The Agricultural Engineer

Incorporating **Soil** and water

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Focus on Manufacturing – 1990 Convention

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Front cover: The prototype 'Pulsar' potato harvester developed by the Scottish Centre of Agricultural Engineering.
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Journal and Proceedings

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The Institution of Agricultural Engineers

The importance of a healthy manufacturing industry

Some extracts from the after-dinner speech by L J Weaver CBE, Principal Guest at the 1990 Annual Dinner.

The question is occasionally asked "Does manufacturing matter?'. Is it not just one of our means of creating wealth? Are we not now in a post industrial world? Would it really matter if we became mainly dependent on invisibles such as services and tourism or, as someone neatly summarised it, 'on Beefeaters, bingo and Butlins'.

The word manufacturing in Britain tends to conjure up an embattled picture of defiant manufacturers defending a shrinking position against the heathen hordes of invading services.

Having spent virtually all my working life in manufacturing industry I would like to highlight three key reasons which I think justify any national economy – not just Britain's – aiming to sustain as much manufacturing as it possibly can.

Success at making things

Firstly, there is clear proof, both historically and currently, that **to create a successful economy you have to be successful at making things.** Britain was the first country to prove it. The industrial revolution made us the greatest economy of the nineteenth century and the pound sterling the strongest currency.

We were followed by the USA and now we see the pattern repeated by the Japanese. The Japanese have created uniquely efficient manufacturing to give their nation substantial economic success and immense financial reserves.

Apart from these three outstanding examples, Germany, France and Italy are also major manufacturing countries that have followed the same pattern and it is fascinating if not rather awesome to see the current industrial development of such countries as South Korea and Taiwan.

So there is no evidence that other nations are giving up manufacturing. On the contrary, the best economies are those that are best at this form of wealth creation.

Exploiting technology

My second reason is that **manufacturing industry provides the best exploiter of technology.** Technology is the knowledge and skill by which man transforms natural resources into useful products. Technology is at the very heart of the wealth creation process. It is the means by which a struggle for existence becomes a decent standard of living.

Len Weaver is Chairman of Polymark International plc and President of the Institution of Production Engineers.

The role of industry and commerce is crucial; it provides the means by which mankind at large benefits from invention and innovation, the means by which the ideas of the few can benefit the many.

The exploitation of technology is not only the purpose of industry and commerce but its social responsibility.

Whatever the merits of service industries they do not provide the breadth of scope for using technology nor the richness of opportunities for using individual talent.

Providing trade goods

My third reason is the vital role that the manufacturing sector plays in **providing internationally tradeable goods.** Last year about £70bn was exported from Britain. This represents more than half our export trade and more per capita than any other country including the Japanese. Manufactured goods provide us with a greater export contribution than banking, insurance and oil put together.

UK industrial decline – and recovery

It is paradoxical that the country which created the first industrial revolution and which was once regarded as the 'workshop of the world' should have a national antipathy to industry which seems to be deeply embedded in our social and educational systems. Government attitudes over the years have also been very ambivalent. As a result our gross domestic product per person has declined steadily since 1945.

In the late seventies the rest of the world talked about 'the British disease' and shook their heads. In 1980 our problem was succinctly defined in terms of poor productivity. We were using 22 million people to do what it would have taken only 12 million Germans, 13 million Americans or 16 million Frenchmen to do.

Although we are today suffering from high interest rates and the threat of high inflation there is absolutely no doubt that we have come a long way in the past decade –

- during the eighties the UK has grown faster than all the other major nations in the European Community;
- during the eighties our growth in manufacturing productivity has been greater than all other major industrial countries;
- company profitability last year was at its highest since 1969.

Major challenges ahead

This recovery is very encouraging but we cannot become complacent again. We are facing major challenges.

Our first challenge is the creation of the single European Market in 1992. We must become more enthusiastic about this. A casual attitude to 1992 is unwise.

A further major challenge arises because of the way in which the world's manufacturing capability is developing. As we progress into the 1990s we shall certainly witness the clear emergence of three major manufacturing areas: Europe, USA and those countries around the Pacific rim. In time, this situation may polarise into one of intense competition between East and West.

The third and probably greatest challenge is our national ability to apply modern manufacturing technology and systems.

There have been major and irreversible changes in our manufacturing industries in recent years. In the past, many companies manufactured low varieties of products in high volumes. Production engineering in those days focussed on the specialisation of machines, processes and people.

Today the scene is very different:

- product life cycles have become much shorter (technology and international competition);

Annual
highlights manuf

The 1990 Annual Convention o
Conference Centre, NAC

Day One of the Convention commenced with the Annual General Meeting at which Douglas M Walker, Managing Director John Deere Limited, was elected President.

Following the AGM, the Presidential Address "Economics of manufacturing agricultural machinery" provided the lead-in to the Conference theme "Opportunities and development in manufacturing". Geoffrey Burgess, Managing Director Kidd Farm Machinery, and current President of the Agricultural Engineers Association chaired the Conference sessions.

With formal Conference sessions in the forenoon of the 9th and the afternoon of the 10th there was opportunity also for a number of Specialist Group Meetings. An alternative activity, popular with many members, was a visit to view the computer aided design and manufacturing system at Dowdeswell Engineering Limited.

In this issue we present some of the

Convention
acturing industry

the Institution was held at the Stoneleigh, over 9 and 10 May.

papers from the formal programme and just a 'sample' paper from a Specialist Group Meeting. Further papers from the Conference will be published in our next issue.

The Annual Dinner of the Institution was held on the 9th May. L J Weaver, President-elect, the Institution of Production Engineers, was principal guest. He spoke on the importance of a healthy manufacturing industry and we are pleased to publish in this issue the main points of his address.

Following dinner the President presented Long Service Awards to three members. Tom M Hutchison of Aberdeenshire received a 50-year Long Service Award. He joined the Institution in 1939 a year after its founding. President-elect J B (Brian) Finney and Vice-President J A C (John) Weir were each presented with 35-year Long Service Awards.

- companies now often have to make high varieties of products and thus have to use very flexible manufacturing processes and systems;
- the range of materials processed has grown dramatically so that in addition to a wider range of metals there are now many plastics, composite ceramics and alloys often processed with sophisticated surface treatments;
- the whole approach to design is also changing. It is becoming increasingly recognised that design for function alone is unlikely to achieve competitive product costs. The concept of design for economic manufacture is steadily being translated into practice in many industries;
- computers are now used extensively in manufacturing industry for design, for operating and controlling machinery and processes, and for control of flow, storage and distribution of materials.

If we are to succeed in this new global situation we must seize our opportunities and use our abilities. We have a lot going for us:

- we are very good at science and invention;
- we are still one of the world's major trading nations;
- we have world class performers in such industries as aerospace, chemicals and pharmaceuticals;
- we have a relatively large and skilled labour force;
- English is the most widely used language in industry and technology.

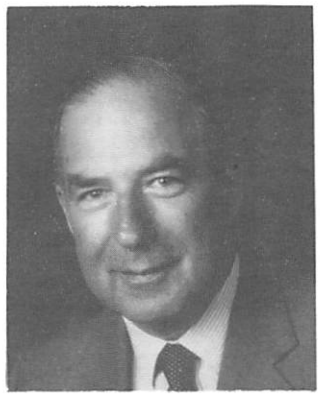
Our universities and polytechnics are beginning to respond to the changes.

Role of higher education

In recent years more courses in manufacturing engineering have been created and last year government and industry provided £25m to set up nearly 20 new degree courses in manufacturing systems engineering with an intake last year of over 500 students.

Whilst these trends are encouraging I consider that our HEIs still have much to do if we are to sustain our position as a major manufacturing nation. There is quite clearly a need to increase the flow of manufacturing engineering graduates into industry. Because of the pace at which technology is advancing there is also a vital need to contribute more to the ongoing education and training of these graduates throughout their future career.

Economics of agricultural machinery manufacture



The Presidential Address to the 1990 Annual Convention by D M Walker

There are four main sub-divisions in the agricultural machinery industry. Each of these has its own special requirements. The sub-divisions are:

- high volume, sophisticated machinery requiring large capital investment. Examples are tractor and combine harvesters;
- low volume but sophisticated machines such as pea viners, sugarbeet harvesters, potato harvesters, sprayers, etc;
- low technology products, relatively simple to manufacture, such as cultivators, disc harrows, ploughs;
- products assembled from bought-in components – the so called "bolt-on" group. This group may include high technology products but little manufacture is involved.

Manufacturers mostly small – less than 10 employees per enterprise

According to a 1987 report from the Department of Trade and Industry there were at that time 898 manufacturers of agricultural machinery in the UK with a total workforce estimated at around 20,500 people. Only 6 companies employed more than 1000 people and 721 companies employed 9 or less. In fact there were 868 companies employing 99 people or less with an average of only 7 employees per enterprise.

With such small manufacturing units it is difficult to benefit from economies of scale and indeed the use of advanced paint systems, CAD/CAM and sophisticated numerically controlled machine tools is virtually impossible.

Douglas Walker is Managing Director of John Deere (UK) Limited and President of the Institution.

Seasonal business

Another problem is that agriculture is a seasonal business (with the possible exception of dairy machinery which is in use every day of the year). Although the customer demand is on a seasonal basis – why should he buy a combine harvester in November – the factory has to produce on a regular basis with the products ideally being sold throughout the year.

Clearly, we are faced with a problem essentially peculiar to our industry which has to be resolved and therefore some form of programmed flexible manufacturing has to be introduced if economic manufacturing capabilities are to be cost effective.

Along with the seasonal considerations one must consider product mix and the need to be sufficiently flexible to react to market demand through flexible machine tools, flexible labour; to switch quickly from one model to another or even different but similar products, eg combine harvesters and self-propelled forage harvesters.

For efficient flexible manufacture and production we must ensure as far as possible that the most efficient and cost effective manufacturing techniques are designed in at the beginning.

Batch manufacture – standardisation

Essentially we are in a batch manufacturing industry because of the limited volume.

Taking tractors as an example, it is estimated that some 20,000 tractors will be sold in the UK this year. This compares with an expected two million car sales.

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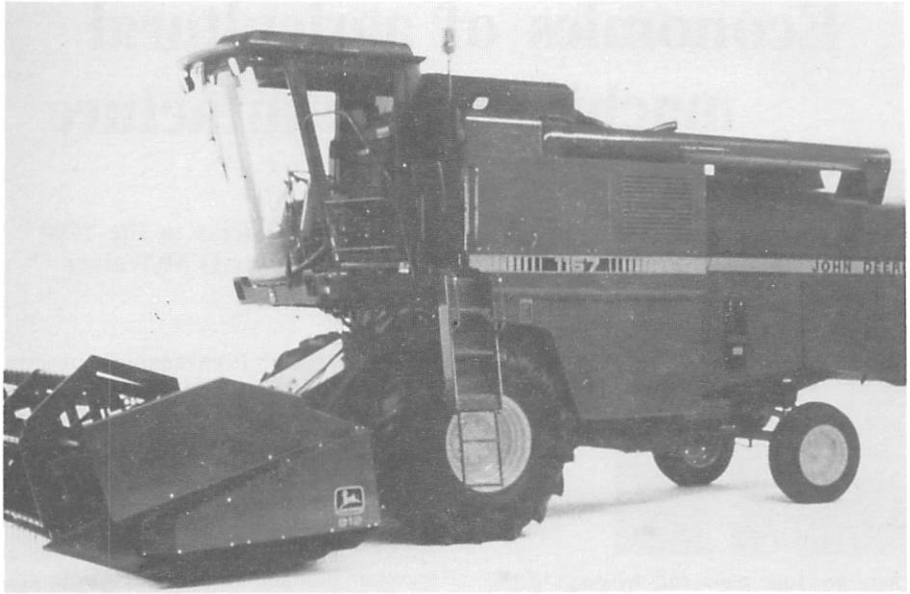


Fig 1. Component standardisation for cost reduction. Cabs and straw walkers are among standardised items in the John Deere range of combine harvesters.

Reckoning that there are some 25 car manufacturers, total sales, if shared equally, would amount to 80,000 units each. In the case of tractors there are some 32 manufacturers competing in the UK market – an even split would result in sales of 625 units each. The situation becomes much worse when you consider that some 75% of the market is shared by only 4 manufacturers, giving them sales of around 3,700 tractors each with the remainder averaging only 90 units each.

As a result tractor manufacturers have become remarkably efficient in producing at relatively low volumes.

Some standardisation is called for. The combine harvester offers some good examples of what has been achieved.

Combines are a surprisingly low volume product and therefore although they usually have sophisticated electronics the basic design is such that there are many common components across the range in order to keep costs down. On many combines the most obvious is the use of the same cab with maybe slight changes on a range of models. Inevitably the cab looks aesthetically pleasing on some models, usually the biggest, but not so pleasing on the smaller models.

To give some indication of what this means in cost terms. If we assume the basic cost of a standard cab is 100 then 500 work out at roughly 65 each – an appreciable cost reduction.

Likewise, there would be the cost penalty on the windscreen glass if we were to produce a different cab for different models. If one curved glass windscreen is taken as 100 then the cost reduces to 50 for 1000 pieces. This is a cost effective solution which can be considered acceptable and is maybe not even noticed by the buyer.

Another example of cost effective design is the standardisation of straw walkers on the combine. It is possible, and indeed it is done, that one design of straw walker will be used in different combine models, say in 4, 5 and 6 walker machines. In a sense one could consider this a form of modular design which can be a very cost effective method.

These concepts can be considered a compromise from a design and manufacturing point of view but with relatively small volumes there is really no practical alternative. It is likely we will see an extension of engineering compromise within the agricultural machinery industry.

The concept of modular design will become more widespread in future designs, particularly to simplify manufacturing and to make specification changes easier.

Product reliability a critical factor

Turning now to the second sub-division of the industry – the low volume but sophisticated machines. Here we have a need for even greater component commonality to keep costs down to the absolute minimum. The measure of this problem can be seen in the case of self propelled pea viners where the total market, I am told, is only 20-40 units per annum.

It simply is not possible to manufacture all the necessary components for machines of this type. Machines have to be designed round commercially available components. This, of necessity, brings with it certain design restrictions. We can look at the long list of possible outside suppliers: engines, transmissions, axles, hydraulic pumps, hydrostatic drives, hydraulic cylinders, electronic monitoring systems, quite apart from such things as tyres, drive belts, chains, bearings etc.

Besides possible design restrictions there is still the question of after sales service. The first choice component may be rejected in favour of one with better product support within the market where the machines will eventually operate.

This group of machinery has some very special problems when it comes to providing what the customer requires; proper performance, a competitive price and efficient parts and service support. Product and component reliability becomes a critical factor to the successful marketing of this group. Economic manufacturing techniques may be very difficult to implement.

High labour content of low technology products

The third sub-division is a most interesting sector. It is an area of manufacture particularly well developed in Europe. Probably the best example of machines in this group is the cultivator.

In manufacture of a machine in this group there are three distinct factors to be considered:

- Farming tradition;
- Can it be sold for export?;
- Manufacture must be cost effective.

Taking the example of the cultivator – farming tradition is a question of what the cultivator is required to do – burying trash in wet areas and leaving it on the surface in dry areas. The same frame will probably be acceptable but the tines probably will not. Secondly, a different cultivator frame will be required to meet different farm sizes and tractor horse powers. For a manufacturer seeking to cover the market, and few companies try to, you would need to produce at least 6 basic frames with perhaps 12 different types of legs and maybe 24 different types of tines.

Then the question is how big is our market? Obviously it must be more than the area round the factory, therefore, the cultivator must be designed to be shipped in the smallest possible package to keep freight costs to a minimum. Bear in mind that we are discussing basic low technology products.

Having considered all this it is self evident that efficient manufacture is absolutely essential. It appears that there is today no major manufacturer of cultivators in the world but there are several covering certain regions where they can provide a specialised product.

Simple CAD/CAM systems can be, and are, used but one of the weak areas with many of these manufacturers is the number of welding jigs required, a welding process which is unlikely to justify robots and the handling of large unwieldy sections.

I suspect that because of these manufacturing problems this sector will remain fragmented and will continue to supply its relatively local specialised market. As there is a high labour content in these units we will likely see a production move to more low cost areas.

The fourth sub-division – the bolt-on group – can offer very cost effective production when assembling components supplied on a Just-in-Time basis. An example might be in the building of a small line of lawn mowers where the mowers are designed on a CAD/CAM basis by the parent factory and, because of the carefully planned and limited product range, simple and effective robots can be used.

CAD/CAM – brings design engineer and production engineer closer together

After the foregoing brief overview of the main divisions of the agricultural machinery industry I would now like to consider in more detail the first grouping and to review the new ideas and techniques in tractor and combine harvester manufacture.

Clearly, every company wishes to produce at a consistently high rate with the factory running as close as possible to maximum capacity and with a low "break even" point.

All the major tractor manufacturers have identified the reduction of "break even" as a pressing priority. In the late '70s and early '80s "break even" figures of 80% were not unknown, then the recession caused factory manufacturers to look closely at how this could be reduced.

Today we can see "break even" figures of 40% and some claim even less. How was this possible?

There is no one answer but rather a number of major, to relatively small, changes involving re-design of product, Just-in-Time, cellular manufacture, CAD/CAM robots, computer controlled machine tools and unfortunately, reduction in people.

CAD/CAM is frequently given credit for starting the revolution in manufacturing techniques. This is probably true. If CAD/CAM has done nothing else it has brought the design engineer and the production engineer together at the concept and design stage. This helped to get the product designed not only to suit the market but also, in conjunction with the design engineer, to be manufactured in a more cost effective way.

Just-in-Time

If CAD/CAM has led the way in achieving greater cost effectiveness then the concept of Just-in-Time can reasonably be considered next in line.

With a properly established Just-in-Time system the supplier – very often known these days as the vendor – is provided with a lay-down area in the factory which he constantly replenishes according to a predetermined schedule. When the parts are removed for the production line it is noted by an "on-line" computer system to the supplier at which time the item is invoiced to the manufacturer.

Preferred suppliers are now expected not only to provide components on time but also to supply absolute specification without fault ie 100% reliability without the need for the customer to inspect more than a very few random samples. This is very demanding but only by working this way can costs be contained.

Clearly there are two important prerequisites – there must be efficient and constant discussion between the manufacturer and supplier to discuss production volumes and quality problems. Bear in mind also that the principle must apply evenly to parts manufactured "in house" and those coming from outside suppliers. It is essential that there should be no fundamental difference between these two suppliers.

Before Just-in-Time it was not unusual to have 2 or 3 suppliers for a component which very often could be carried in stock for 3 months.

It is not easy to calculate all the savings of JIT as it is not just a reduction in stock, it is a freeing of space, money not being tied up, less inspection and the possibility of design changes more quickly introduced (less old stock to use up or scrap).

There is no doubt that Just-in-Time has contributed greatly to substantial reduction in manufacturing costs. In one example costs were shown to have been cut by 25%. There is also the unknown cost saving of better reliability and quicker design change.

Cellular manufacture

It is obvious that labour has been a large part of manufacturing costs and to improve productivity, it is essential that some of the traditional manufacturing processes and techniques had to change. Even the largest tractor factory in the world is by automobile standards relatively small and therefore, the same level of automation is difficult to achieve but there are some alternative solutions overcoming some of the problems.

We are seeing significant changes towards cellular manufacture where this is appropriate. It was first forcibly brought to my attention when I was visiting a factory and being shown round by the general manager. We arrived at a section where I was greeted by an operator who welcomed me to his factory where he is the general manager!

This particular cell manufactures a bevel gearbox from machining to assembly by one man. The operator is responsible for 6 machines in which he obviously takes great pride. He had prepared a board to tell visitors what it is that this cell does. Other cells work in a similar way.

What are the advantages? From what I have said you can see pride and responsibility by the operator. He is responsible if the products are faulty and today there is almost 100% first time reliability which is an enormous cost saving in itself. Putting the machines in a cell also substantially reduces handling and inventory costs as the mini factory produces its product in this one place compared with components coming from separate areas as was the case formerly.

Of course, one must have the computer people capable of producing the programs for these cells and the managers who understand the rationalé behind the cellular concept.

Some modern paint facilities can be regarded as operating on a cellular basis. Automated paint facilities have the further advantage of taking people out of an environment hostile to health.

In the manufacturing area there have been many changes. I mentioned the high level of production in a car factory and as a consequence, machine tools are replaced relatively frequently as they are depreciated more rapidly than might be the case with a tractor company. It is quite possible to buy these units, recondition them, add a suitable numerical control system for a total outlay of half that of a new unit. This seems to make a great deal of sense at the lower levels of production in a tractor factory.

The way ahead

The Agricultural Machinery Industry in the UK is clearly in a difficult situation in utilising many of the techniques necessary to reduce costs and increase efficiency because of the substantial number of very small companies often with relatively short product runs.

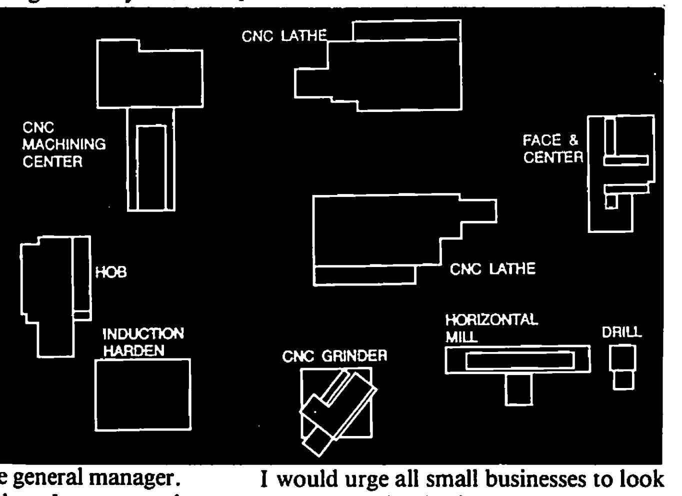


Fig 2. Cellular manufacture for cost benefit and improved quality. The plant layout for production of spindles for John Deere combine harvesters.

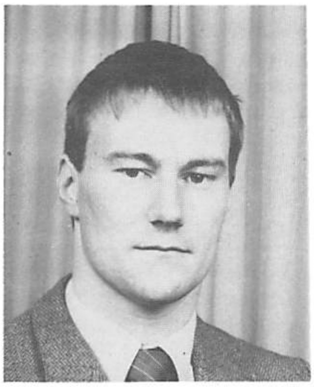
I would urge all small businesses to look at some of the simpler forms of CAD/CAM which can be effective with a relatively small investment in hardware and software but give a real bonus of savings in time.

