove an excellent introduction to the subject. The specialist may be a little disappointed because, with the title of Handbook, it can be criticised for not containing quantitative data. However, most chapters contain a substantial number of references and there are lists of relevant journals, professional bodies, manufacturers and research and development organisations involved in the development and testing of dehumidifying equipment and its application.

B J Bailey

Bernard Bailey is at the AFRC Institute of Engineering Research, Silsoe, where he is involved in dehumidifying insulated greenhouses.

The Agricultural Engineer

Instructions to authors

1 Preparation of the text

The manuscript should be typewritten with double spacing and wide margins on one side of A4 paper. The original and one copy are required for editing and printing.

2 Length of paper

Papers for presentation at Conferences *must not* exceed 5,000 words in length.
Papers for direct publication must not exceed 10,000 words in length.

3 Headings

All main and sub headings should be in lower case typescript except for the first letter of the first word, proper nouns and generic names. The main headings should be typed as a separate line of text with an extra line space above and below and without any underlining. Sub headings should precede the first line of the paragraph to which they relate.

4 Format

Underlining should be used only to denote italics for parts of the text and for scientific names of pests, plants, etc.

There should be no stop at the end of any heading or caption unless the last word is an abbreviation of which the stop is a part.
For example:
Yield stability in Vicia faba in the United Kingdom.

5 Title page

The title page should include: the title, and the name(s) of the author(s), their affiliation(s) and passport photograph(s).

6 Summary

The manuscript should include a summary of not more than 400 words.

7 Abbreviation of units

The SI system should be used throughout the text as well as in the tables and figures, British Standard PD5686 (1972). The plural of all abbreviations is the same as the singular, eg kg (not kgs). The solidus is used to denote "per" except in the case of more than two units when negative indices are used, eg m/s and $W\ s^{-1}t^{-1}$.

8 Symbols

Symbols should be defined in the text where they first appear. Where many symbols are used in the paper, they should be listed in a "key to symbols".

9 Illustrations

All illustrations should be numbered by arabic numerals.

Drawings should be on tracing paper, artboard or faintly lined graph paper in black ink. Use stencils, flexicurves or Letraset in preference to freehand lines. Lines finer than 0.4 mm do not give adequate quality of reproduction.

The original diagrams should be submitted without labelling or captions which should be given on an attached photocopy.

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Photographs should be supplied as glossy prints, unmounted and unattached. Full plate prints are preferred.

For part reproduction of a photograph, an overlay should be attached and the relevant area marked with a soft pencil.

The figure number and the top of the photograph (if not explicit) should be indicated on the back. The caption should be provided on a separate page.

11 Tables

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References in the text should be cited as the name(s) of the author(s), followed by the year of publication (Smith and Jones 1970). Multi-author works should be quoted in the form: "Smith *et al* (1982) developed . . ."

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(a) for periodicals
Smith A B, Jones C D, Frank E F (1982). A mathematical simulation of grain drying. J agric Engng Res, 12, 105–123.

(b) for books
Cochran W G, Cox G M (1964). Experimental designs. 2nd ed New York, Wiley.

As in the text of the paper, underlining indicates the use of italics.

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(a) *Scientific papers* Papers submitted to the Journal may be afforded the opportunity of being refereed before publication if the author so requests and if the paper contains a record of original work or presents an original commentary not previously published elsewhere. Refereed papers will be annotated accordingly.

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