Look carefully at your purchasing plans and reduce needless inventories by negotiating frequent deliveries from your supplier.

Investigate your area of expertise and see if you can develop complementary products which can basically utilise your existing manufacturing facilities and resources.

Finally, go and see how others are applying these techniques and see if they can be adapted to your requirements.

From education to your first job in engineering – a gigantic step?



M J Watchorn highlights and challenges the traditional relationships between education and industry. He emphasises the need for communication skills, teamwork and problem solving to be developed within courses, to ensure that graduates more readily satisfy the needs of industry. Interchange of personnel between industry and education together with continuing professional development are suggested as ways in which the full potential of the employee and the industry can be realised.

Every working person has made the step from education into the world of earning a living. If you are now working, how successful was that initial leap? If you want to work in engineering what steps are you going to take to improve your success?

Two groups have a direct interest in the transition from college to work. The employee must be prepared to settle down to working as quickly as possible. The employer must quickly have the job description reliably filled.

Are educational establishments showing sufficient interest in the level of success students achieve in their first jobs? This may well highlight areas of any recurring problems within courses. Engineering is changing all the time. Are the courses which are producing the work force of the future keeping pace?

For the employee, background both in terms of education and overall experience will play a large role in determining the success of the move from college to work.

For the employer, the type of organisation, exact job being taken over, current work load and existence of an organised job training scheme will determine how successful is the move.

Errors in education can be expensive

If you are now asking "Why question a process which has gone on for generations?" let me outline some of the possible problems which arise from not getting it right at the outset.

Time is money, both in terms of wages and lost output. The quicker an employee begins productive work the more efficient it is. Mistakes can further increase the amount of money which must be invested in the learning curve.

UK manufacturing industry is about to experience a drastic skills shortage and a massive increase both in the markets available and in the levels of competition. Efficiency of all workers will become ever more important during the next few years.

A job description may include work for which an employee has insufficient base knowledge. Once away from the teaching establishment, how easy is it to rectify this situation?

To a student the working environment into which they are merging is an unknown. Each company has its own strategy, and to work efficiently the particular system must not only be understood but be familiar. The exact tasks required by the work are also very diverse and certainly do not stick to strict discipline boundaries.

Course accreditation – to maintain standards, influence structure

Higher education courses are a learning process. The output of this process should be engineers ready to begin work. If we agree with this broad aim of higher education in the engineering sector, are engineering businesses obtaining the service from the educationalists which they require?

If the students are not fulfilling the requirements of their employers, what is to be done?

Professional bodies such as the IAgrE and Engineering Council provide a forum where industry and education meet. Could course accreditation be used as a method of not only maintaining standards but also as a route for influencing course structure? Are quality assurance, project planning, safety management and a host of other everyday topics regular features of all engineering courses?

With 1992 and our closer links with the Common Market approaching, are higher education students being provided with the facilities for learning at least one second language? This need not be to a high level but sufficient so they can confidently converse with a person (maybe a client) who cannot (most unusually) speak English!

Encourage teamwork

Professional bodies like to see courses designed where students work alone. It improves the clarity of accreditation for the individual engineer.

Much engineering work however is done in the context of teams.

Is teamwork being taught from the earliest age? Or is it being left until the student leaves the bosom of education and has plunged into the new world of work? Should not marking schemes be devised to take account of teamwork? Or are they being shunned just because it is too difficult to assess?

Courses are taught in clearly defined sections, yet problems at work do not fall into the same simple categories. Are engineering students able to pull diverse ideas together by the end of their course?

Learn to make assumptions

During the studies for my MPhil I became aware of the hours which lecturers spend trying to organise lifelike and yet soluble problems. Most problems in industry cannot be solved without the use of assumptions.

Should it not be normal practice for students to be taught how to make assumptions, even if their lack of experience may make the final answer incorrect?

The precise answer to some problems is less important than the thought processes required to obtain the solution.

Is sufficient attention being placed on gaining experience in "Assumption making" during a course, or is it left until after commencement of the first job?

Improve communication skills

Engineers are required to communicate their ideas either as drawings, writing or by speaking. Are engineering students being encouraged to be proficient in all three media?

Undoubtedly I have had to improve dramatically my communication skills whilst at work.

The use of computers makes even the most untidy writer legible. If engineers cannot type, it would be wise for them to learn quickly and to become computer literate.

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Michael Watchorn is a Design Engineer with Soil Machine Dynamics of Stockesfield, Northumberland.

New products / new markets

Markets and products follow life cycles. J Bradley and R Webster show how the mature phases of the cycle impose different challenges from those experienced in the growth phase. They explore alternative strategies of market penetration, market extension, product development and diversification. The highest risk, they say, is in diversification and this should not be embarked upon until all other avenues have been thoroughly explored.

The implication of the title of this paper is that the search for opportunities in new markets, with new products, is a necessary evil in today's world. Why should this be so? Why do we need new products and new markets? What is wrong with our current products and markets?

Typically the answer would be:

- static or falling markets;
- increased competition;
- increasing segmentation;
- falling market share;
- static pricing;
- eroded margins.

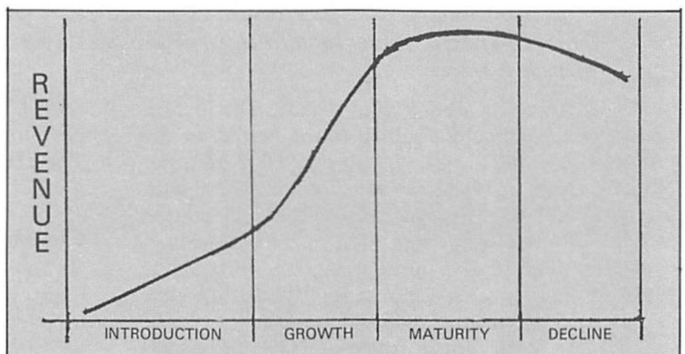

Fig 1. Product life cycles.

And with such a scenario no one could be blamed for thinking the grass is greener on the other side of the fence.

Mature markets are characterised by increased competition, overcapacity in manufacturing facilities and converging product attributes (product parity). The passage of time tends to reduce all products to commodities, that is they are only marginally differentiable.

There are many examples of products where this has happened, cars, electrical goods, etc. Manufacturers therefore have to differentiate on non-product factors, such as image and status. For example, the latest press advertisement for the Peugeot 309 GTI does not even show the car. These factors together act to reduce manufacturers' cash flows and production volumes.

However, other forces including:

- satisfying shareholders' needs;
- maintaining and sustaining effective distributors;
- making advances in productivity;

all combine to create the need for a continued growth in output.

Such growth has to be fuelled from some-

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John Bradley is Corporate Marketing Director, JCB Sales Ltd.
Bob Webster is UK Market Development Manager, JCB Sales Ltd.

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The importance of deadlines

The working world is governed by deadlines and schedules. Are students learning the importance of meeting deadlines? If a delivery is late, the next order will go to a competitor. The Japanese work ethic is not prevalent in most sections of UK manufacturing.

If we are to compete, should students be taught how to set and reach their own deadlines?

Industry is the customer to the education service, and, as such, the customer is always right. Research is vital, but a thriving industrial base to manufacture inventions and market them to the world is more so.

High flying transfers

Are there sufficient exchanges between education and industry?

If industry allowed its high fliers into education for one year, to fulfil some mid-career research, the lecturers thus released could work on an exchange basis within industrial establishments.

The engineer from industry could participate at the forefront of research. Lecturers would recognise, at first hand, fresh areas requiring research and new technology would be dispersed more rapidly into the market place.

The college or university would profit by having an active industrialist within its midst, and students would have the advantage of lecturers with up-to-date company experience. Companies would gain an expert in a particular field, as well as up-to-date research information.

Action by professional bodies

Could professional bodies enforce such a system by making it a requirement of course registration? Would the same bodies be able to exert pressure on industry to co-operate?

The final responsibility for the quality of engineers coming from higher education must lie with the individuals. Can the pitfalls of not having enough knowledge be outlined to students early in their courses?

Improving training at work

Work experience before or during college allows a student to recognise the limitations of the course whilst the opportunity exists to fill in the gaps. Once a job has begun there may not be enough time to learn information even if a good source could be found.

For employers a short term contract with a young person allows a perfect opportunity to observe the prospective employee.

There will always be areas of knowledge which will need improvement during the working period. A change of job or new responsibilities will leave most people wishing they could learn new things. What avenues present themselves in such situations?

Do employers actively encourage engineers to attend technical meetings of, say, the IAgrE? Are mid-career courses advertised generally? Could professional bodies such as Engineering Council provide a data base of such courses?

Some schemes and pilot projects exist over this broad area. Some companies provide young engineers with the environment in which they can blossom.

If we are to survive the pressures being applied to our manufacturing companies and indeed to increase our level of output I think we must treat our young and new engineers as the most valuable resource we possess.

where and there are only two possibilities:

- to find more customers for our existing products;
- to increase the rate of consumption or usage with our existing customers.

The concept of the Product Life Cycle is useful to focus our attention on the consequences of ignoring the stages of growth that each product is at.

As shown in Fig 1, products follow a cycle, going through four broad stages before their eventual demise. We need to be constantly aware of where our brands are in their cycle to ensure we have a balanced mix of products. This is vital because of the cash flow implications associated with the different stages of the product's life. We will return to this concept later when we look at the strategies open to firms in choosing their products and markets.

Desired objective – realistic forecast – The 'Strategic Gap'

All organisations have an ideal or desired objective of where they want to be, usually measured in terms of growth in volume and/or cash flow over a given time. There must also be a realistic forecast of what can be achieved by present strategies in current market conditions. It is this difference between the ideal and the reality that marketeers refer to as the 'strategic gap'.

Examples in tractors, trucks and backhoes

Before we examine the options open to us to fill the gap (and there are only four) let us have a look at some real situations in the UK market for three different products and the implications for the players in those markets.

The three products are: the agricultural tractor, commercial vehicles over 3.5 tonnes (ie trucks) and the product JCB is best known for, the backhoe loader. These products are clearly similar in the engineering involved, in the level of technology incorporated and the method of distribution. They even have overlaps in the customer base, and, of course, several of the international tractor manufacturers also manufacture backhoe loaders.

However, looking at the market situation in the UK for the 7 year period from 1983 through to 1989 we see some significant differences in behaviour and, as a consequence, the opportunities and threats to the manufacturers involved (Fig 2).

During the middle and late 80's the UK market for commercial vehicles over 3.5 tonnes has shown consistent growth – from just under 50,000 units per year to over 69,000 units last year – a growth of over 38%. However, current indications are that the market is set to fall this year by as much as 30%.

If you think the truck market is volatile with a 38% shift, consider the backhoe loader market during the same period. Although much smaller than the truck market the backhoe loader market is worth approximately £150m a year. The market has actually doubled in the period we are looking at, growing to over 6000 units per year in 1988 and 1989 from only 3200 back in 1983. However, as with the truck market – knowing what high interest rates have done to the housing market – backhoe loader sales are also forecast to fall back this year (to 1984/1985 levels).

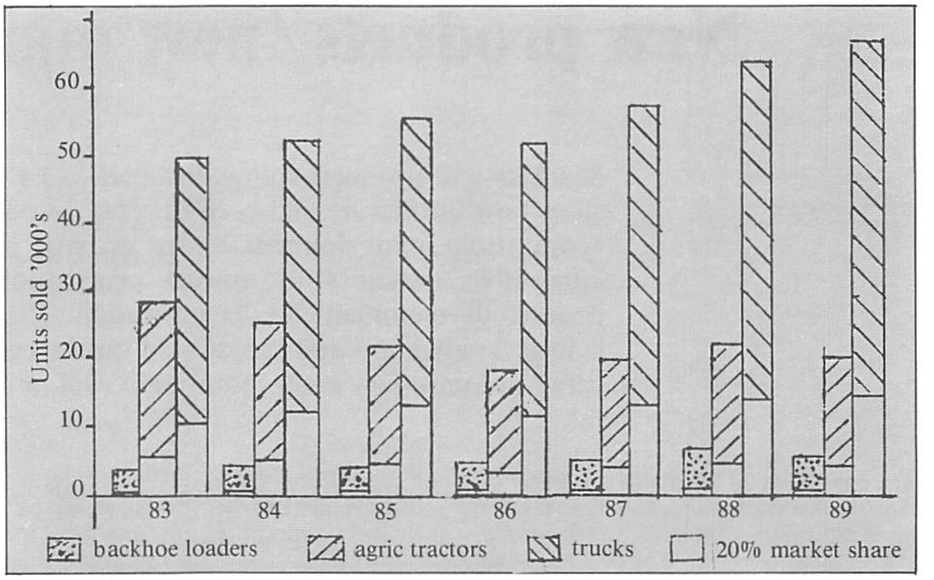

Fig 2. The UK market for three different products, 1983-1989; with indication of 20 percent market shares.

With agricultural tractors the market has shown steady decline in the period, from over 28,000 units per year back in 1983 to just under 20,000 units in 1989 – a drop of 30%.

To put this into perspective, it is helpful to look at the effect on a hypothetical manufacturer taking 20% – a realistic market share – of these markets.

It has been good news for the UK Sales Director of our truck manufacturer. He has seen his volume grow from 10,000 units per year to 13,800 (with a corresponding increase in his bonus, no doubt!). However, with a falling market to contend with and a factory pumping out trucks at the rate of 63 per day, what is he going to do? To maintain his sales volume in a market 30% down our friend would have to increase his market share from 20% to 28% – hardly likely in a single year.

A similar problem is being faced by competitors in the backhoe loader market. At 20% share, sales volume has doubled in the period from 650 units in 1983 to 1340 in 1988. However, with a falling market on our hands and a factory geared for record production there is a strong need to increase market share and develop new markets.

Table 1. Market dependence – tractors

	1983	*1989*
Market volume	28,000	20,000
Market share of manufacturer 'A'	20%	20%
Units sold by manufacturer 'A'	5600	4000

The agricultural tractor manufacturer has already seen his market fall steadily. The effect on his 20% share is shown in Table 1.

Four basic strategies

As explained earlier there are only four basic strategies for bridging the 'gap' between our objectives (our wish) and what is likely to be achieved.

We can seek to increase our market penetration – take a bigger slice of the cake available in the market we know (known consumers) – or we can try market extension, selling the products we have to new customers.

The third strategy is product development, finding new products to sell to the consumers you already know, and the last is diversification – manufacturing new products for sale to new customers.

A structured way of looking at the alternative strategies is a matrix developed by Professor Igor Ansoff. The matrix has four boxes – a box for each strategy (Fig 3).

If we label 'existing' at the topmost corner and 'new' at the right and left corners; and if we say the upper right section refers to the products we sell or can sell and the upper left refers to markets or customers then we can slot the strategies we have mentioned neatly into the appropriate boxes.

Market penetration is all about making the most of your existing products and customers, so it fits into the uppermost box; market extension is new customers for existing products and hence is the lefthand box; product development is new products for existing customers therefore it is the righthand box; and, of course, new products and new customers is by definition diversification and sits neatly in the bottom box of the diagram.

This is an enormously powerful tool in helping us to evaluate our options. It tells us about the relative risk of any strategy.

The uppermost corner is the safest, it

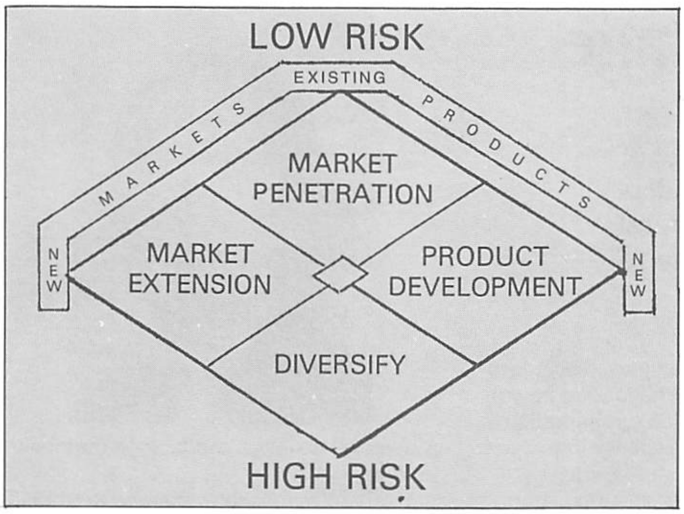

Fig 3. The Ansoff Matrix.

is minimum risk – we know the product inside out, we know the customers well, we are in a position to maximise the benefits we desire. The right and left corners are medium risk because we know about 50% of the picture (either the products or customers) intimately.

So it is possible to imagine a neutral axis of risk, joining horizontally the right and left corners of the diagram, above which risks are steadily decreasing as we proceed North and below which risk steadily increases as we head South until we reach the highest possible risk; attempting to sell totally new products to customers we do not know.

The usefulness of the Ansoff Matrix does not end there, however.

The boxes also describe phases in the life cycles of products (as we have discussed earlier) which have markedly different requirements for cash and, similarly, generate differing amounts of cash.

When we are in the Product Development box, research and development expenses are high, as are promotional costs, whilst sales revenue grows slowly. Hence nett cash flow is negative in this area.

In the Market Penetration box we are maximising our sales to existing customers for the product we already make. The expenses from capacity expansion and promotional costs to meet or create these extra sales tend to cancel out the revenue increases with the result that cash flow is broadly neutral.

In the Market Extension phase, cash flow is strongly positive. A slower market growth has reduced the need to expand capacity, experience has reduced our costs and high market share lets us increase margins.

Diversification, on the other hand, is an expensive strategy as investment in R&D, production capacity, market intelligence and distribution all have to be paid for.

First choice – market penetration

Our recommendation is to apply resources first to market penetration strategies which depend on increasing volume. Some of the methods which could be applied are:

- further segmentation – the process of focussing on groups of customers with common needs. This allows marketing mixes to be designed specifically for customers that may previously have been ignored because of concentration on the larger, well established customer groups;
- re-examine methods of distribution: are Rutland/local authorities/potato merchants being ignored because current distributors do not have access to these potential customers?;
- consider ways of increasing the frequency of purchase of existing customers: offering trade-in allowances or stimulating demand for secondhand products;
- encourage customers to buy more units at each purchase by package pricing, or to buy more value by increasing specification as car manufacturers do;
- promote the use of a product for some new purpose; thereby increasing usage without changing the product;
- bring forward the purchase dates by offering special trade-in allowances or finance terms for early purchase;
- target a vulnerable competitor with special incentive for trading in his product (inducing brand switching, or 'conquest selling');
- attract new users to the market – people who have not previously realised their need for the product.

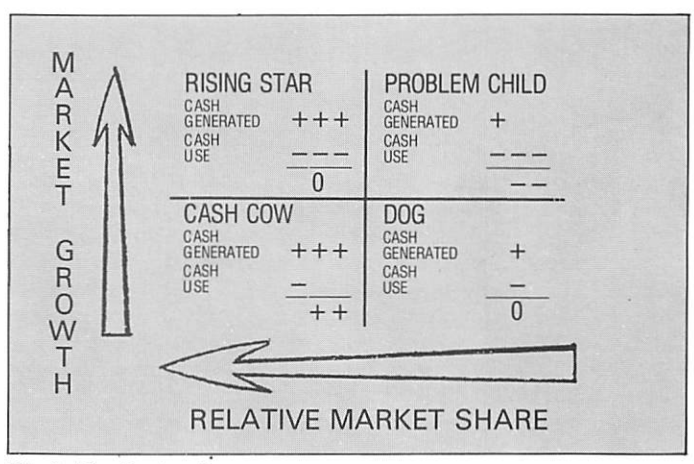

Fig 4. The Boston Box.

New products/new customers

Of course, there are stages in the evolution of companies when new products and new customers are essential to maintain growth or to sustain the company at its existing size.

The Boston Box (Fig 4) is a matrix that allows the resources used in the whole business to be assessed against the cash they generate. Products are positioned according to their phase of product life cycle:

- *Problem children* are products which are in high growth markets but need a lot of cash to realise the potential offered by that growth.
- *Rising stars* are grown-up children which are now market leaders in high growth markets. Even though successful, they may still absorb a lot of cash in keeping pace with growth and fighting off competitors entering this attractive market segment.
- *Cash cows* are the market leaders in stable markets, enjoying high market share, high margins and generating the cash to support the other products.
- *Dogs* are products with low market shares in declining or slow growing markets. If there is no prospect of an upturn in the market or no opportunity to take market leadership, these need to be dropped like a hot potato.

Another name for the Boston Box is the Product Portfolio Matrix. If you position all the products you manufacture on this matrix it shows:

- if you have sufficient cash cows to finance those problem children and rising stars;
- if you have enough rising stars waiting to be the cash cows which will finance development of your business in the future;
- if you are developing an unrealistically large number of new products for new markets and can your cash cows suckle those problem children?;
- it is probably time to shoot a few dogs.

Diversification – the last resort

In summary, the highest risk and the greatest negative cash flow comes from the new product/new market strategy. Before you embark on that route – a route which sometimes seems both unavoidable and very attractive – you should squeeze every ounce of opportunity from the customers and products you already have.

When you do follow the new product and/or new market route, there are relatively simple tools available which let you balance the risks and financial costs and benefits over your portfolio of products.

True diversification, like JCB making jet aircraft, is to be avoided whenever possible.

The skills shortage

B A Pamment gives his views on the shortage of skilled workers in British industry. He considers how this may affect the future of agricultural engineering and outlines what must be done to rectify matters.

We cannot avoid being influenced by what we read. In recent months, a barrage of headlines have proclaimed:

- "1992 will bring increased competition"
- "The demographic mix of the UK will change dramatically"
- "The British engineering industry fails to tempt recruits"
- "Engineering applications are in decline".

But the most serious of them all from our point of view must be:

- "The Skill Gap Could Be Lethal".

A crisis situation

Both Industry and Government have become increasingly concerned about the shortage of skilled workers. The phrase 'Skills Shortage' has become commonplace. The Training Agency – one of the bodies geared to meet the needs of industry – defines it as the situation which "results when companies seek to recruit more people with particular skills than there are available".

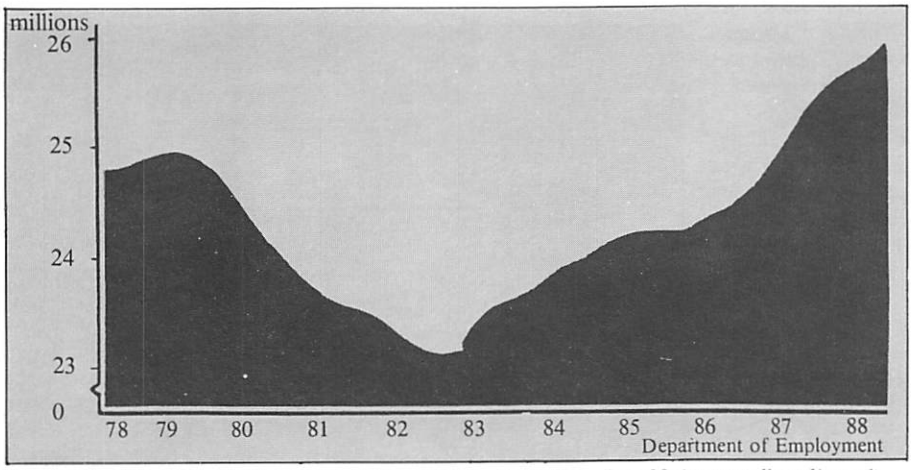

Fig 1. Workforce in employment: Great Britain, Dec 78 – Dec 88 (seasonally adjusted).

A few years ago, it would have seemed an unlikely topic, and even now it seems strange. But there is a mass of evidence which tells anyone who cares to look that we are in the midst of a crisis situation.

Department of Employment (DoE) figures (Fig 1) reveal the pattern of workforce employment between 1978 and 1988. There has been a steady rise in employed people since 1983 and last year there was an unprecedented demand for labour from all sectors of industry. The growth has expanded the numbers of employed people to a record level. Over 26 million are now in work from a total working population of only 28 million. The previously large pool of available labour has all but dried up.

Also, according to at least one source, the calibre of our working population is not good. In his book "1992: A Zero Sum Game", author Amin Rajan lists some frightening statistics: seven out of ten left school at the minimum school leaving age; seven out of ten had only a short initial training for their jobs; seven out of ten had no training at all after that.

Engineers are rarest

Taking these figures into account, is it any wonder that we now face a situation where employers face severe skills shortages in key areas?

A recent CBI quarterly Industrial Trends survey revealed that professional engineers are the rarest of people. One in four companies surveyed was having trouble recruiting engineers and while most companies expected the problem to peak between 1988 and 1989, the fact is that it is **still** a major concern – and will remain so unless we do something about it.

As well as there being more people in employment, the rise in self-employment and new small businesses is sucking up much of the available skilled labour. Since 1979, more than 1 million have disappeared from the pool into self-employment – seven times more than for all of the previous 20 years. In 1988, the number entering self-employment or joining small businesses was over 1000 per week. These potential employees are no longer available on the labour market.

DoE projections show that, between 1988 and the year 2000, the labour market will change drastically. Successive years of strong economic growth, and major changes in the population profile (or demographic changes as they are also known) are putting skilled shopfloor workers at a premium.

Fewer young people, more women in work

We know there is a looming shortage of school leavers. It is estimated they will drop by 1 million over the next five years. Yet still many employers naïvely assume there will be a continuous flow of youngsters eager to join them!

Apart from having far fewer young people to draw on, there will be dramatic increases in the 35-54 age bracket (Fig 2). The effect will be an average 15-year upwards shift in the age of the working population. What is more, the civilian labour force is projected to increase by only 1 million by the year 2000 – with 90 per cent of these being women. They are not traditionally known for wanting to become engineers.

The Department of Employment is not alone in signalling serious change. The Institute for Employment Research at Warwick University has made projections of employment to the turn of the century. The Institute predicts that employment will continue to grow, but in all the wrong areas for the likes of your firms and mine. It says the growth areas are likely to be the service industries connected with tourism and

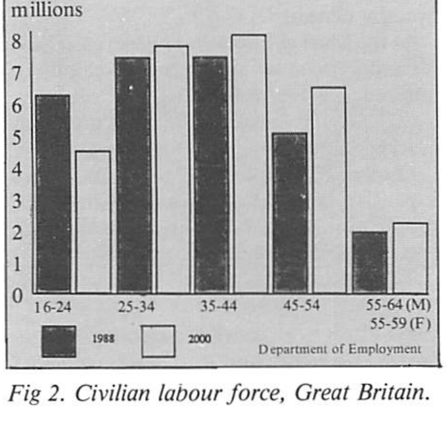

Fig 2. Civilian labour force, Great Britain.

Brian Pamment is Managing Director, F W McConnel Ltd.

leisure, who will take 75 per cent of the projected increase.

A further projection to the year 2000 (Fig 3) shows the components of employment change, and here there is a dramatic shift from shop floor skills and major increases in managers, professionals and the services – yet another warning sign.

While subject to error, these projections give useful insights into areas of growth and decline. The forecasts are vital for vocational education and training and for guiding planners to assess where proper training programmes can prevent industry's skills shortages.

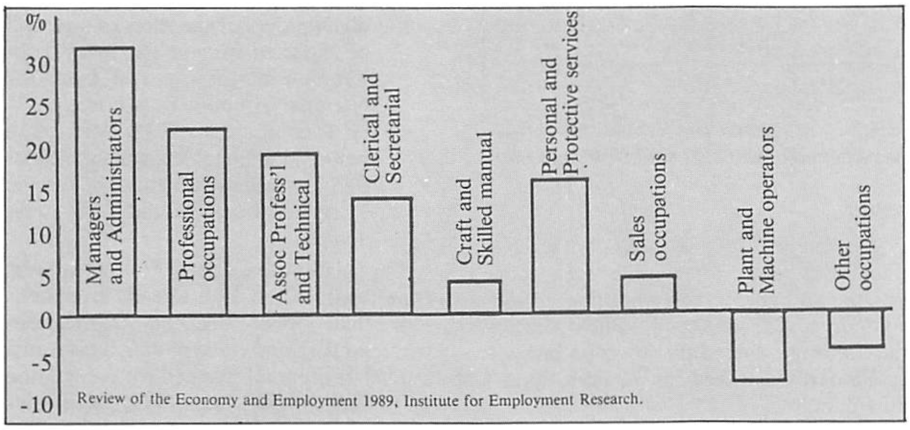

Fig 3. IER Occupational employment projections, components of change 1988 – 2000. All industries = 100 per cent.

Engineering – a poor image

It does not leave agricultural engineering manufacturers much to go for. The portents are bad and, in common with other engineering industries, we suffer from a poor image.

Fewer students are applying for Engineering degree courses, according to the University Central Council on admissions. 1990 applications show mechanical, electronic and conventional engineering courses are worst hit – and it reflects a 15-year slide. Decreased demand has led at least one university – Manchester – to accept mechanical engineering course students with fewer qualifications than ever before.

Furthermore, those on the courses may not necessarily go on to practice engineering. Indeed, a report last December from Imperial Venture Limited found only one third of the country's engineering students intended to do so. It found that another third would go for careers in general management and that 12 per cent preferred commerce.

The image problem runs deep. The Imperial Ventures report gives a large thumbs down to engineering. It makes alarming reading. From a student's view, it reveals that engineering company presentations are felt to be boring. Recruitment brochures are seen as untruthful. And the report concludes that many students see engineers as socially inept, narrow minded and unambitious.

Students believe that engineering careers are financially unrewarding and slow to develop. The report states that the more ambitious, forceful and socially skilled students are the ones least likely to stay in engineering.

Gloomy trading prospects

The picture is grim. How long can we allow it to continue like this when the USA, Japan and – come 1992 – the rest of Europe are waiting for the trade barriers to fall?

What about 1992 and the Single European Market? You might ask what is the connection with skill shortages. Well, our main market competitors also have skill shortages and productivity problems, in particular France, Italy and West Germany. But they commenced rectification procedures years ago.

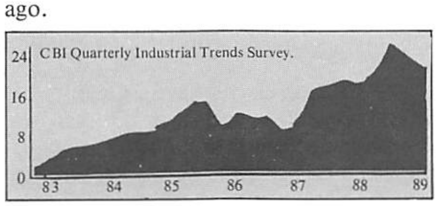

Fig 4. Percentage of manufacturing firms expecting shortages of skilled labour to act as a constraint on output (Jan 83 – Apr 89).

We keep hearing of preparations for 1992 by companies who are considering collaborations, mergers and acquisitions, but to remain competitive in real terms, we must deal with the human resource base problems which will affect design, technology and production.

A CBI survey (Fig 4) reveals a worrying number of manufacturers who expect skills shortages to affect their ability to trade.

The same survey also reports on the types of skill shortages being experienced. It is the shortage of engineers and machinists which has the worst effect on a company's output. Fig 5 illustrates how shortage of these two categories is causing severe or significant problems to manufacturers.

In another survey, TA/CBI Skills Survey in Manufacturing Industry 1988 it was found that 65% of mechanical engineering firms and 55% of general engineering firms reported skills shortages had affected their production (Fig 6).

What is to be done? – Training

Consider first traditional training and apprentices. Years ago, we saw apprentices in great numbers. Not any more. The apprentice has been added to the list of endangered species.

The craft apprenticeship has traditionally been the supply route for all skilled shop-floor labour, but with the cutbacks over the years in all major companies, the number of apprentices has been drastically reduced.

Fortunately, in the last few years, some companies – particularly in the north east – have realised that apprenticeship schemes and the more traditional training methods, are the correct way to avoid skill shortages, especially in those essential craft areas.

The Engineers Employers' Sheffield Association – EESA – revealed last December that 114 new apprentices had been taken on by 37 firms in the area, this being an increase of 63 per cent. Nicholas Kemp, the Director of the EESA, stated that companies are at last responding to the

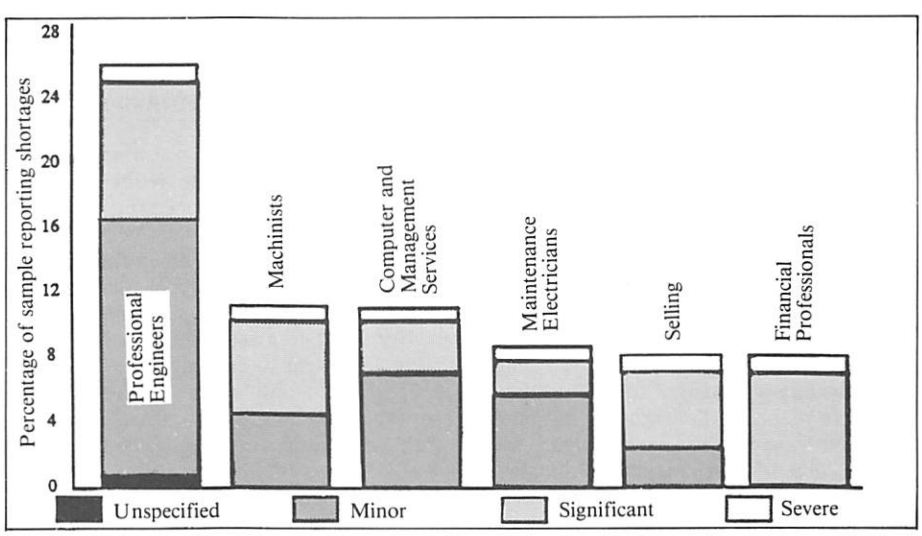

Fig 5. Occupations most frequently reported as shortages affecting output.

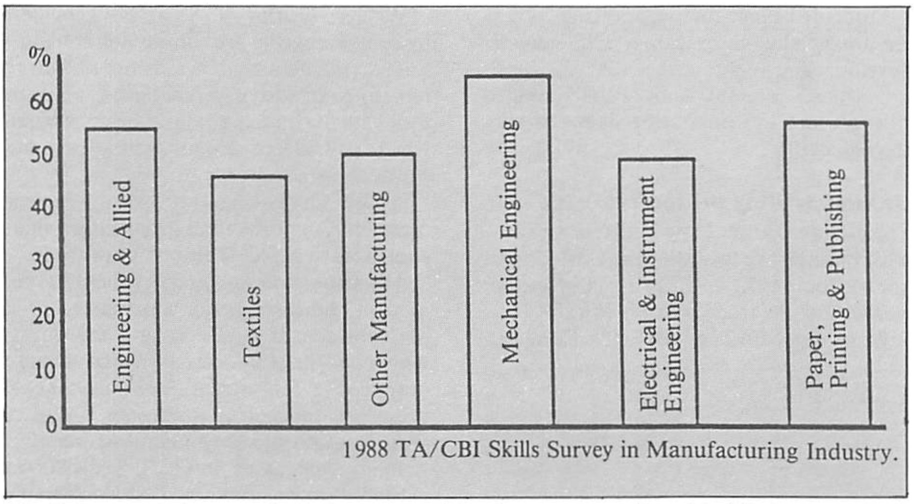

Fig 6. Reported shortages by industry – weighted percentage who said skill shortages had impact on production.

acute shortage of skills in traditional craft areas. Kemp surveyed 60 local companies employing over 18,000 people and found 25 per cent of those concerns had skills shortages in their traditional craft areas.

Most recently, however, the latest CBI quarterly survey of manufacturing industry told us that, in their efforts to remain competitive, British companies are about to shed thousands of jobs.

The survey suggests that the high cost of labour and the high interest rates are affecting companies' profitability, and this may well be true.

The real road to survival though is that companies must quickly consider how to change their recruitment, personnel and training strategies to cope with the decline. Failure to do so will starve them of skilled manpower at precisely the time when international competition is most threatening. Immediate actions should include:

- retraining and updating of existing employees;
- improving engineering's image among potential employees through closer liaison with schools, colleges, and through student sponsorship;
- improving the employment package for existing workers. This should not be restricted to shorter hours and higher pay – which is exactly what the CBI have warned against – but the package should include better training to enhance career prospects.

– Recruitment

We should also be looking at other sources of labour – the unemployed – by making training packages available, and those returning to the labour market – notably married women. The forecasts show women to be the largest potential source of labour in future years and this industry should be prepared to capitalise, even though it will seem a foreign idea to many traditionalists.

– Technology

Investment in the latest technology is, of course, an obvious move, with CNC machining centres becoming even more versatile and able to carry out many functions on a reduced set-up. But operators must improve their skills to cope and we have a particular need for the multi-skilled individual.

Training and Enterprise Councils (TECs)

That summarises what has to be done – but exactly how do we do it? The Government has set out its aims and policies for training and enterprise in the White Paper 'Employment for the 1990s'.

For years, industry has been asking for a say in industrial training. Now we have got it – in the shape of TECs – Training and Enterprise Councils which will cover the country.

All TEC boards will have a majority of industrialists on them. Their aim is to set up a programme which will help businesses improve their performance by encouraging them to plan and undertake training.

It is time to treat training as a serious investment, not just on an ad hoc, casual, basis. Directed and guided by industrialists, the TECs will ensure that young people are trained in the skills that the economy needs; also that the unemployed – particularly the long-term unemployed – acquire the skills, experience and enterprise to help them find and keep jobs.

TECs will also encourage new business starts, thus reinforcing the trends I pointed to earlier. And they will encourage existing businesses to expand.

A main aim will be to direct the trainers – the providers of vocational education – to meet local needs and to promote links between education and employers. TECs will formulate plans to ensure that both young people and adults go in for recognised National Training qualifications. Overall, their most significant objectives will be that:

- By the end of 1992 –
  - no young person should be employed in a job without formal training;
  - two thirds of young people should have achieved an NVQ – National Vocational Qualification – at level two;
  - all adult employees should be involved in company-driven training or personal development activities.
- By the end of 1995 –
  - all young people should have an NVQ level two by the time they are 18; and at least half should have reached NVQ level three;
  - at least half the existing engineering workforce should be in meaningful training for NVQ qualifications;
  - all employers, regardless of size, will be expected to have the Investor In People seal of approval from the National Training Task Force;
  - ALL companies will be expected to report to shareholders and employees on how they are investing in people. They will be accountable for their actions.

The National Council for Vocational Qualifications (NCVQ) already recognises more than 150 work-related qualifications from industry and trade bodies. This is just a third of the total planned for recognition by the end of next year. NVQ certificates are already being awarded at the first four levels of competence, so we can expect to see NVQs cropping up fairly soon in job applications – just like O and A levels.

The Engineering Training Authority

The Engineering Industry Training Board – the EITB – is the body responsible for the engineering sector, and during the 1990/1991 training year, the EITB is to be succeeded by the Engineering Training Authority (ETA). The ETA will take over responsibility for standards-based training, and will issue certificates to people who have gained the necessary training and experience from approved training providers.

The role for senior management

There is already tremendous enthusiasm for TECs from industry. Of the proposed 82 councils, 55 are already at the development stage, covering two thirds of the working population. Another 14 TEC applications are in and, by the end of this year, most of the planned 82 should have either full contracts, or at least be opening under development funding.

It is therefore up to us as employers – if we want to survive the undoubted pressures that will be forced upon us – to train our human resources and treat that training as an investment, just like an investment in plant and equipment. Investments in new plant are based on a corporate strategy. Our investments in people should be, too.

The key to the success of the TECs is that they are EMPLOYER LED. This is OUR opportunity to get it right for OUR industry.

The challenge for senior management in the 1990s is to plan to ensure that the skills shortage is nipped in the bud – and that it never recurs.

Manufacturing in the Third World

D H Sutton outlines the agricultural machinery and equipment needs of the developing countries and describes some of the means of meeting these needs through various levels of local manufacture. The potential for collaboration in transferring engineering design, manufacturing and business skills from industry and the professional institutions in the developed world is emphasised.

It is almost 10 years since the Institution last addressed the issue of manufacturing in developing countries. That was at the 1980 Autumn National Conference. The agricultural engineering manufacturing industry was already in difficulties and a great deal more has happened both in Europe and the rest of the world since then. Perhaps if parts of our industry had followed the advice of the distinguished speakers on that occasion they might still be in business today. But then with hindsight it is all too easy to be wise and conveniently forget the effect on even the most imaginative of managers of a bright red bottom line in the company accounts.

The major changes that have occurred in the industry in the past decade and the many difficult corporate and personal decisions that have been necessary are perhaps somewhat painful reminders that in the final count the ability to succeed in manufacturing agricultural machinery, as in most other businesses, depends as much on politics, economics and even sociology as it does on our skills as engineers or businessmen.

As engineers we may concentrate on the fascinating details of design and manufacture in isolation from the real conditions of the market place, but we do this at our peril. After all, what is the point of designing and making the best mousetrap in the world if in fact the customer cannot even afford the cheese, and in any case wants to kill locusts not mice!

The hard fact is that millions of our fellow men and women are constrained by circumstances beyond their control to a mere subsistence level of existence.

The extreme gap between those of us in the industrialised countries who routinely use modern computers as our 'tools' and those in the developing countries who still have to use the wooden plough or planting stick as their only 'tools' seems to be getting greater not less.

Helping to bridge that gap must be a major challenge for the agricultural engineering profession as we near the end of the century.

Derek Sutton is Head of Overseas Division, AFRC Engineering, Silsoe, and is Agricultural Engineering Advisor to the Overseas Development Administration, London.

Invest overseas – still sound advice

At our conference in 1980 much sound advice was provided which is just as important and relevant today.

In his summing up, the chairman concluded that the growth of small manufacturing plants in Third World countries was inevitable with the consequent reduction in export potential from the industrialised world, and that although the financial benefits from local involvement in manufacturing in the developing countries would be modest at best, it was probably the only way for some companies to stay in business.

So what has changed? Probably not very much.

Blacksmiths are, and will be, important in manufacturing in Third World countries.

An eventual trend towards larger, more highly mechanised agricultural production units is more than likely in most countries when economic and political factors allow. Meanwhile however, (and for some considerable time) there will be a large market for a wide range of often simple appropriate tools, implements and machinery which will not be satisfied by imports from industrialised countries but for which technical and managerial skills readily available in the industrialised world will be required for local manufacture.

Study the user

In the past thirty years or so considerable efforts have been made to develop improved small farm mechanisation technology. The take-up and impact of the results of much of this effort have, however, generally fallen short of expectations and the adoption by farmers – the acid test of effectiveness and appropriateness – has often been extremely low.

The technologies were sound in theory, but were generally too expensive for small farmers to buy and sustain. Inadequate attention was paid to cultural, economic and political factors.

An important message, therefore, for those of us working in agricultural engineering for small farmers in the developing countries is that our job is to provide technologies, tools, implements or machines for *people to use* – they serve little purpose on their own – and in order to ensure that the technology is appropriate and sustainable, we must have a thorough and deep understanding of the user of that technology.

Farm power – primarily human labour

The advanced farming systems of the developed world depend almost exclusively on fossil-fuelled mechanical power sources with the human element restricted generally to control functions rather than those demanding high levels of physical effort.

In developing countries where the small farmer predominates the situation is generally very different. The majority of farmers and their families are faced with a daunting level of physically demanding, often tedious, tasks crucial for survival and farm power is mainly provided by human or animal sources.

Table 1. Source of farm power* in developing countries.

Territory	*Labour* %	*Tractors* %	*Animals* %
93 developing countries	71	6	23
– Africa (sub-Sahara)	89	1	10
– NE/N Africa	69	14	17
– Asia (excluding China)	68	4	28
– Latin America	59	22	19

*Note – Total power use in man-day equivalents is derived by converting the estimated tractor hours and the work days of draught animals into labour day equivalents.

Source: African agriculture: the next 25 years, FAO, 1987.

Data published in a recent FAO study indicates that in Sub-Saharan Africa, only 1% of farm power is provided by mechanical means, 10% from animal power, and 89% from human power. (See Table 1.)

Decision on equipment must rest with farmer

The main issue for the governments of developing countries, therefore, is not whether to mechanise, but how to do so in the most cost-effective way. Considering mechanisation as an objective in itself is to confuse means with ends.

Although governments may have a strong influence on the outcome, the final decisions on type and scale of mechanisation are likely to be taken by farmers and machinery owners themselves.

What the end user needs and wants (not always the same thing) and can afford are therefore crucial to the development of agricultural engineering in any country.

Given the choice, farmers generally look for equipment to increase the security in production of food crops; to reduce drudgery by easing the difficulties of daily tasks and to help to clear bottlenecks in the production cycle. Five basic types of equipment may be involved:

- tillage implements and weeders;
- equipment and facilities for processing and storage;
- equipment for daily food requirements (mills, grinders, decorticators, etc);
- equipment for water lifting and transport;
- equipment for transporting people and produce.

Policies and strategies needed

What are lacking in almost all cases, however, are any coherent and sustainable policies and strategies for agricultural mechanisation.

This is an issue which is currently being addressed by the Food and Agriculture Organisation (FAO) who are now providing assistance to some Third World countries in the formulation of such strategies.

Comprehensive national plans must be prepared for the development of the agricultural engineering sector – covering research and development, training, imports, local manufacture, maintenance and repair facilities, parts supply and integration with other sectors in the economy.

In determining the agricultural machinery requirements of the Third World, therefore, we need a thorough knowledge and understanding of local conditions and circumstances and of the individual end users needs and wants.

It will be necessary to improve product selection and development and to set up better systems for marketing, distribution, spares supply and maintenance and repair facilities. It is sadly too common to see equipment and tractors out of service for want of sometimes the smallest part.

We should remember that farm power in the Third World, for the medium term at least, will come mainly from human and animal sources.

Long term potential will be high

In the long term the potential of these countries will be high. Political and economic breakthrough is needed, and I believe that this will occur and it will be those who are already involved and knowledgeable of local conditions who will benefit first.

Anyone who doubts the speed with which apparently impossible changes can occur in this world, has not been watching the news in recent months. When agriculture in the Third World becomes profitable, the change will be rapid.

Efforts to quantify the requirements for agricultural machinery in the Third World are fraught by a lack of complete and reliable data. However, UN agencies have attempted to massage the meagre data available to produce some broad generalisations which clearly should be treated with caution, but may serve as a guide.

In a 1981 forecast by FAO of the gross annual investment required for agricultural tractors and associated equipment by the year 2000 a figure of $26.1 billion was suggested with $4.3 billion for draught animal equipment and hand tools. This was based on an assumed increase in agricultural output of 80% over the period.

However, in view of the poor performance of the agricultural sector in the Third World a revision of the forecast was carried out in 1987. This gave a much more credible figure of $9.2 billion for agricultural tractors and equipment, and $5.6 billion for draught animal equipment and hand tools.

Even allowing for the high level of approximation in these forecasts this does give some indication of the potential.

By comparison it is interesting to note that the estimated output of UK agricultural engineering companies in 1989 was in the order of $2.4 billion – with exports to 179 countries totalling around $1.4 billion.

Meeting the needs

Clearly the agricultural machinery needs of the developing countries can be met in several ways. Through imports, or local manufacture with many variations such as local assembly and part manufacture, joint ventures with external inputs of capital, technology, materials or components and management. The difficulties can be formidable and it is obviously not for the faint hearted or those interested in quick profit in the short term.

Government intervention is often inconsistent and not always conducive to local operations. Fiscal policies vary and often constrain local manufacturing enterprises (for example, in the Philippines where imported equipment is taxed at 10% but steel at 50% or Thailand where parts are taxed at 30%, complete machines at only 5%).

Development assistance agency programmes can also be a problem with large scale provision of tools and equipment under emergency aid projects flooding markets with often poor quality, poorly selected equipment which inhibits the development of local industry.

Existing Third World manufacture covers basic agricultural hand tools such as hoes, knives, sickles and axes, produced in facilities ranging from the lone blacksmith to

Products range from improved hand tools such as this hand planter for maize and beans manufactured in Honduras.

the full scale semi-automatic plant. Animal drawn implements are also widely manufactured particularly ploughs and harrows with a wide range of local types and designs. In many countries production facilities are also well established for mills, threshers, shellers, oil presses and pumps.

Quality varies considerably being particularly affected by the availability of suitable raw materials as well as of skilled staff. Costs too vary considerably but generally farmers are prepared to pay more for a quality product when given the choice.

Much is talked or written about the transfer of technology but with some rare exceptions most technologies are very location specific and require considerable adaptation – often a complete re-design – to be effective in other locations.

The hoe is probably the most important tool for small holder farmers in Africa. But a hoe is not just a hoe! Each farmer has a very clear idea of which type or design is best suited to his particular needs and will often go to considerable trouble and expense to obtain this. Large scale manufacture of a limited range of styles may, therefore, not always be the best approach, and local blacksmiths may be a preferred source. Nevertheless in Tanzania for example, tools and implements have been imported for many years from the UK, China and India. A recent study indicated a potential demand of three million hoes per year.

In spite of the centuries old tradition of using animals for draught purposes in other parts of the world, many countries in Africa have only recently been introduced to this technology. In Tanzania, animal draught did not start until the 1930s, and currently 15-20% of the cultivated area is now ploughed using animals with a total of some 180,000 ploughs. An estimated 75,000 ploughs would be needed to satisfy present demand with a replacement requirement of 50,000 per annum.

Problems – poor communications, limited infrastructure, stifling aid projects

Communications are often poorly developed in the Third World and thus distribution of machinery and parts is generally difficult. As a result, the infrastructure for marketing and after sales service is very weak, and many suppliers can only sell direct to users. The market limitations combined with these communication problems mean that too much competition can have very negative effects where large numbers of makes and models of machines result in small volume sales for each supplier who is thus unable to provide adequate spares and after sales support. Limitations on the number of makes and models may often be necessary.

A high proportion of draft animal implements in Africa are imported in spite of local facilities with surplus capacity. This is often due to the negative effects of aid projects where large quantities of equipment are purchased through international competitive tenders which give the advantage to large scale producers in the newly industrialised countries where production costs and quality are often low. The unit cost of the small volume producers in the developing countries is inevitably higher and this makes competition with cheap bulk purchased imports extremely difficult.

Many markets particularly in Africa are, therefore, dominated by aid donor-funded projects which provide no incentive for the development of local manufacturing facilities.

Product diversification and flexibility

Success in manufacturing in developing countries, therefore, depends on product diversification and flexibility. This may well require consideration of non-agricultural equipment to help smooth out the seasonal demand. Profit margins in the agricultural machinery sector generally are not high and, particularly in the least developed countries where the main client is at or just above subsistence level, it is sometimes difficult to sustain even limited production of low technology products.

A wide range of tillage equipment is manufactured in many countries. This heavy duty disc harrow is manufactured in Mexico.

In some countries integrated manufacturing using blacksmiths or artisans as subcontractors for component manufacture has worked quite well, although it does require a high level of management and supervision for adequate quality control.

Some of the problems experienced by the smaller local manufacturers, particularly in Africa, are:

- Inadequate or unsuitable designs. Few companies can justify the cost of product development and therefore rely either on licensing, the use of designs from local R&D centres (usually inappropriate) or copying.
- Difficulties in supply and quality of materials, particularly steel. Unreliable energy supplies.
- Lack of skilled technical and managerial staff.
- Currency exchange distortions and fiscal anomalies, such as lower duty on complete machines than on components or raw materials.
- Problems of seasonality and the cost of holding stocks of equipment.
- Uneconomic small batch production runs producing higher unit costs.
- Problems in maintaining quality control.
- Marketing problems due to poor communications and infrastructure.

Manufacturing facilities

Blacksmiths and other artisans in the craft sector, particularly in Africa, are numerically the largest group involved in local manufacture, but they mainly make simple tools and animal drawn implements. In most countries there are only one or two larger manufacturers. For example, there are less than 20 industrial firms in Africa, manufacturing agricultural machinery, who have more than 200 employees. Most are medium or small sized companies whose operations are confined generally to fabrication (cutting, welding and assembly), with some machining, but rarely with heat treatment facilities. Often the cost of imported components and materials accounts for as much as 60-80% of ex-factory prices. Local added value is limited (less than 30% for hand tools and 30-50% for animal drawn equipment.

In countries such as Brazil, Pakistan and India where manufacture of a wider range of products including diesel engines has been established for some time almost all small and medium sized manufacturers have lathes, drills, grinders and welders. Larger firms have shapers, disc cutters and power presses (20-60 tonnes) as well as cutting and folding machines, and a few very large companies have milling machines. The use of jigs and fixtures is, however, not common and the lower level of technical skills often results in lack of uniformity and poor quality control.

In Pakistan, local manufacturing facilities are relatively well developed at various levels. There are some 462 agricultural machinery manufacturing units with 11 large companies, 40 medium companies and over 400 smaller companies in addition to several

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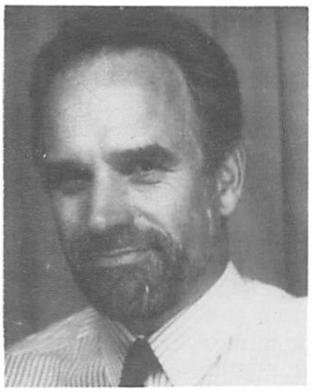
Small span, low cost bridge construction



In this paper, presented to a meeting of the Forestry Engineering Specialist Group, G Freedman discusses the design and economics of bridges for forestry work. He explains that modern concrete, re-inforced slab bridges can have low maintenance requirements but the steel/timber bridge is generally much lower in initial construction costs. However, the ideal would be to find an economical way of doing what the Romans did – build stone arches.

In the Forestry Commission a bridge is defined as a structure of any form for the passage of vehicles, animals or pedestrians, which spans more than 1.5m or has a waterway area in excess of 2.25m² or is more than 1.5m high. Types of structure range from large culverts to beam and slab bridge decks with abutments and piers and some suspension bridges. Forestry bridges being generally built over tributaries of upland streams require only small spans, averaging about 10m.

The type of spanning structure and materials used always relate to the size of the span. Durability and maintenance further help define the details of the structure.

The two basic requirements for farm and forestry bridges tend to be that construction should be as cheap as possible and they should require only minimal maintenance.

These parameters have led to a number of standard bridge designs, choice of which is determined mainly by span, but often by cost. Higher maintenance costs are now accepted if they are accompanied by substantial capital savings. Taking this philosophy further, structures only available intermittently or even temporary ones may be the answer if the price is right. Total appraisal of the project is required nowadays.

Choosing a site

Often the bridge site is strictly defined, but if any choice is available other sites should be assessed, sometimes with surprising results. The ideal site would have the following:

- smallest gap to span;
- a position requiring minimal road construction;
- good base for foundations;
- bank levels to suit required abutments;
- minimal flood characteristics.

The only way to complete the appraisal is to cost out the alternative schemes and compare them. At this stage, there are some important points to be considered:

- a smaller span may lead to more expensive abutments;
- roads cost £30,000/km to construct and bridges on average £20,000, so big detours are relatively expensive;
- bridges can be heavy when fully loaded and bearing capacities below 300kN/m² can give trouble. Rock near the surface is ideal, especially if constructing piers mid-stream where undercutting can be a problem. Sub-soil site investigations are expensive and for the scale of bridge in question need not be carried out prior to construction. The design should be prepared and based on assumptions which are then checked when the foundations are excavated;
- high bridge decks can require expensive abutments and piers. Elevated decks require embankments for approach roads. However, gorge conditions can allow bank seats in place of abutments, with a resultant saving;
- a slight detour may permit a crossing above a river junction which will reduce the catchment area and thus the risk of flooding;
- fords and Irish bridges are cheaper to construct but can be out of use during spate conditions and can cause severe undercutting downstream;
- bridges over public roads or railways may require special features which could cost more money.

Geoff Freedman is the Design Engineer with the Forestry Commission in Edinburgh. He is Hon Secretary of the IAgrE Forestry Engineering Specialist Group.

Definitions

Deck	–	platform over which vehicle crosses the obstacle.
Abutments	–	supports for the deck at either side and immediately adjacent to the obstacle.
Bank seats	–	supports for the deck set back from and above the obstacle.
Pier	–	a support for the deck in addition to and between abutments.
Span	–	distance between supports.

Design criteria

– Live loads

'Live loads' are loads on the bridge additional to the weight of the structure. All new road bridges on main forestry extraction routes are designed to carry the full range of 'Construction and Use' vehicles by allowing for the Department of Transport's highway loading, as given in BS5400, HA* loading plus 25 units of HB* loading. These are empirical loads – to simulate the complex dynamic vehicle loads by reducing them to a UDL (uniformly distributed load) and point loads.

Wind loads are not usually significant for small bridges but footbridges should be checked for their springiness (oscillation frequency) in case troops using the bridge fail to break step when crossing!

– Geometry of decks

A carriageway of 3.5m is now felt to be the minimum for a single track in Forestry Commission use, although 3.2m would do for most farms. A bridge should be approached by 20m of straight road to permit this minimum width, otherwise curve widths for tracking of vehicles (especially articulated ones) becomes a problem.

All decks should have a means of disposing of surface water, which otherwise can puddle and cause deterioration or freezing, thereby creating a hazard. A 40mm camber and 1 in 100 longitudinal fall is usually sufficient for solid decks, whereas timber decks should have minimum 10mm gaps between boards.

– Abutments and foundations

These are usually constructed from mass concrete on subsoil with an allowable bearing capacity of greater than 300kN/m² (3 ton/ft²). This will be achieved by almost all compact sands and gravels and boulder clays.

To test a pure clay soil, a man's weight should be placed on a 300mm diameter bar and it should not penetrate more than about 100mm to prove a bearing capacity of 300kN/m².

If bearing capacity is a problem, gabion abutments and a light steel/timber deck should be considered, however maintenance costs will be greater.

Another method of reducing ground pressures and costs is to use reinforced earth

* *HA loading is a formula live loading representing normal traffic in Great Britain including impact.*
HB loading is an abnormal vehicle unit live loading including impact.

abutments and wing walls. In the USA 85% of all retaining structures are of this type, the FC are about to undertake trials.

All abutments should be designed for stability under all loads. Generally the most critical stage is just before the deck is added, therefore complete backfilling should be delayed until immediately after this stage of construction.

Piers to support vehicle bridge decks should be avoided unless a suitable rock foundation is easily available, eg an outcrop at the correct place. Constructing in water for small jobs is costly and gravel beds can often move in torrent conditions, especially upstream where the streams are small and lively. Piers are, however, common on footbridges where less capital is at risk yet the savings on a clear span are significant.

For aesthetic reasons a more natural abutment face may be required. This is best achieved by building up stone on the inside of the shutter and pouring the concrete against it. Gabions filled with stone are generally accepted as looking 'rural'. Reinforced concrete abutments are not usually appropriate. They require skilled labour, more money and extra time to construct. However, they become necessary if bearing capacity is a problem.

If a ford or Irish bridge is being considered, undercutting of the river bed downstream of the site could be a problem. As the water passes over the smoother and sometimes restricted invert it speeds up thus increasing its kinetic energy. Downstream (within 10m) this is dissipated by eroding the bed. A mobile gravel is therefore very vulnerable whereas rock can withstand the attack.

– Waterway areas

Although physical characteristics of banks and bed will define the span and height of the deck, the quantity of water which will flow beneath it may require dimensions to be altered.

The maximum 50 year flood should be calculated using the 'Flood Studies Report' and possibly river gauge station information; then, by using (for example) Manning's formula for flow under the bridge, the required cross-sectional area may be calculated.

For smaller catchments, up to about 1km², the Countryside Commission have put forward a simplified formula which would do for many cases. When a reduced flood return period (less than 50 years) is designed for and a bridge is therefore overtopped frequently but still used in light flood it is called an Irish bridge. The ultimate Irish bridge is a ford which is a flat running surface at bed level.

Choosing a bridge type.

Having chosen the site, the approximate span will be known; by planning the road levels and calculating the required waterway area, the span and deck level can be finalised. The abutments or piers are then chosen

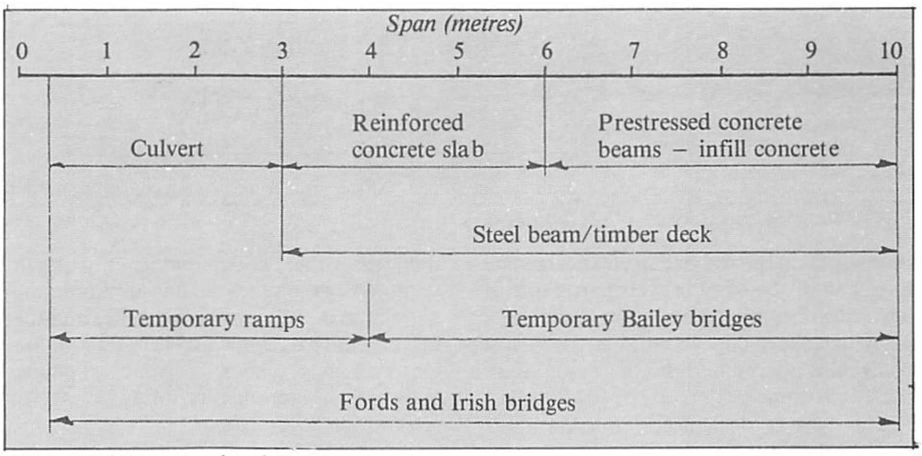


Fig 1. Bridge types related to span.

on the basis of aesthetics and allowable bearing capacity. Finally the deck, ie bridge type, is chosen. This choice is generally based on span, but there are parallel choices which, for example, may be more economic, involving less capital but requiring more maintenance or limit on usage. The choices of bridge deck as related to span are illustrated in Fig 1.

– Culverts

Although in Fig 1 culverts are shown as being used in spans up to 3m, multiplate corrugated steel pipes are commonly used up to 6m span. However, in one-off cases a small slab is usually more economic than these large sizes. Culverts interfere with the river flow and cause scour of the bed downstream; the greater the flow the more severe the damage.

In the small sizes they are very cheap and easy to install. Concrete pipes are best up to 600mm diameter, above that size, steel ('Armco') is best. Concrete pipes can be back-filled with less care whereas steel ones must have well graded material laid and compacted in layers to support the sides, which in turn support the soffit.

Literature on concrete and steel pipes is easy to come by and very helpful when the size has to be calculated. Sources recommended are Asset International (for Armco) and the Concrete Pipe Association*.

Multiple pipe culverts should be avoided since they form a trap for debris: one large pipe disturbs the flow less and gives debris a better chance to pass. Irish bridges suffer the same problems – see later section on 'Fords and Irish bridges'.

* *Asset International Ltd, Stephenson Street, Newport, Gwent NP9 0XH.*
Concrete Pipe Association, 60 Charles Street, Leicester LE1 1FB.

– Reinforced concrete slab

This construction is used for 3m to 6m spans (Fig 2).

Reinforced concrete became very popular in the 1950s and this 'maintenance free' material was used extensively for small estate bridges. It has since become apparent that concrete can suffer damage and require expensive repairs, therefore this is not always the automatic choice nowadays. However, with the use of air-entraining concrete additive, a cement-rich mix and carefully supervised work, a virtually maintenance free bridge can be built. The requirement for skilled labour, for steel fixing, the need for ready-mixed concrete to be available in the locality, the use of shuttering and the curing time needed by concrete all go towards making a reinforced concrete slab a difficult job and a more expensive one, particularly in remote areas.

A common problem with slabs is also that records are not often well kept and as vehicles increase in size the bridges need to be reassessed for load capacity. Not knowing what reinforcement is contained in the slab can make it cheaper to demolish the deck and reconstruct rather than carry out expensive detective work.

Costs today would be in the region of £2000-2500 per metre span of bridge, but as discussed there are a number of variable factors. In general, if conditions are favourable, this is the best bridge for the span range.

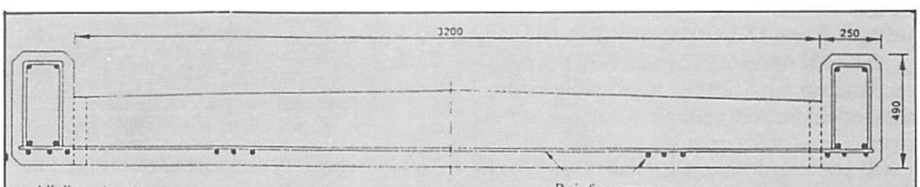


Fig 2. Standard reinforced concrete slab deck.

– Pre-stressed concrete beams

This has been a first-class solution to the 6-16m span range, tried and tested now for 30 years (Fig 3).

The factory-produced units have stood up well to the elements, in fact the exposed soffits have shown only negligible faults over

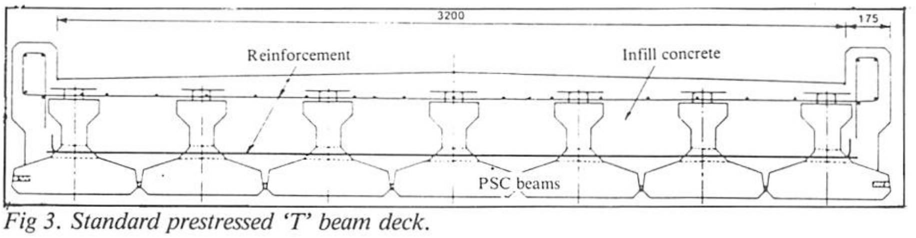


Fig 3. Standard prestressed 'T' beam deck.

this period on the more than 200 bridges we have had of this kind. This is partly due to the bridges being in compression all the time. They have been easy to build as the in-situ concrete is poured into the spaces and only the edge beams have required shuttering.

This type of deck needs concrete abutments since it cannot tolerate any differential settlement. It requires skilled labour, ready-mixed concrete and all the bits and pieces that contribute to making for a fairly difficult job.

Costs range from as little as £1500 to £2500 per metre span with the optimum span at about 10m.

General advice is that this solution must be considered for this span range and if the location is right it will probably be the optimum choice.

– Steel beam and timber deck

This type of structure is suitable for spans of 3m up to 14m.

Estate bridges at the beginning of the century were built like this to replace rotting wooden structures or instead of building expensive stone arches. Unfortunately, the steel corroded, the timber decks became loose and rotted and at the same time the new wonder material, concrete, arrived on the scene. However, another generation has passed and steel can be galvanised, timber may be pressure-treated and a lot of lessons have been learned about construction. Coincidentally, concrete has suffered carbonation, reinforcement corrosion, alkali silica reaction, etc, which have reduced its popularity as a durable material for low cost, low maintenance bridge construction.

The Forestry Commission has, therefore, designed a new steel beam and timber deck bridge to new DTp standards (Fig 4).

This type of bridge fits well with the rural environment and can be moved quite easily, the deck is flexible enough to tolerate some twist, therefore gabion abutments can be used, the construction is really "rails for wheels" therefore skews do not have to be designed for and it all costs less.

Forestry is a finely balanced financial enterprise which cannot support large early capital investment and farming is now the same, therefore this type of bridge becomes even more attractive at £1000-£1500 per metre of span. Very heavy use can wear and loosen timbers, so there will always be a place for the concrete bridge.

– Arch bridges (3-10m span)

For some time now the Forestry Commission have realised that their stock of 200 or so arch bridges have required less maintenance than the other bridges which are much younger. If the joints do not need pointing and the spandrel walls do not bulge and the barrel retains its shape there are no worries. Unfortunately, if something does go wrong it is usually serious, resulting in severe restrictions.

It is the intention now to design a standard arch using precast concrete blocks and develop a system to bring cost down near to that of other types. There are limitations as arches require very good foundations to reduce settlement and fairly high banks to avoid expensive approach embankments. Spandrel walls will be of stone and generally there will be no parapets unless the general public have easy access. To avoid spandrel bulge, certainly on smaller structures, the arch fill will be lean mix concrete.

When costs can be predicted more accurately a life appraisal will be done which, hopefully, will prove that arches have a place in today's standard bridge types.

– Temporary bridging

Prefabricated temporary bridges may be used in spans from 3m to 22m. The only true temporary kit bridge is the proprietary Bailey bridge, used mainly by the armed forces. The Forestry Commission and many estates have used these over a number of years with great success. However, the complex system of steel angles and channels invites corrosion and the pins linking the sections can suffer fatigue.

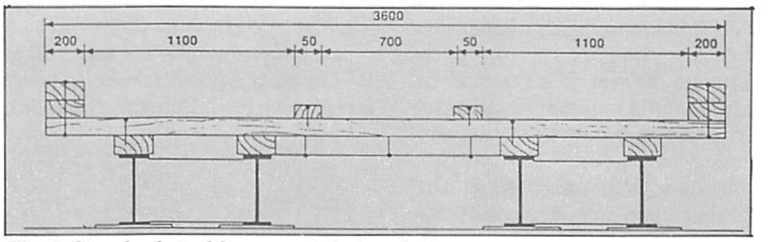


Fig 4. Standard steel beam and timber deck.

A reconditioned, galvanised bridge purchased and erected would cost about £2000 per metre span. However, as they are temporary and recoverable they are often much cheaper when appraised against a period of time rather than costed for life.

– Short span ditch bridges ('ramp' bridges)

These 'ramp' type bridges have recently been adopted by the Forestry Commission for traversing ditches and hillside burns.

The steel units must be light enough to be loaded and carried by a medium sized forwarder which constructs the bridge using 4.8m logs as bank seats and lays the units on top. They must be capable of withstanding torsion loads from the 12 tonne axles yet weigh only about 0.75 tonne. A 3m long unit costs about £1250, with two required per bridge. They are suitable for all construction-and-use vehicles and are available for hire for about £20/week/unit.

Larger span units are heavy and therefore cannot be moved easily, these should be considered for more permanent temporary structures.

– Fords and Irish bridges

A ford is a levelled out area of river bed over which a vehicle can run. This is the cheapest crossing of all, but has many obvious disadvantages.

A ford cannot be used when the river is in flood and as this cannot be predicted, operations may be interrupted. It can freeze in the winter and is a source of pollution from vehicle wheels washing into the watercourse. Freezing is common as fords are always low lying and skidding off can be very dangerous. There should be height markers to indicate depth of flow but these are often ignored or removed. A vehicle may stall part-way across requiring the occupants to wade to safety or the vehicle can be washed downstream. Either event can be fatal as it always happens at a time of high flow. Two local people were drowned this year in Northumberland.

An Irish bridge is a ford which has been elevated and culvert pipes placed beneath. They are not designed to take peak flow and the bridge is frequently over-topped. It has the problems of the ford, with the addition of causing under-cutting of the bridge and scour of the bed. This happens because the water flowing under the roads speeds up through the pipes to maintain the flow through a smaller cross sectional area, then slows up again on the downstream side. The deceleration energy creates scouring downstream; as this works back it eventually undercuts the structure, unless particular care is taken with the design and maintenance.

Icing is more dangerous than even on fords as Irish bridges are elevated and cannot have kerbs because they interfere with over-topping flow.

Maintenance costs can be high because concrete is usually wet which encourages freeze thaw cyclic deterioration. Blockages due to vegetation and tree branches cause damming and associated damage. The downstream undercutting can be serious with certain gravel beds.

However, these structures are suitable for temporary use or where traffic flows will be periodic and light and can be planned. They are particularly economic where they replace a long span structure. Nevertheless the dangers should not be underestimated and some day the Health and Safety Executive may find that these crossings pose an unacceptable risk.

– Footbridges

There are many types of footbridge on the Forestry Commission estates, ranging from long span suspension bridges, through those using ex-military girders, to quite small timber ones. The average span is about 6-8m. The Forestry Commission has standardised on its own design – the 'Galloway' footbridge.

The 'Galloway' design overcomes the two main problems:

- skilled labour not required for erection;
- future maintenance simple and economic.

Most of the fabrication is done in the joiner's shop and put together on site in such a simple fashion that it can be totally dismantled for maintenance (Fig 5). Very importantly the main beams are not holed, thus avoiding this source of rotting in timber beams or the expense of drilling steel ones.

Details of this bridge design and indeed many others, may be found in a publication by the Countryside Commission for Scotland, who have adopted the idea. The Army have built over 50 and are still pleased with the concept.

For longer spans it is usual to use piers where possible and reduce the effective spans but if this is not possible a suspension structure will be required. Traditional suspension bridges are very difficult to build while complying with HASAW (Health and Safety at Work), they are also very costly to maintain. A recent development by the Forestry Commission is a cable-stayed footbridge which has the advantages of suspension without the disadvantages.

Handrail design is now influenced more by liability than aesthetics. The traditional timber rails which gave a bridge the right visual geometry and merged with the environment are now considered by some to be a hazard where uninitiated public and animals have access. Mesh panels must have spaces small enough to reject a small child's fist, yet large enough not to provide a trap for a small finger. Most designers are, however, erring on the side of traditional rails until specific legal precedent is set.

Slippery wooden decks are a constant problem and should be handled according to location. Where only true walkers are to be found wire mesh nailed to timbers is sufficient. This, however, catches stilettoe heels therefore a bauxite/epoxy board should be used nearer civilisation. Where horses are to be found a non-slip, easy on the hoof surface, is trowelled bitumen with stone chips.

Maintenance

Civil engineering is not so different from mechanical engineering as is often made out. When machinery moves, works and deflects it suffers wear – so do civil engineering structures and, without maintenance, they deteriorate until eventually they 'fail their MoT', becoming unfit for further use. In the case of bridges, foundations can easily become undercut, materials deteriorate, vehicles may cause mechanical damage etc.

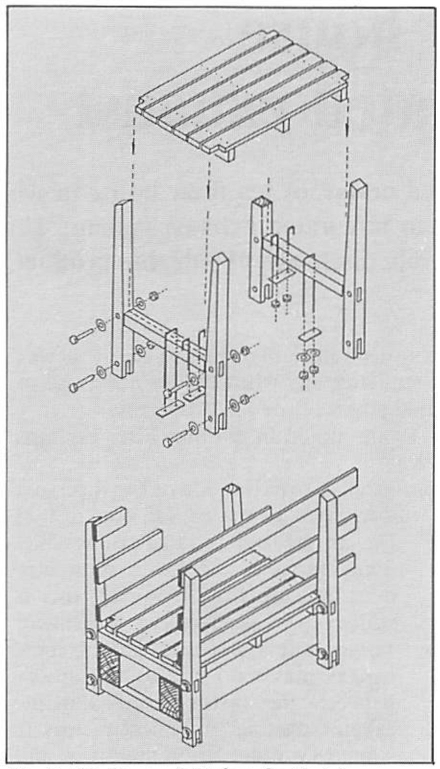


Fig 5. 'Galloway' timber footbridge.

All Forestry Commission bridges are inspected once a year. This inspection is mostly visual, with a little prodding here and there and great importance being placed on the rate or progress of any deterioration. This inspection regime is felt to be more appropriate for small, usually simple, structures in remote areas than biannual visual checks backed up by periodic structural inspections as carried out by the highway authorities.

Research continues into ways to protect bridges and prolong their lives. Two current projects are ramps and cement stabilisation of the approaches to avoid pot holes in the roads at the edges of the deck and the use of wax on steelwork in place of paint.

Costs

Fig 6 illustrates approximate construction costs as related to bridge type and span. Perhaps it should be said that unit prices increase as spans decrease as two abutments still have to be constructed. Similarly, the unit price may increase as span increases when deck construction becomes the major factor.

As regards the important, medium-to-short span bridges, the choice must lie between the cheaper steel/timber solution or the more expensive concrete bridge. Maintenance costs will be higher with the steel/timber bridge but even concrete, under tension, in a harsh environment, will eventually give some trouble.

The forestry industry is finely balanced financially. Large, early capital investment cannot be supported.

So, despite the extra maintenance required by the steel/timber bridge, this is a good investment. All pieces can be man-handled, beams can be spliced and the bridge may easily be dismantled and moved. Gabion abutments can be used where ground conditions are suitable, stone is available and height not excessive.

However, even this optimum solution still has a problem – it uses material in tension and the only truly maintenance-free structures are those which owe their entire stability to compression stresses. Therefore, the real way forward is to find an economical way of doing what the Romans did – build stone arches.

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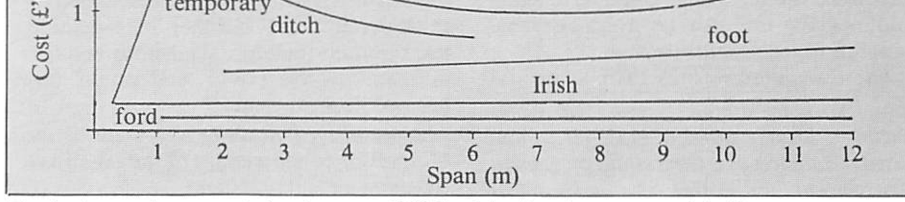


Fig 6. Approximate costs (at January 1989 levels) related to span and bridge type.

A tea drier house with integrated exhaust

J G S Norman describes an improved design of tea drier house in which the roof space is incorporated to form an integrated exhaust system. This gives improved dust extraction and negligible discharge of saleable product.

The task of the tea drier is to remove moisture from leaf which has been withered, cut, and fermented. The drying process must be carefully controlled, to reduce moisture content from approximately 65% to around 2.5%, without overheating (or 'burning'), with a good colour to the end product, and with the flavour-making elements of the fermented leaf un-spoiled. Furthermore, the product must be consistent, since buying of an 'invoice' of several thousand kg of product is based on tasting and visual tests of small samples.

In modern tea manufacture, fluid bed driers are almost universally employed, taking advantage of the small particle size of most modern teas. The larger-size or 'orthodox' tea such as some of us remember will not easily fluidise and has to be dried in moving-tray driers. These have relatively low throughputs for a given size and are mechanically complicated.

The fluid bed drier (FBD) commonly has a bed 8 to 9m long, and about 1.5m wide, and the drying process takes approximately 20 minutes.

Scope for improvement in exhaust systems

Drier exhaust systems are designed to remove air, which has become nearly saturated with moisture and is of no further use, from the drier, with as little carry over of tea particles as possible.

Some driers use a fan-powered extraction system, passing the exhaust through cyclones to remove the suspended particles, or else blowing them into the open, where they can become a nuisance to office dwellers and an eyesore as they accumulate. The arrangement is wasteful of electricity, which is relatively expensive in developing countries, and is open to back-pressure problems.

Many other driers have an upward facing divergent duct, where the used air can slow down, and allow most of the particles to fall back into the drier. The exhaust air then finds its own way to the open air but carries with it a considerable amount of suspended matter which could in fact be sold. Again, this can be a considerable nuisance to local residents.

The tea industry tends to re-vamp old factories rather than build new, so it was a red-letter day when the chance arose to build a new house for two driers.

Points noted in existing FBD exhausts were:

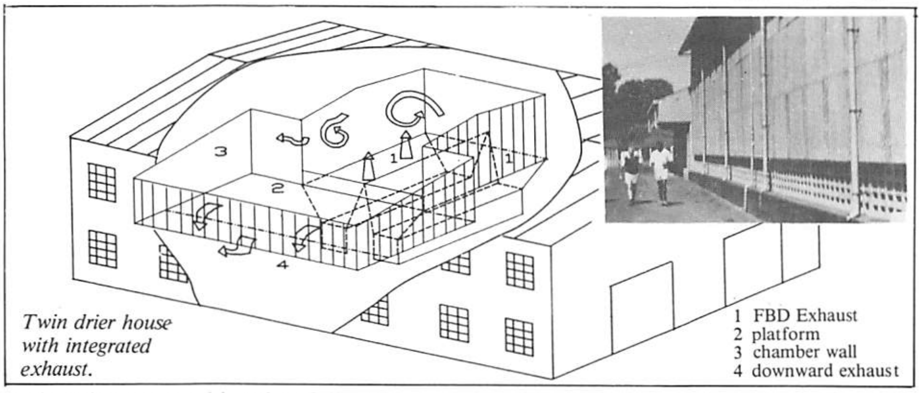
- exhaust over the side of the divergent duct gives a very wet fall-out, so that the carried-over product is unusable. Some factories employ a subsidiary drier to cure this. However, this is seldom a very satisfactory arrangement;
- fan-cyclone types and indeed most others make no use of the space between the factory roof and the exhaust ducting. A typical factory is some 18m wide, 5m to the eaves, and 8m to the peak of the roof;
- most exhausts to the open air discharge horizontally and give considerable fall-out, and can be vulnerable to reverse flow caused by unfavourable winds.

Design considerations and achievement

It was decided to aim for the following:

- simplicity;
- minimum back-pressure;
- minimum fall-out;
- the driest possible carry-over material, with maximum recovery;
- minimum alteration of a standard factory cross-section.

The design evolved is shown in the sketch.



Twin drier house with integrated exhaust.

1 FBD Exhaust
2 platform
3 chamber wall
4 downward exhaust

Design aims were achieved as follows:

Simplicity – there were no moving parts to the exhaust system. We considered electrostatic precipitators, but they are expensive, use high and therefore dangerous voltages and considerable power, and would have been difficult to clean.

Minimum back-pressure – there is no obstruction to the passage of the exhaust to the open air.

Minimum fall-out – this was achieved by having the exhaust system integral with the house. A chamber formed by the roof of the building and a platform over the loading end of the drier allows all exhaust air to expand gently and mix thoroughly. Here the exhaust can loiter and particles drop to the platform.

Driest possible carry-over and *maximum recovery* are ensured by mixing of exhaust, low velocity over the platform and the downward facing exhaust which is the principal novel feature of the design.

Minimum alteration of standard factory is achieved because the new exhaust system uses to the full the normally un-used space in the building. The only alteration is the addition of the side extension which provides the downward passage of exhaust air and minimises the chance of stray winds reversing the exhaust flow.

Experience in use

The system has been very successful, with good collection of dry saleable fibres and dust on the platform, and negligible fall-out into surrounding areas.

There was some condensation in the top of the exhaust during cool humid weather. This was cured by fitting a false roof over the outside of the building, giving a trapped layer of air as insulation. If necessary, rock wool could be added as a further insulator.

When a larger drier was installed, giving increased airflow and therefore increased velocity, there was some increase in fall-out. This indicated that the original design would need modifying to give more settling space, almost certainly achievable by increasing the width of the platform. However, the increased fall-out was not enough to justify the cost of modification.

John Norman retired recently as Chief Engineer, Brooke Bond, Kenya. He is now based in London as a Consultant on general management, tea, coffee, rice and tropical agriculture mechanisation.

Criteria in topsoil selection for sports turf

Soil properties are critical in determining the quality of sports surfaces, says S W Baker. He reviews the main criteria by which soils should be assessed.

Sports turf areas are characterised by repeated compaction with many sports taking place throughout the winter months when the soils are generally at or above field capacity. Furthermore there are strong financial pressures for play to continue throughout periods of wet weather.

For example, the members of a golf club will soon complain if their course is closed by waterlogging and for professional soccer cancellation of games causes major problems in terms of cash flow because of the loss of gate receipts.

This means soil properties, in particular their drainage potential, are critical in determining the quality of sports surfaces. Thus soil examination, either for the assessment of potential sites or for imported soils for construction and maintenance, is one of the most important factors in sports turf provision.

Soil texture for drainage and aeration

Most sports pitches and golf courses which are developed on natural topsoils, rely on the maintenance of soil structure to give adequate drainage and aeration.

In sports such as soccer, however, where there are strong shearing forces at the soil surface, this structure is rapidly destroyed and the volume of pores greater than 75μm in the surface 20mm is frequently <5% (Gibbs and Baker, 1989). This places a strong dependence on mechanical aeration to keep the surface open, eg weekly spiking to a depth of 100-150mm with slit tines. If there is more deep-seated compaction this can be relieved using a Twose Turf Conditioner (with a series of vibrating blades and 'bullets' acting to a depth of 200mm) or a Verti-Drain (tines up to 400mm in length giving a lifting action to loosen the soil).

It is only possible to rely on soil texture to give sufficient permeability after compaction when the sand content of a rootzone material is >90% (Fig 1). Even this can only be achieved when the sand component is sufficiently coarse (0.125-1.0mm, depending on the sport concerned) and of a uniform size distribution which prevents interpacking of the sand grains (Baker, 1988, 1989).

Fig 2 indicates the suitability of topsoils of different texture used for sports surfaces. For soils to sustain heavy use without intensive maintenance or some form of supplementary drainage there must be a high sand content.

Zone A of the textural triangle indicates those soils with ⩾90% sand and <5% clay for which the texture may be adequate to give acceptable drainage after compaction. There are very few natural topsoils which satisfy these textural limits, the most obvious exception is the very sandy terrain on which links golf courses are constructed.

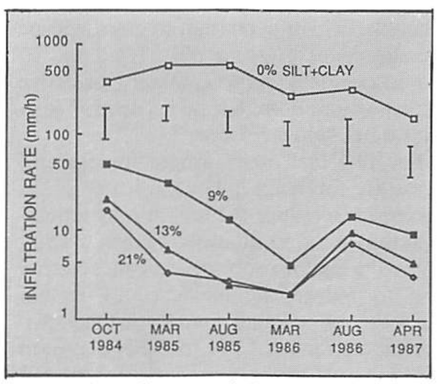


Fig 1. The influence of silt plus clay content on infiltration rates of rootzone layers receiving simulated wear (modified from Baker, 1988).

The second category of soils (Zone B) is generally suitable for sports turf areas as long as there is a reasonable soil structure, adequate maintenance (particularly aeration and heavy sand dressing) and providing that play is not too intensive. These soils, falling mainly in the loamy sand and sandy loam textured categories, can give an acceptable surface for winter games pitches (Baker and Gibbs, 1989), as long as play is relatively light (<4 hours/week). However, goalmouths and the centre circle can become fairly muddy in wet weather.

Where a sports surface is subjected to intensive use or a high standard of performance is required, the drainage capabilities of a sandy loam soil would have to be upgraded, for example, using slit drainage.

Baker and Canaway (1990) found that slit drainage at 0.6m centres, on a sandy loam soil (16% clay, 23% silt) gave an infiltration rate, after one season of wear, of 12mm/h compared to a rate of 0.5mm/h on the same soil with pipe drains only. This had significant effects on the retention of grass cover and on the playing quality of the surfaces and these advantages were even more pronounced when a 25mm layer of sand was placed on the surface before the slit drains were installed.

Assuming that the subsoil is relatively permeable, Zone B soils are generally well suited for golf fairways but for golf greens or bowling greens constructed to a relatively high specification, amelioration with sand would normally be used to improve drainage characteristics. For example, a topsoil containing 15% clay and 25% silt would have to be mixed in the ratio of 1 part soil : 2.6 parts sand to satisfy the criteria of <5% clay and <10% silt plus clay which is often specified as the rootzone mix.

If soils in Zone C are used for sports turf areas they will usually require either slit drainage in the case of winter games pitches or very heavy sand amelioration in the case of their use on, say, a golf green. For example, a soil with 25% clay and 30% silt would have to be mixed in the ratio of about 1 part soil : 3.9 parts sand to satisfy the criteria for rootzone mixes given in the previous paragraph. Where the soil has a well developed structure such soils can still be used in less intensively trafficked areas, eg golf fairways.

There are a number of constraints which make it unlikely that an adequate sports surface will result if soil from outside these textural zones are used. For example, if slit drainage is installed on a soil with a high

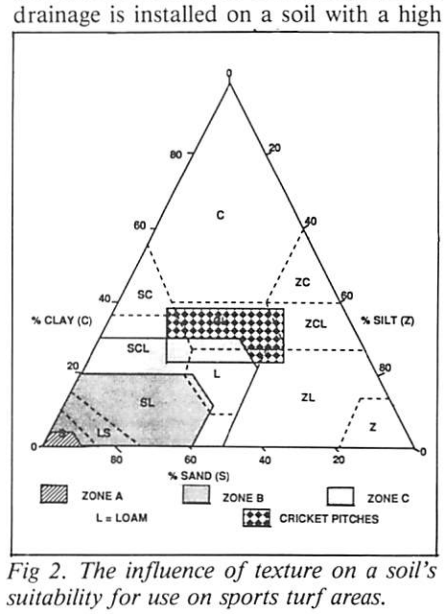


Fig 2. The influence of texture on a soil's suitability for use on sports turf areas.

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clay content, soil swelling becomes a serious problem as the sand may settle in the summer as the result of shrinkage and then the slits may be capped as the soil re-swells in wet weather. For soil amelioration, accurate mixing becomes difficult once the mixing ratio of soil to sand exceeds 1:4. Furthermore, on heavy soils it is difficult to achieve the limited range of moisture contents which allow the soil to be sufficiently friable for mixing to take place.

Cricket soils – a special case

One other textural category is shown in Fig 2. Whereas drainage is the main factor for most sports, cricket pitches and, to a lesser extent grass tennis courts, are dependent on the binding properties of the soil to give a good playing surface. This is particularly important on First Class cricket pitches where clay contents of 28-38% are recommended (Adams, 1983).

Structure and organic matter content

Under low and medium intensity sports use, soil structure has an important effect on the quality of the surface. Even in well compacted sand-soil mixes, aggregate size and clay dispersibility have been shown to have significant effects on hydraulic conductivity, total porosity and air-filled porosity (Baker, 1985).

Table 1. Interpretation of clay dispersibility coefficients

dispersibility	*soil quality*
< 10%	Exceptional
10-29%	Good
30-45%	Acceptable
> 45%	Poor – soil is prone to mechanical breakdown when wet

In assessing topsoil suitability, it is important that material has not been stripped in wet conditions or damaged by excessive compaction.

The main criteria are visual examination to establish that the soil has a well developed crumb structure and clay dispersibility measurements, which relate the quantity of clay particles (separated by shaking in water) to the total clay content of the soil (Table 1).

At the Sports Turf Research Institute we measure organic content by the loss on ignition at 400°C for eight hours. We generally look for an organic matter content of 4-12%, although in very sandy soils, an organic matter content as low as 2% can be accepted as drainage will rely on textural rather than structural porosity.

Chemical composition and contamination

On sports turf areas, the relatively high level of management compared with many other forms of land use, means that it is relatively easy to correct any deficiencies in soil nutrients by the addition of an appropriate fertiliser. Furthermore, in situations in which grass clippings are allowed to 'fly' rather than being boxed off, there is a considerable re-cycling of nutrients.

Therefore, the most important chemical factor is usually the pH of the soil and this is closely related to the type of turf being grown. On winter games pitches, for example, where perennial ryegrass will be the dominant grass, a pH of 4.0 to 7.0 would normally be acceptable. Corrective liming would, however, be needed for soils with a pH below 5.5.

For fine turf areas, where fescues and bents are the main grasses, a lower pH is preferred to reduce the invasion by annual meadow-grass, to limit earthworm activity thus reducing the problem of surface casting and to reduce the incidence of certain diseases, eg take-all patch disease. An acceptable range of pH for soils imported for fine turf areas would be 4.0 to 6.0 (corrective liming being used as needed). There are, however, certain situations, most notably links and chalkland golf courses, where the characteristics of the course allow soils with a higher pH to be used.

Table 2. Maximum acceptable levels of heavy metals in topsoils

Metal	*Max. level*	*Extract*
Copper	50ppm	0.05M EDTA (pH 7.0)
Nickel	20ppm	"
Zinc	80ppm	"
Lead	400ppm	"
Manganese	40ppm	1.0M Amm Acet

Problems of soil toxicity do occasionally arise, particularly if 'topsoil' has been stripped from areas of industrial activity. This can either be assessed by suitable chemical analysis (Table 2) or by growth tests in the laboratory.

In many sports the participants regularly fall or slide onto the playing surface creating a need for a soil which is free from glass, wire and sharp stone. The current British Standard for topsoil (British Standards Institution 1965) suggests that a stone content of up to 20% by dry weight is acceptable even for playing fields. Ideally this should be lower, eg 10%, and even with this amount provision must be made for stone picking.

Conclusion

A detailed laboratory examination of a topsoil proposed for the construction of an area of sports turf would cost under £100. This is the equivalent to the cost of between 5-10 tonnes of good quality topsoil. With the construction of, say, a soccer pitch requiring up to 2000 tonnes of topsoil, soil testing is a sound investment in view of the potential management problems associated with the selection of the wrong material.

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New tractor cab legislation

New legislation came into force 14 June 1990 to amend the Agriculture (Tractor Cabs) Regulations 1974.

Under the earlier Regulations, tractors must be fitted with approved and appropriately marked safety cabs when first sold or let on hire for agricultural use and no new safety cab might be sold or let on hire unless both approved and marked.

The new legislation amends the 1974 Regulations to accommodate six European Directives relating to the testing of safety cabs on certain agricultural or forestry tractors. This now allows tractor cabs tested and marked with a component type-approval mark in accordance with those Directives to be sold or let on hire in Great Britain. Safety standards are not reduced by these changes. The requirement for driver-perceived noise levels not to exceed 90dB(A) remains in force.

The new Regulations should encourage manufacturers to test in accordance with the Directives and seek type-approval under them, thus obviating the need to seek approval by the Health and Safety Executive (HSE), although the latter option remains open.

For the first time, the Regulations will allow for the sale and use of narrow-track wheeled agricultural or forestry tractors having a roll-over protection structure fitted in front of the driver.

The Agriculture (Tractor Cabs) (Amendment) Regulations 1990, SI 1990 No.1075, is available from HMSO and booksellers, ISBN 0 11 004075 9, price 95 pence.

Control the water and you control performance

P L K Dury discusses the design and construction of artificial (non-vegetative) sports surfaces and the methods of ensuring adequate drainage.

Whether it be natural turf or an artificial surface, the removal of surplus water from the surface and base layers is critical in determining the performance parameters of all sports facilities.

Synthetic structures are no different in this respect to natural turf.

Ball bounce, traction, rolling distance, shock absorbency properties and durability are all influenced by the amount of moisture retained within a structure. Furthermore, on artificial surfaces, the retention of excess moisture can have devastating effects on the materials used in construction, particularly the adhesives/resins etc when subjected to rapid changes in temperature.

Designing an artificial sports surface

In designing an artificial surface whether it be for soccer, hockey, cricket, etc, there are three major factors to take into consideration. They are:

- stability;
- stiffness;
- shock absorbency or reflection properties.

All the above are affected in varying degrees by:

- the amount of moisture retained within a structure;
- the effects of climate;
- the size and shape of particles making up the structure.

It is relatively easy to produce a structure that drains rapidly but the important consideration is what effect will such a structure have on the shock absorbency properties, the range of performance parameters, the overall stiffness and stability.

The importance of particle selection

The size and shape of the particles making up the sub-base formation and surface play a major role in determining the stability of the construction and the extent to which it will absorb or reflect energy; in other words, how shock absorbent it is.

Research in Nottinghamshire indicates that for small ball games like cricket, tennis or hockey, the size of the particles has a major role to play in determining the reflection of energy.

Where a material with a narrow range of particles is used, the larger the particles, the more solid the base formation and the greater the reflection of energy.

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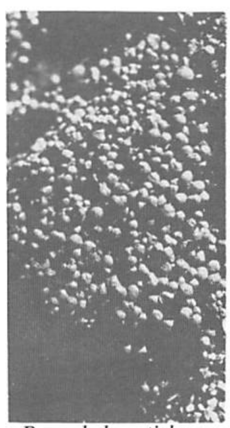
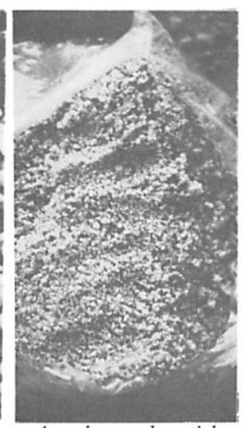
Particles in excess of 10 to 12mm can provide sufficient energy reflection to equal a bonded structure, whereas particles less than 10mm are capable of becoming firm but at the same time absorbing a degree of energy. This means they are capable, when carefully selected, of providing structures which are safe to fall on, but firm enough to give a level of bounce which is often similar to natural turf.

Where a material using particles less than 10mm is used and the range is from, say, 10mm to dust, the bounce will be determined by the moisture content and the percentage of fines in relation to larger particles. Because moisture can be held within the structure the firmness will vary and so will the bounce and shock absorbency properties. Such structures can become very hard giving



Rounded particles with high shock absorbency and ideal for a fluid system.

Rounded particles and angular rubber particles. High shock absorbency, not fluid.



Angular sand particles. High critical tensions and only fluid in very dry conditions.

A mixture of angular particles and rubber chunks. Very high stability.

a high bounce, ranging to very soft providing a low bounce. They are capable therefore, when carefully selected, of copying the playing characteristics of natural turf for sports where ball bounce needs to vary, which in some sport is important to the game.

Particle shape determines need for surface stiffening

It is important to bear in mind that the more rounded the particle and the narrower the range the greater the degree of movement which can have a major effect on surface smoothness, often referred to as evenness.

Where very round particles are used such as pea-gravel, structures require a stiffened topping to spread the load of impact, thereby maintaining surface smoothness. Angular particles on the other hand interlock and hold together thereby reducing the need for surface stiffening. However they be affected by high point loadings and therefore they too need some form of surface stiffening.

Angular, elongated particles not only tend to interlock, but also to lie flat. They therefore firm up considerably, and reduce still further the need for a stiffened top.

Stiffened tops can be formed from numerous materials ranging from bitumen macadam, fibres and sand, geotextiles of varying thickness, bonded rubber crumb, all used with varying degrees of success.

The base structure and the soil

The finer the particles within the base structure, the more water will be retained and this can have an effect on both performance parameters and levels of evenness unless, of course, there is a bitumen macadam layer or concrete between the base material and the surface. However, when materials like bitumen macadam are used, shock absorbency is extremely low and the surfacing materials have to compensate for the over-stiffness of the structure.

If fine particles are used, the greater is the moisture retention and therefore the softer the structure. In wet conditions, where soil is used as the base formation, as is the case with some cricket pitches, it is extremely important that a highly stiffened top is used if performance levels are to be within the required parameters.

Clay loams make very good sub-base structures for some artificial cricket pitches provided they can dry out during the summer months. If not, they create a 'pudding' which provides slow low bounce pitches.

The most consistent performance levels for multi-sports parks are where the base structure has no fines, the particles are within a narrow range, and the base formation is covered with a stiffened structure, perhaps a shockpad, and an appropriate surface.

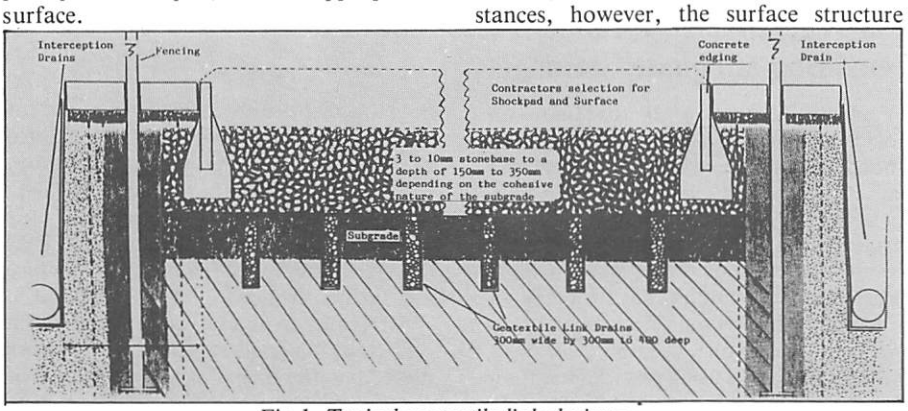


Fig 1. Typical geotextile link drainage.

Large areas, laid on cohesive soils, require a permeable base formation much deeper than areas laid on non-cohesive soils where drainage is good. Indeed, on highly permeable sub-grades, the depth of foundation can be as little as 100-150mm of small aggregate whereas on highly cohesive soils, the depths could exceed 0.5mm.

Drainage – the link drainage system

It is important to ensure that moisture is not retained in the base if adequate protection is to be provided during cold, frosty weather.

Foundations can be very expensive and one way of reducing the depth of the foundations is to use a link drainage system which is designed to shed water rapidly into highly permeable trenches. The base of the trenches must be at a depth exceeding the known depth of frost penetration within the structure.

Closely placed drainage runs are filled with a highly permeable material, with or without pipes (depending on circumstances) and preferably encased in a geotextile membrane (Fig 1). The distance apart, width of trenches etc is determined by the site conditions.

Incorporation of a link drainage system can allow a reduction in the required depth of base. However, it is important that expert advice is taken as to the feasibility of using such a system.

The wider and deeper the trenches, the further apart the drainage runs. The narrower and shallower the trenches the closer apart. Distances apart range from 10m with very wide trenches to as little as 2m with narrow trenches. It is suggested that the depth of base formation of such structures is never less than 150mm and may even be up to 300mm.

The important factor is to minimise the amount of moisture penetrating into the subgrade. This reduces the subgrade moisture content thereby reducing the available moisture to rise to the surface when the installation is frozen. The higher the moisture content within the subgrade, the greater the risk of damage due to frost.

An alternative approach is to utilise a very permeable fluid-like aggregate, ie rounded gravel or Sportag which is capable of self-levelling after frost. Under such circumstances, however, the surface structure must contain a flexible high load-bearing stiffened layer.

Ideally, particles should be in the range of 1mm to 6mm to obtain the greatest self-levelling effect. Sands have been used for this purpose but these are not as effective as a very rounded gravel or man-made materials above 1mm in size. Sands, particularly round ones, will self-level when dry but during wet conditions the critical tension between the sand particles holds them together reducing the fluidity of the material.

As with all sports pitches, the drainage and the base formation is critical to the success of the installation.

Selection of materials for the base

The types of materials used in the base formation vary from large aggregate to dust, or clean large aggregate to clean small aggregate, the choice of which is often determined by the type of system to be used. There is no doubt in my mind that the best range of particles for sub-base constructions ranges from 20mm down to 3mm with the most effective, for the surface layers of the base, being between 10mm and 3mm. This provides for a level of shock absorbency depending, of course, on the shape of the particle and gives maximum permeability without the risk of fine particles filling the voids created by the coarse particles and otherwise reducing the flow of moisture.

One of the problems with the Department of Transport (DTp) grades of aggregate is that they can include a percentage of fines in order to bond the structure and provide a firm base. It must, however, be borne in mind that the DTp specifications are designed to build roads and much of the moisture falling on a road is shed across the surface to the drains – indeed, roads are designed to be impermeable. This means that the water contained within the subgrade is minimal because the bulk of moisture is shed to the sides and any moisture in the subgrade is there as a result of lateral movement beneath the road and some moisture transfer within the overall structure.

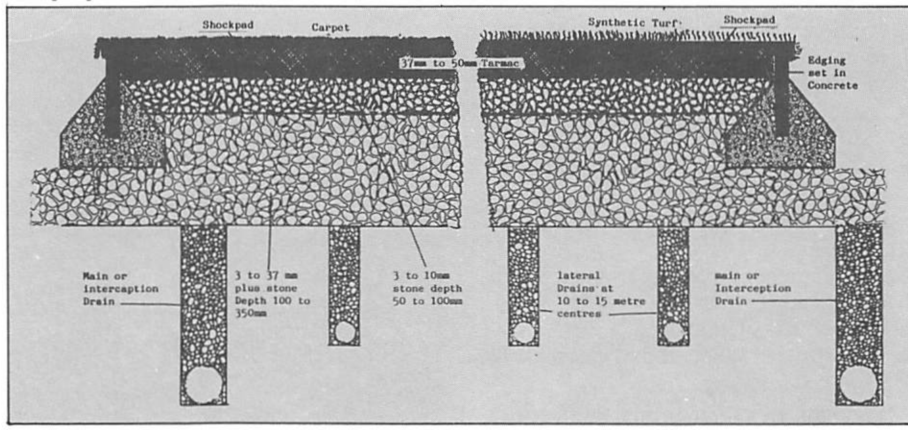


Fig 2. Typical pipe drainage static construction.

With sports pitches, it is critical that moisture penetrates through the structure rapidly and that surface run-off is minimal. On large areas like soccer and hockey parks, minimum moisture should be retained within the surface so that the effects of freezing and thawing do not have a detrimental effect on surface evenness nor on the backing of synthetics and especially on the adhesives used to join them.

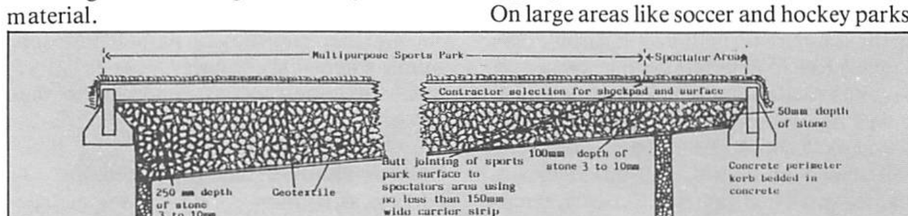


Fig 3. Typical graded base formation drainage.

Drainage for restored sites

Many types of drainage systems can be used under artificial surfaces ranging from conventional systems of pipedrains 10 to 15m apart (Fig 2) to where the entire sub-base is the drain (Fig 3). The depth of base formation varies, commencing on one side of the installation at, say, 150mm deepening to 250mm or 300mm on the lower side. The particles used in such structures have to be small but not less than 2mm. Such systems work on the basis of shedding all the moisture rapidly across the subgrade minimising the effects of any sub-structure movement, should it occur.

This type of construction is best suited to made up land where the quality of tipping has been uncontrolled or where the land has been built up but there are few records as to the nature of the tipping or where the land is unstable. In such cases, the objective is to minimise the risk of disturbing the subgrade and therefore the surface of the subgrade should be as impermeable as possible or, alternatively, very highly permeable. This type of construction was first laid in Nottinghamshire in 1975 and has performed very well.

Structures laid direct onto soil give nearest to natural turf performance

Types of construction of artificial surfaces vary considerably from densely packed stone supporting bitumen macadam of varying densities, surfaced with shockpads and synthetic materials to highly fluid

Water logged hard porous area due to fines and interlocking particles.

structures using very rounded particles surfaced with either a shockpad (not always necessary with very rounded particles), or an appropriate surfacing material. Examples of cross-sections through constructions are indicated in Figs 4 and 5.

Designing sub-structures for artificial surfaces is extremely important and has a major bearing on an installation's performance levels. From a playing characteristics point of view the nearest to natural turf is to lay structures directly onto soil, thereby producing changeability within the playing performance.

Such pitches have been laid in Nottinghamshire since 1979, with varying degrees of success. Overall they have been very successful for cricket and also as multi-sports areas of 2000m² and 3000m².

Alas, however, natural turf and its playing performance is not what is wanted for all sports – the structures have to be designed according to the sports being played.

Only with cricket and bowls is a range of changeability required by the players where the performance of the pitch or green varies from day to day and is a 'part and parcel' of the game. Even then performance levels must be within defined parameters.

Natural turf stabilisation

Although not seen as artificial turf, the stabilisation of natural turf with fibres is increasing and here again there is a wealth of knowledge available. This, of course, is another subject in its own right but the general principles regarding rapid shed of moisture are equally important. However, it is no use shedding moisture rapidly from the vegetation if there is not also the means to put sufficient moisture on to maintain the sward during dry weather conditions.

Stabilising the soil with fibres can increase surface stiffness, thereby making it capable of supporting more play in very wet conditions.

Getting the balance right is as important with natural turf where fibres are used to stabilise the structure, as it is with natural turf without artificial support.

Indeed, getting the balance right is the key to sports pitch provision at an economical cost. The location at which the facility is to be provided plays a key role in determining the costs of provision. It is a complex subject and with over 40 years' experience I am learning every day.

Further particulars on the subject are given in the Nottinghamshire County Council publication 'To Play Like Grass'.

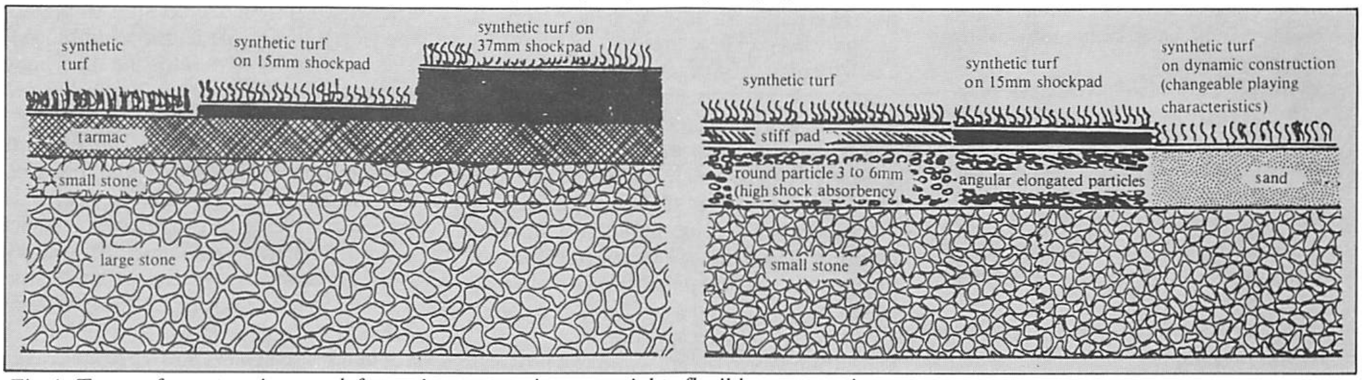


Fig 4. Types of construction: on left, static constructions; on right, flexible constructions.

20% by 2000 – the Soil Association's target

The Soil Association reports increasing support in its campaign to promote organic farming. From a register of around 100 organic producers at the start of the 1980's the numbers had grown to 1500 at the end of the decade. Organic farming is said now to cover over 40,000 acres, and there are a further 60,000 acres in process of conversion.

A challenging target has now been set for the 1990's. Under the slogan '20% by 2000' the Soil Association is calling for the conversion of 20 per cent of Britain's farmland to organic methods by the year 2000. Consumer surveys, they say, suggest that, by then, the market for organic food will reach about 20 per cent and also, by then, some 20 per cent of Britain's agricultural land will change radically in use due to extensification, nitrate limitation and conservation methods.

Organic agriculture is seen as the logical way forward. "Such development will, however, need government support for organic producers," declared Patrick Holden, director, British Organic Farmers, speaking at the Association's 1989 AGM. "The loyalty of consumers prepared to pay a premium for organic foods cannot, by itself, overcome the other economic and structural impediments to farmers wishing to change their organic systems.

"The end may be clear," continued Mr Holden, "but the means are not yet agreed and will be the subject of intense debate during 1990 and beyond.

"Let us hope," he exhorted, "that the great philosophy that led to the formation of the Soil Association in 1946 can help change the world for the better as we move into the last crucial decade of this century."

Footnote: Lady Eve Balfour, founder of the Soil Association in 1946 died earlier this year at the age of 91. She was awarded the OBE in the 1990 New Year's Honours List. It is ironic that the day after Lady Balfour died the Government announced the first ever British grant to help farmers convert to organic methods.

Irrigation of turf grass sports pitches

B Parker notes an increasing interest in automatic irrigation systems on both existing and new golf courses. He sees this trend extending to other sports turfs.

At the present time, there is no published survey data of how sports pitches are watered, if at all. However, the trade side of the irrigation industry has confirmed that, since 1960, there has been an increasing interest in automatic irrigation systems on both existing and new golf courses – and the trend is expected to follow for turf grass sports pitches.

The cost of sports field maintenance has increased and, more importantly, the difficulty of finding trained staff has encouraged clubs, municipalities and private owners to look at automation as a means of reducing peak work loads. Automation also helps to attract the younger professional groundsman, keen to reduce the level of manual work, typical in the past.

The need for irrigation

There are certain situations where the cost of installing an automatic irrigation system could be worthwhile:

- areas of low rainfall;
- areas where the natural soil is sandy or light and retains relatively little water;
- newly constructed sports pitches where coarse sands have been used as the growing medium;
- sports pitches which have excessive use and in situations where the turf must be able to revive after constant wear;
- newly constructed sports pitches where the owner requires the earliest establishment of the turf grass;
- fashionable and famous sports pitches where media coverage by television requires a visually luxurious growth that may not necessarily be required by the players;
- partially covered, or totally enclosed sports pitches where rainfall is diverted off all playing surfaces, so as to keep the surfaces dry during use. An automatic irrigation system applying the water at managed times, ie during the night only, is obviously appropriate;
- sports pitches situated in towns in the lee of tall buildings or other structures where localised dry spots cause patchy growth;
- where the money has already been spent on an irrigation system to one aspect of a multi-purpose complex, eg Disneyland, Paris, where the golf courses are to be irrigated as well as the landscape and sports complex facilities. In such circumstances, having paid for the basic infrastructure of water storage, pumps, electricity and pipework, it becomes economic to extend the system;
- in the situation where the sports surface is clay which dries out, an irrigation system can reduce 'dust' and reduce dry-surface scuffing.

Bruce Parker is a Consultant on amenity irrigation for Philip York and Partners.

In contrast, it should be noted, however, that sports pitches in schools, municipal parks, private clubs, which are well established on a well drained and water-retaining soil and which are situated in an area where summer rainfall is significant can safely keep to their manual watering facilities, provided they can accept grass set back and wear in the driest years.

If the well-established sports pitch appears to have a range of problems – poor drainage; diseases in turf grass; summer water shortage, it would normally be prudent to correct the soil drainage status problems before considering the installation of a fully automatic irrigation system.

Methods of irrigating turf grass sports pitches

Five alternative methods of irrigation must be considered. These are:

Cell/Purwick subsurface water table control – probably the most costly system to install, involving a sub-surface impermeable layer below the turf grass with a small pumped drainage system, which circulates the water both into and out of the area. The system has not as yet become popular in Britain, mainly it is thought due to poor uniformity through the soil and possible root drowning or salt build up in the water being circulated, giving patchy grass growth.

Subsurface drip irrigation – various products have been tried to distribute water below turf grass, but they tend to cause striped growth – where grass, directly above a drip line, has grown better than grass between lateral runs. Root intrusion of in-line or subsurface leakhose products is to be expected with time as are blockages due to carbonate precipitation or micro-organism activity. Turf conditioning soil slitting is likely to damage any permanently installed subsurface system.

Fixed set below ground pop-up sprinklers – the most common method of 'mechanised' irrigation of sports pitches in the UK. Various arc pattern and turning mechanisms are available which enable the designer to irrigate exactly where necessary and control accurately the quantity of water required, despite any local physical obstructions.

Hose reel sprinkler – the smaller hose reel or self travelling rain gun system as used by horticultural units is also widely used to water sports pitches. The system is relatively inexpensive but requires staff to move the irrigators and this work usually takes place during the day, which may interrupt the use of the sports pitches.

Manual watering – probably the most common means by which sports pitches have water applied to turf grass. The hose and sprinklers are moved by the groundsmen and the work involved is labour intensive. Both over- and under-watering problems are most likely with this method. As with hose reel sprinkler systems, watering is likely to interrupt the use of pitches during the day.

Designing the irrigation system

The design and layout of the irrigation system depends on a number of factors. The following remarks apply particularly to the design of a pop-up sprinkler system.

Firstly, it must be recognised that the sprinkler throws water in a circular arc or in segments or an arc. It can be limited to segments of 45°, 90°, 120°, 180° etc, or to any arc required up to 360°.

It is an inefficient way of spreading water as it loses water by evaporation in the air as it is thrown, also it deposits water unevenly and with different droplet sizes throughout the length of its arc. As the wind blows, it also distorts the pattern of the throw quite arbitrarily according to wind speed and the type of sprinkler.

The designer is aiming at achieving the best uniformity of cover and especially making sure that the driest sector of the sprinkler's arc of throw receives sufficient water. A typical well designed sprinkler system in an average wind situation achieves a coefficient of uniformity (CU) of about 70% or in design terms, overwatering by about 40% to achieve sufficient coverage to water the driest sector.

Sports pitches are usually square or rectangular in shape so normally the designer is limited to square spacing for sprinkler positions. Normally good design would involve 90° arc sprinklers on the corners with 180 – ° arc sprinklers along the sides and 360° arc sprinklers in the centre as required – with all sprinklers throwing water in an arc which touches the next sprinkler position.

Assume soils free draining and design for worst case use

Once the sprinklers have been selected to give a uniform pattern of coverage, the designer must consider the features of the site (areas in the lee of tall buildings, or obstacles not to be irrigated, ie outside eating areas, pitch-side cafes), and then modify the design to suit.

The availability of water and at what times of the day, should be considered, together with the need for the provision of emergency water storage in the event of drought.

The designer does not usually consider climate as he is designing a system which can cover the pitches in a dry period and usually within 10 hours during the night. The fact that rain falls during the summer is seen as a bonus which does not affect sports pitch irrigation design.

The soils are usually assumed to be free draining and rooting depth is assumed to be shallow, the soil is not assumed to retain much water and would tend towards the sandy loam to loamy sand texture.

The designer for sports pitch irrigation systems, unlike agricultural or horticultural irrigation design, is designing for worst case use, with little regard to crop, soil or local climate.

Management and control

The groundsman with an automatic irrigation system will normally have an electronic controller inside his office or, at the very least, a rain gauge on the sports pitches in order to manage the irrigation system according to the needs of the site.

More sophisticated controllers can be used which not only control the system but also provide records of water use, together with a link to a weather station to modify use automatically. More normally, a sports pitch irrigation system has a simple electronic or electromechanical controller which is programmed to operate valves to sprinklers in a simple daily pattern.

Watering is usually between midnight and 8.00am but the provision to syringe the pitches during the day should be an option of the control system. A syringe is a short burst of water during a mid-day free period when the pitches are not being used. (Clay tennis courts use this for dust supression and to reduce scuffing.)

Some thoughts for the future

- Cheap water is a thing of the past, and clubs should budget to see some 400% increase in costs for water within the next 10 years, and also take account of water from public supplies being less freely available.
- Dry summers will mean restrictions on water use and clubs will need to consider water storage as a feature of any of their watering/irrigation systems.
- More attention to soils' water holding capacity will be considered together with more deeper rooting grasses which can tolerate dry periods. (In the USA, grasses which can withstand drought are being bred, and our own cultivars will be required to do this, whilst continuing to give the surface that players require.)
- Soil drainage and hence soil aeration of sports pitches will help to keep sports turf healthy despite an increasingly hawkish attitude to watering during dry periods.
- Sports pitch irrigation, automated, and with a computer based control system will continue to be important but must be geared to water budgeting and relate to soil types, drainage status, and the introduction of drought tolerant grasses suitable for the UK climate.

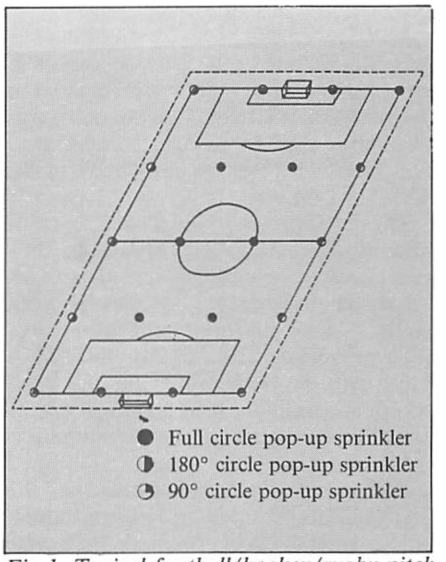


Fig 1. Typical football/hockey/rugby pitch pop-up irrigation sprinkler head layout.

It is unlikely to be the contractors or those with interests in selling irrigation equipment who will be at the forefront of the changing attitude to the water requirements of turf grasses on sports pitches.

The independent irrigation consultants and research institutes which study the water requirements of turf grass will lead the way in reducing the water requirements and saving on capital expenditure in irrigation. They will probably also be promoting better drainage and the selection of deep rooting drought resistant grasses.

Continued from page 81

thousand blacksmiths and other craftsmen. Since 1970 tractor sales have risen from 400 per annum, to a peak of 32,000. There are five makers established in the country assembling CKD units with currently up to 50% locally made parts.

It is important to recognise, when considering the viability of agricultural machinery manufacture in developing countries, that economies of scale differ enormously depending on the character of the production technology being used. It is often possible to obtain very worthwhile economies of scale at much lower levels of production in developing countries than would be the case in the industrialised countries.

As a general rule, there is little research and development capability at company level, and this is one of the main barriers to technological progress as it inhibits appropriate design and adaptation of machinery to local needs.

There are a number of regional organisations such as ARCEDEM in Nigeria established to assist the development of rural industries, but these generally have a poor record of success.

Local manufacture vital for future

Events in Eastern Europe and South Africa will inevitably distract attention and draw resources away from the heavily-indebted, over-populated, under-producing, disadvantaged nations, particularly in Africa and South Asia. With the increasing difficulties being faced by these countries in selling their only exportable commodities of primary agricultural products, foreign exchange will be even more scarce. Commercial exports of agricultural machinery to the Third World are therefore, unlikely to grow at more than a modest pace. The development of local industries geared to the real needs of the large number of small farmers will take on greater importance.

Increasing attention will be given to the development of technical skills at the village level. There will be more local development of entrepreneurial skills in setting up workshops for light manufacture and repair. This will form a strong foundation for the development of agricultural equipment manufacture in a similar way to that in which the industry developed in Europe and the United States through the efforts of the John Deeres, McCormicks, Harry Fergusons and Ransomes of this world.

The continued operation of large, expensive manufacturing facilities in developed countries with limited product range for export will not be feasible. However, with the latest advances in computers and manufacturing technology and management, it is perfectly feasible for a production line to produce versions of a particular machine adapted to the end user's particular needs. Surely these same skills that have enabled companies such as Massey-Ferguson to adapt to changing circumstances can be used to develop appropriate manufacturing technology in the developing countries to meet the actual needs and purchasing power of local markets.

Aid agency funding will continue to be important in the medium term and imaginative proposals for projects to strengthen agricultural engineering policy and strategy formulation, and local manufacturing, distribution and repair infrastructure in the developing countries will not always fall on deaf ears.

Role for the AEA; the Institution?

Trade Associations like the AEA should, perhaps, be more dynamic in promoting contact with Third World industries as their Dutch, Belgian and French counterparts seem to have been, and to consider assisting local manufacturers, associations or groups. One such group of agricultural machinery manufacturers established in Indonesia in 1967 now has over 60 members.

As a final thought, perhaps we in the Institution should look more closely at how we can be more active internationally, as well as cater better for the needs of our overseas membership.

Straw and Moore

Sam Moore, one of the great characters in agricultural engineering, was recognised in the New Year's Honours List when he was awarded an OBE for services to agriculture. This follows his election as a Fellow of the RASE in 1984.

The development of reduced input cultivation owes much to Sam Moore. In 1963 he was responsible for the introduction of the design which later became the Rota Seeder – a slit cultivator used for rejuvenating grassland. The famous "3D" drill which was the backbone of the ICI drive into direct drilling involved Sam Moore as part of the development team for machinery.

Moore Unidrill Limited was established at Ballymoney in Northern Ireland and the first Unidrills became world leaders in high output direct drills for grassland. These were followed by All-Till drills; arable drills that could be used as direct drills in conventional seedbeds, behind the plough or into trash, including stubbles.

The system for the 1990s from the Moore stable is a tractor with a rubber-tyre roller on front linkage, a drill on the rear and all this following only a plough with furrow press. All other passes are cut out. This system is claimed to be particularly suitable for those wishing to incorporate straw and/ or using the flexible blueprint developed by IF Research for ICI as the "Cost Cutter Planner".

Moore Uni-drill Ltd, 33 Kirk Road, Ballymoney, County Antrim, Northern Ireland. Tel: 02656 64444.

Bill Mann – the Claas combine man

We regret to record the death of J R "Bill" Mann who passed away at the age of 74 years on May 8th following a lengthy illness.

Bill Mann is best known for his achievement in founding J Mann & Son Limited – the Saxham-based Claas Combine and Machinery Importers – and building this into a nationwide opeation which included Yorkshire and Scotland-based Parts and Service Centres.

Born on June 27th, 1915, Bill was christened James Raymond but since his forename was the same as his father's, he was known as 'Bill' from an early age.

The first Claas Combines were imported from West Germany in 1947 when Bill formed J Mann & Son Limited. It is significant that the announcement of the sale of the 24,000th Claas Combine in the UK to a Norfolk farmer was made only a few days before Bill's death.

Bill sold J Mann & Son Limited to Rotary Hoes in 1969 and the company was subsequently taken over by Claas OHG – the West German manufacturer whose equipment the company has now marketed in the UK for 43 years. He remained on the Board of Manns until his 70th birthday.

We extend our sincere sympathy to his widow and family.

F W McConnel 1902 – 1989 An Inventor and a Pioneer

I like to think that the RASE Silver Medal awarded to Shelbourne Reynolds Engineering Ltd, for the grain stripper head for combine harvesters is also a tribute to Freddy McConnel, as he was known to all his friends; surely the innovator of this and many other designs of agricultural and other types of machinery.

Sadly Freddy died on the 27th February 1989 but last summer his family allowed me to look through some of his papers, patents and photographs in order to write this tribute.

Freddy McConnel was born in 1902 in Dumfriesshire, the middle son of a colliery owner and mining engineer, and lived at Sanquhar. In 1955 I met his father, a charming old man, who graphically described mining at the turn of the century and who had in his day regularly descended to the coal face, something that was almost unheard of in the days of top hats and frock coats. Freddy undoubtedly inherited much of his father's engineering skill and, after an education at Harrow and Pembroke College, Cambridge, he took a two year engineering apprenticeship at Erith.

In 1926 he married Pansy Pollock and she told me last summer that, shortly before their marriage and for some time after it, Freddy had been working on a revolutionary rotary engine which was liquid sealed. It was patented in 1927 and, to judge by the drawings, consisted of two rotors, the inner one containing six U-shaped combustion chambers but no pistons, connecting rods or crankshaft. In 1928, before the engine was started, Pansy very sensibly decided to view the proceedings from the safety of an attic window, but to her surprise it ran successfully and did not explode.

Freddy took out further patents on it in 1931 but I have been unable to discover the final outcome. The previous year he was with Metal Castings Ltd, where he patented a new type of bobbin for the weaving industry and subsequently became a director of the company.

However, it seems that in the early thirties he was mainly interested in agricultural machinery and took out patents for the Robot Transplanter and the first Midget Self-Propelled Toolbar which was later manufactured by M B Wilde Ltd. The driver of this machine sat in a 'deck chair', very close to the ground and steered with his, or more often her, feet leaving the hands free to do the weeding or singling.

The Harvester Thresher

1935 and 1936 saw the patents for two types of fruit graders for the South African market and the sharing of ideas with his great friends, Douglas Bomford and the Hinds brothers. From one idea conceived by F & G A Hinds, Freddy designed and built the first mechanical hop-picker.

Another of his designs started with Douglas Bomford noticing that if he ran his stick through a standing crop of wheat much of the grain was knocked out. This led to the aforementioned Harvester Thresher.

However, the war intervened and Freddy came south and joined the Admiralty Mine Design Department at HMS Vernon at Portsmouth until it was badly bombed, which led to a move to Lee Park at Havant.

Following the war there followed a succession of patents of which, in my opinion, the most interesting was the Growing Corn Thrasher from 1943 to 1954 and the rotor with loops for it from 1952 to 1956.

Shortly after the war the McConnels moved to Fartown, Pensax in Worcestershire. Freddy was experimenting with a mounted model of the Harvester-Thresher. It was quite different from his original design, which was front-mounted on a Fordson tractor and land wheel driven, or the models made by M B Wilde & Co, which were trailed and driven by a 10bhp Petter twin cylinder petrol engine.

The NIAE had two machines for test purposes and some machines were used abroad for rice crops. In June 1966 E S E Southcombe, a student at Silsoe College, wrote the history of the machine, a copy of which is still in the College library. The Harvester-Thresher development was shelved in 1958 and it was not until recently that new work by the AFRC supported by the British Technology Group, led to production by Shelbourne Reynolds Engineering Ltd, using rotary combs made of modern plastics instead of Freddy's discs and vanes.

An early member of the IAgrE

In 1952 Freddy was invited by the IBAE, as it was then, to deliver a paper – 'The Problems of the Development Worker' – at its open meeting in London, and in 1954 Tony Lees, of Harry Ferguson Ltd, asked him to read a paper – 'The Gap between the Inventor and the Manufacturer' to the Midland Centre.

McConnel Verge Cutters, Power Arms, Hedgecutters and Ditchers, etc, etc

The name McConnel will probably be best remembered for the Verge Cutters, Power Arms, Sawbenches, Sheep-foot Trimmers and particularly his Hedgecutters and Ditchers which still bear his name.

Freddy McConnel had a large circle of friends and he will be sadly missed but his good humour, his kindness, his Company's name and his many ingenious inventions will remain a tribute to a great engineer.

Robert H Litton

Agricultural mechanisation policy and strategy
by A G Rijk

Publisher: Island Publishing House Inc, Manila, Philippines.
ISBN: 92833-1112-4

The contents of this book have been submitted as a PhD to Wageningen Agricultural University. It is the result of the author's involvement in agricultural mechanisation in Asia since the mid-seventies. The research was a direct result of consultancy with the Economic and Social Commission for Asia and the Pacific regions.

The object of the work was to provide a guide on how to organise agricultural mechanisation to support national development.

A general introduction presents the rationalé, scope and objectives of the study. This is followed by a review and assessment of mechanisation in both an economic and historic context.

Several distinct stages are proposed relating to increasing sophistication in technology. These are related to the effects of market pricing, capital investment as well as the socio-economic situation. It is a well argued case producing a most interesting set of conclusions for which I had much sympathy.

The work then considers the status of mechanisation in Thailand, which is further developed by expanding the data base from which a model for amalgamating the mechanisation processes is presented and its validation by comparison with the 1986 situations is shown.

The final part of the work concentrates on using the model as a predictor to measure the effects of such issues as wage rates, interest rates, cost of machinery and fuel. Further work investigates the effects of changes such as cropping, labour force on capital, stock and productivity.

From this work forecasts are made relating to various policy decisions possible in Thailand's agricultural sector. A final section provides conclusions and recommendations related to the predictions from the model.

MJH

Living water: Viktor Schauberger and the Secrets of Natural Energy
by Olof Alexandersson

Publisher: Gateway Books
ISBN 0-946551-57 X
Price: £5.95 (paperback)

This is the first book in English describing the life and work of Viktor Schauberger, pioneering Austrian naturalist and Agricultural engineer.

Viktor Schauberger (1885-1958), had no formal scientific training, but based his observations and inventions upon his years of practical experience in forest husbandry.

Schauberger's motto was "Kapieren und Kopieren", or; 'first understand nature and then copy it'. In an extraordinary career, he used this principle to develop systems for log transportation, irrigation, water purification, and agricultural machinery harnessing air and water power. For example his flood barriers were always inserted in the river bed, as he believed "a water course should never be regulated from its banks, but instead from within, from the flowing content itself".

Olof Alexandersson who has written this readable and interesting account is a Swedish electrical engineer and active conservationist. It is easy to see the current appeal of Schauberger's 'vision' to the contemporary conservation movement.

Some readers will no doubt be sceptical at some of the more radical conclusions of Schauberger's later work. Nevertheless there is much appeal in his simple, and inventive approach to many areas of land management and agricultural engineering.

Rather than being a Text-book, *Living Water* is an entertaining and thought provoking read. While being particularly aimed at conservationists, it will also be of interest to students, and anyone concerned with scientific or agricultural history, land, forest and water management. The accessible style and presentation of the paperback edition additionally make this introduction to Viktor Schauberger's work attractive to a wide variety of readers.

NJB

The failure of reinforced plastics

Papers reprinted from a Special Issue of The Journal of Strain Analysis for Engineering Design. Vol 24, No 4, Oct 1989
Edited by F L Matthews
Pub.: Mechanical Engineering Publications
ISBN 0 85298 7099 Price £18

The last 20 years has seen the rapid development of the use of composite materials in agriculture. Most of us have a limited understanding of the complex materials science related to the topic of reinforced plastics. It is therefore a pleasure to announce that there is now this excellent set of papers available to review the current levels of knowledge in this area of great importance to agricultural engineering. The list of contents is as follows:

- The failure of fibre composites: an overview,
- The fracture mechanics of delamination tests,
- Damage development in composites: mechanisms and modelling,
- The role of moisture diffusion and matrix plasticisation on the environmental stress corrosion of GRP,
- The fatigue behaviour of fibrous composite materials,
- Edge effects and delamination failures,
- Modelling and characterisation of textile structural composites: a review.

I am sure with the range of work from international experts this special publication will become a source of reference for those working in the field of reinforced plastics for the agricultural engineering industry.

MJH

A guide to designing welds
by John Hicks

Publisher: Abington Publishing
ISBN 85573 0030

One of the most common techniques in the design and fabrication of agricultural equipment is welding.

This book is written with the designer very much in mind, informing him of much that he requires to know about design of welds and setting out the information he should provide to the welding engineer or fabrication overseer. This should then assist in providing engineering performance, safety, reliability, cost and appearance.

The publication is presented more as a handbook, being a total of 68 pages in length. The short chapters give in note form information on preparation, distortion, calculation for static welds, welding method, as well as weld properties, defects and testing.

Presentation is easy to follow with plenty of accompanying diagrams and illustrations. It does, however, lack an index which is a little frustrating. By its very nature it is by no means an exhaustive text but the areas it covers are well explained.

A most useful text for any engineer.

MJH

Harvesting machinery – Shire album 234
by Roy Brigden

Publisher: Shire Publications Ltd.
Price: £1.75

Published to coincide with the Food and Farming exhibition at Hyde Park, this 32 page booklet by Roy Brigden, the Keeper of the Museum of English Rural Life (University of Reading), considers the history of harvesting machinery in the UK.

It firstly traces the history of the early reapers and binders and threshing and winnowing machines, until we see the final phases of development in the combine harvester including the likes of the Clayton and Shuttleworth and the Californian horse-drawn machines.

In a similar way the development of hay making, grass drying, silage making and root crop harvesting is traced from its roots to the early 1950s. It is a concise booklet full of excellent and, in some cases, rare photographs of our harvesting past.

An absolute must for the historic machinery buff, but I am sure of interest to all who work or have worked (as my back will happily record) in the harvesting business.

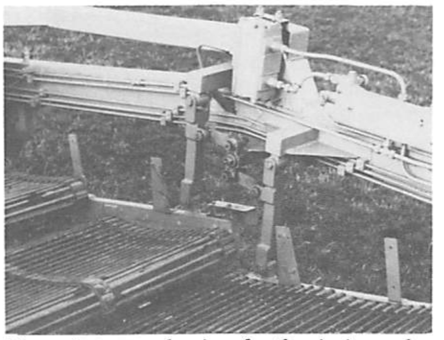
MJH

'Pulsar' potato harvester from SCAE

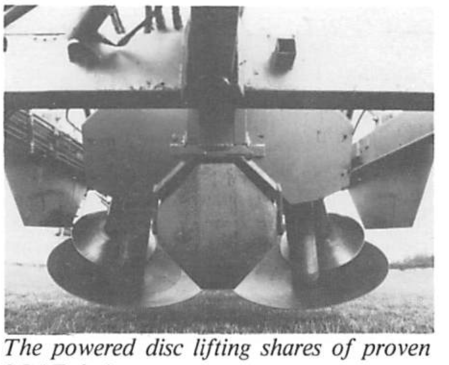
British Technology Group, the world's leading technology transfer organisation, has announced that it has licensed the Dutch company, Riecam Borselle BV to manufacture and sell Pulsar, a novel design of potato harvester, developed at the Scottish Centre of Agricultural Engineering.

The Pulsar, so called because of the pulsating horizontal agitation of the sieves, is a two row unmanned machine with the proven SCAE powered disc lifting shares. This type of share has been shown to reduce potato damage by almost 30% and the draught can be over 80% lower than with conventional flat shares. A single central depth roller runs between the field ridges, avoiding compaction of the ridge crowns. The sieving webs incorporate horizontal agitation throughout. This method of sieving has been shown to be at least 15% faster and 15% less damaging than vertical agitation in heavy conditions and even better when the soil is dry. Adjustments can be made quickly. The amplitude of horizontal agitation can be adjusted over a wide range, as can the frequency of the sieving webs.

A prototype Pulsar harvester is illustrated on the front cover of this issue.



The agitator mechanism for the sieving webs.



The powered disc lifting shares of proven SCAE design.

Riecam Borselle BV, a subsidiary of Ploeger-Riecam Holding BV, is a leading company involved in the marketing and manufacturing of planting and harvesting systems for 'root' crops such as sugarbeet, potatoes, carrots, onions, etc. In the UK, these systems are sold via its exclusive distributor Market Rasen Engineering Ltd, which will also build and sell the new Pulsar potato harvester.

Riecam Borselle BV intends to offer a number of different options of the Pulsar. In its simplest form, it will be marketed as a windrower. The trailed machines will be similar to the existing SCAE two row, unmanned, direct loading prototype but with the option of tanker and picking table versions. The top of the range will incorporate all the benefits of the Pulsar into the existing Riecam self-propelled harvester.

'Market Rasen Engineering Ltd, Gallamore Lane, Market Rasen, Lincs LN8 3HZ. Tel: 0673 843402.

The new KM220 light-weight thermometer from Kane-May Ltd of Welwyn Garden City covers a temperature range of −30 to +150°C and −20 to +200°F. A membrane tactile keypad with simple operation enables the operator to switch from Celsius to Fahrenheit. The thermometer has 0.1° resolution and automatically records maximum and minimum values. It also has a 'hold' facility.

Priced at £49.50 the KM220 is suitable for use in a wide range of applications where the convenience of this pocket-sized unit will ensure that a thermometer is always to hand.

Dowdeswell awarded RASE Silver Medal for Front Press Linkage

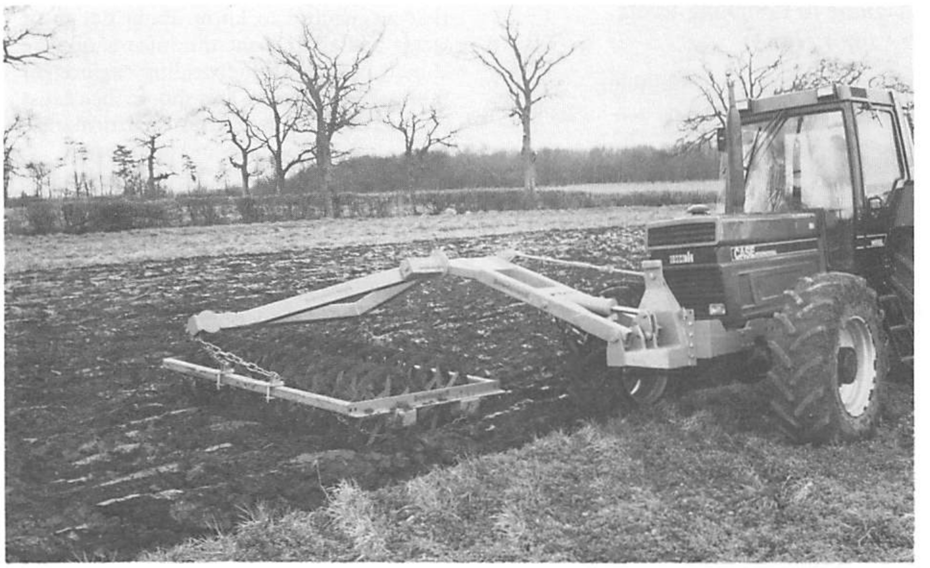
The patented tractor front-mounted press linkage developed and manufactured by Dowdeswell Engineering to improve the flexibility and ease of use of a furrow press has secured a Silver Medal in the RASE's 1990 Machinery Award Scheme, sponsored by TSB Bank.

In awarding a Silver Medal, the judges acknowledged the advantages produced by the press in terms of manoeuvrability, time and effort saving as well as the effectiveness of front mounting on the tractor.

Designed for use in combination with reversible ploughs of up to five furrows, the press linkage is mounted at the front of the operating tractor, towing and guiding the attached press over the furrows turned on the previous pass across the field.

In addition to making turning at headlands easier, the hydraulic lift facility is also extremely useful when manoeuvring around obstacles such as trees or pylons. The tractor driver simply lifts the press from the ground on its linkage, lowering it back into work when the obstruction has been passed.

The Dowdeswell Front Press Linkage is priced at £2685. Mounting brackets suitable for most modern tractors are available at extra cost. Full information is available from: Dowdeswell Engineering Co Ltd, Blue Lias Works, Stockton, Rugby, Warks CV23 8LD. Tel: (0926) 812335.

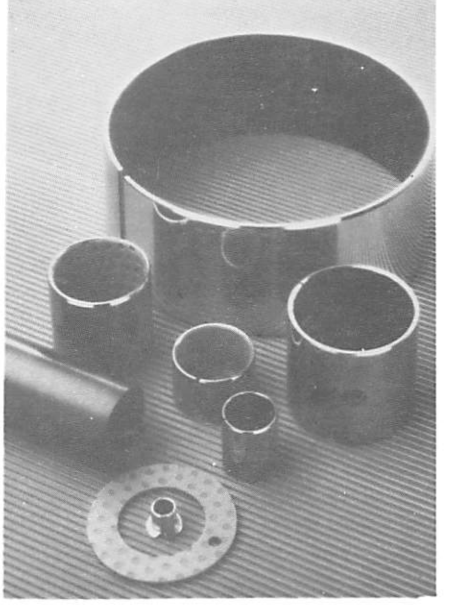


The Baddeley Rose Welly Washer is available via mail order for £29.95 from Baddeley Rose Ltd, Unit 9, Park Industrial Estate, St Albans. The stand handle is 28 inches high for stability and the base incorporates a scraper bar and boot jack.

Know your bearings

The Glacier Metal Company, a unit of Turner and Newall plc and with manufacturing plants in Kilmarnock, Glasgow, Ilminster and Manchester ranks as the largest plain bearing manufacturer outside America.

Peter Dolman, Glacier's Bearing Applications Engineer, brings us up to date with what is currently available.



Bearings to operate without lubrication

Glacier DU – designed to operate without lubrication in areas such as packaging and labelling equipment, wood processing machinery (lathes, circular saws), light aircraft and office and medical equipment (hydraulically operated tables, chairs, sliding doors).

Glacier DU resists most solvents and many industrial liquids and gases, including water and oil, tolerates dusty environments and runs smoothly with negligible 'stick-slip'. It is available as wrapped bushes, flanged bushes, thrust washers or strip.

Glacier DU-B – where corrosion resistance is important, Glacier DU-B is available with bronze replacing the normal mild steel backing.

Glacier DQ – a dry bearing material available in solid form as bars or tube or, where quantities allow, complex moulded shapes. PTFE based, it is suitable for less severely loaded applications which include bushes, thrust washers, locating pads, valve port plates and wearing components for a variety of mechanisms.

Bearings for marginally lubricated applications

Glacier DX – designed for use in situations where continuous oil lubrication is uneconomic or inappropriate. Typical applications include agricultural machinery (ploughs, tractor attachments, combine harvesters), machine tools, construction equipment and materials handling (pallet/fork lift trucks).

Glacier DX is steel-backed and lined with an acetal co-polymer and is available as wrapped bushes, thrust washers and strip with a choice of surfaces – indented for grease application or plain where fluid lubrication is available.

Glacier Hi-eX – a steel-backed composite material lined with polyether ether ketone (PEEK) as well as various fillers including PTFE.

With a high fatigue strength, Glacier Hi-eX operates well under high loads with fluid lubrication and is particularly suited to water-based hydraulic fluids. Applications include diesel fuel injection pumps, rock drills and heavy duty hydraulic pumps.

Glacier Hi-eX is available as wrapped bushes, thrust washers and strip, and with an indented or plain surface.

Further information: The Glacier Metal Co Ltd, Joel Street, Northwood Hills, Middlesex HA6 1LN. Tel: (09274) 26100.

A new machine for cleaning has been introduced by Michael Williams.

The Big Brute 3000 is specifically designed for use in grain stores, vegetable stores, mill/mixer mixing installations, pig houses, poultry houses, warehouses, etc.

Priced at £625 ex-works the basic machine is provided with 50 feet of flexible hose and a steel general purpose suction tool. Many specialised tools are available.

Manufacturers are: Michael Williams Ag Systems Ltd, Unit 2, Hall Farm, Saffron Walden, Essex CB10 1XA.

Agricultural land tenure

The Centre for Rural Studies at the Royal Agricultural College, Cirencester has carried out a survey for the Royal Institute of Chartered Surveyors (RICS) to establish the extent and nature of arrangements for the occupation of agricultural land in England and Wales.

The results of the survey are now published and some interesting and significant trends have been revealed. Comparatively few farmers can be classified simply as owners or tenants. One in five of farmers in England and Wales occupy land on an unconventional arrangement with grass keep and gentleman's agreement being the most frequent.

The authors of the report see such unconventional tenure as a cause for considerable concern in the management and use of land. The evidence from the survey is that land held on unconventional tenure is not managed in the same way as land held on secure tenure or freehold. A recommendation is made that the industry should better understand the facts and issues involved.

The RICS is urging that fresh solutions should be found through a permanent working group with a wide brief to view tenurial developments and to investigate means of establishing new tenancies.

Copies of the report are available from: The Surveyors Bookshop, Norden House, Basing View, Basingstoke, Hants RG21 2HN.

Velcourt farming partnership

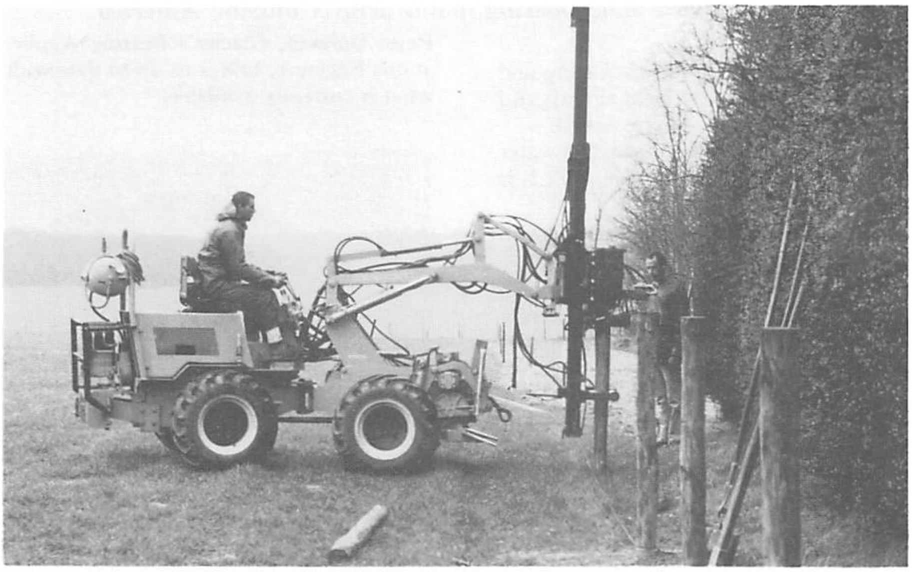
Velcourt Group plc, the Hereford-based corporate arable farming business, is looking forward to a period of growth in its farm management and technical consultancy activities over the next decade, particularly with the advent of the single European market and the opportunities presented by the political changes in eastern Europe.

Already farming over 10,000 hectares of arable land across the UK on behalf of tenants and both private and institutional landowners, Velcourt funds an average of 70% of the working capital with a turnover in excess of £6m. A wide range of profit-sharing agreements exist with farming and landowning clients, which are arranged to suit individual needs.

The company's 30-strong management team draws on a wide range of experience and knowledge based on over 20 years of direct farming experience. The application of the latest farming techniques, based on planned trials and research, has resulted not only in consistently high yields but also a sizeable reduction in unit costs of production for all the major arable crops.

This year, at the company's annual crop demonstrations, a number of important, topical environmental issues were featured including the effects of slow-release agents on nitrogen levels and the practical aspects of residue testing.

New vibratory post driver from Culford Fencing



Culford Fencing Ltd of Bury St Edmunds (Tel 0284 706880) announce their hydrostatically powered new 'Thumper' vibratory post driver.

Easily attached to the tractor, the Thumper is said to be suitable for any type of wooden fencing post up to 3.5m long and to be capable of forcing a normal 5 inch diameter post 1 metre into the ground in about 60 seconds.

Not only is the speed of post erection greatly improved, so too is the accuracy of post positioning. Due to full fore/aft and side to side control of the main mast a post can be placed to within 10mm of true position.

Culford Fencing state that tests undertaken to determine what force was needed to extract posts showed that a Thumper-placed post could not be withdrawn with 7000 kilos of pull whereas, auger-erected posts required just 750 kilos of force to pull them out. Equally, however, Thumper's vibration process reversed can easily raise a post if it has been positioned too deep or if rock is encountered.

Prices range from £25000 for a tractor-mounted unit up to £55000 for a self-propelled machine incorporating winch and a compressor.

Organic farming – trials by Rhône-Poulenc Agriculture

Boarded Barns Farm at Ongar, 57 hectares of traditional Essex clay, has been managed by Rhône-Poulenc Agriculture for 18 years. Last year the company announced that it was to convert a third of the farm to organic farming, so that it could study closely this approach to agriculture over a ten-year period.

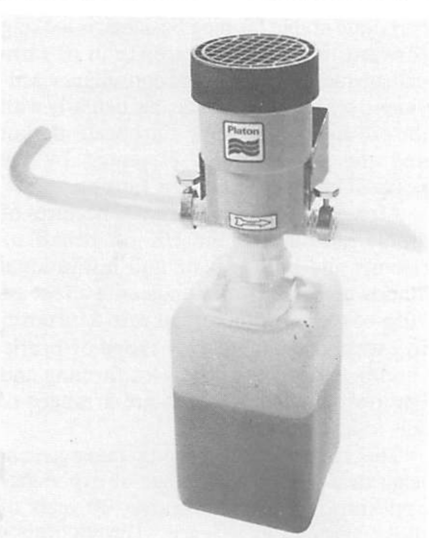
The organic area of the farm was entered on the in-conversion register of the United Kingdom Register of Organic Food Standards and the period of conversion to organic farming will take three years. The flora and fauna are being monitored and the effects on yield, quality, flavour and nutritional value, profitability, the ecological effects on the farm, and the management and operational procedures will all be studied and recorded.

Soil survey establishes that trials area forms valid base for comparison

In order to be sure that the area under organic farming presents a valid basis for comparison, Rhône-Poulenc called in the Soil Survey and Land Research Centre (based at Silsoe, Bedford).

The Soil Survey Report shows that the soils at Boarded Barns Farm are similar in certain important respects to those in large parts of lowland England, and that results from the two regimes being operated on the farm will be valid in other regions.

The report also concludes that soils from the land specially selected for the organic and conventional farming studies "are sufficiently similar to allow valid comparisons to be made of trials both within and between the organically and conventionally farmed areas".



A range of self-acting, self-priming fluid operated diluters, which utilise the pressure energy of the fluid to provide extremely precise flow control, is available from Platon Flowbits Ltd, Basingstoke, tel: (0256) 470456.

The Flo-Ration utilises the pressure energy of the water, at a minimum pressure of 0.3 bar, and pumps an additive to produce an accurate solution concentration, from 0.2-10% for flow rates from 0.25l/min to 20m³/hr.

Ultrasonic depth control

A new fully automatic ultrasonic depth control system for tillage and seeding machinery has been developed by K Eldredge Electronics Pty Ltd of Clare, South Australia.

According to Mr Eldridge, accurate depth control is one of the most significant factors governing crop yields in Australia.

Working on a similar principle to an echo sounder, the controller measures the distance between it and the ground by timing echoes from ultrasonic pulses.

The unit is set up with a series of sensor blocks, each containing an ultrasonic transducer, spaced across an implement to give an even and accurate assessment of ground undulations and variations. Each transducer produces 100 pulses per second which are reflected back from the ground about three thousandths of a second later.

The exact time taken for the pulses to be reflected back is measured and used to assess the distance between the sensor and the ground. Within the computer this distance is subtracted from the known distance between the sensor point and the part of the implement that actually enters the soil, the difference being the working depth of the machine.

Any changes in the pre-set working depth is then computed and signals sent to adjust automatically the height of the implement through its hydraulic system.

Bio-treatment prices slashed

Rapidly increasing demands in America plus improved production technology have brought a sharp decrease in the price of the bio-treatments supplied by Domindus Ltd of Stone, near Dartford (Tel: 0322 226590).

The biological recovery of land (including beaches) contaminated with heavy tars, oils and other hydrocarbon or phenolic pollutants, will now cost about £300 per acre (say, 8p/sq m) which could be offset by savings in labour, detergents, etc.

On the farm, bio-treatments are available for 'composting' manures (including sewage) and ploughed-in stubble. Biological reduction of smells in cow-sheds etc leads to healthier stock (and happier stock-men) with fewer flies and other discomforts.

ADVERTISERS INDEX

The Douglas Bomford Trust

Sixth Memorial Lecture

presented by Wilfred E Klinner C Eng FIAgrE MemASAE
Silsoe College, Thursday, 1st November 1990, 5.00 pm

"Innovation : Commercial success or failure"

In agricultural engineering the path from first conception to commercial acceptance of a new product can be strewn with numerous and formidable obstacles. On the basis of examples the Lecture will define and examine the sequence of steps usually involved in the innovation process, and it will seek to suggest possible ways of avoiding or overcoming difficulties.

Admission to the lecture is free – by ticket only.

Applications should be addressed to:-

Ray Fryett, No.1 Manton Spinney, Knuston, Wellingborough, Northants NN9 7ER. Tel. (0933) 55329

BOOK NOW
the next
Soil Management Course
7th – 11th January 1991
Silsoe College, Beds MK45 4DT

Institution of Agricultural Engineers
Soil and Water Specialist Group
Wednesday, 14th November, 1990 (2.00pm-5.30pm)
Clement Stephenson Lecture Theatre
Faculty of Agriculture, University of Newcastle upon Tyne

Session 1 – Soil Strength & Structure

Soil mechanics research
D R Hettiaratchi, University of Newcastle upon Tyne.
Controlled traffic research
D J Campbell, Scottish Centre of Agricultural Engineering
Effect of mineral working on soil physical properties
D Hewgill, ADAS

Session 2 – Soil-Water: Solute & Gas Movement

Land-use strategy and the environment
J R O'Callaghan, University of Newcastle upon Tyne
Nitrate leaching: state of the art
J K Syers, University of Newcastle upon Tyne
Gas movement in soil cores
B C Ball, Scottish Centre of Agricultural Engineering

Contact: John Gowing, Faculty of Agriculture, The University, Newcastle-upon-Tyne NE1 7RU. Tel: (091) 2328511.

Thursday, 15th November, 1990 (forenoon)

Visit to **National River Authority**, Middlesborough

Contact: John Ray, Brasenose Farm, Steeple Aston, Oxford OX5 3QG. Tel: (0869) 40645.

Make a note of the date!

Institution of Agricultural Engineers

Second International Conference

2-5 Sept 1991 – Robinson College, Cambridge

Engineering the Rural Environment

The wide spectrum of the subject theme will be covered by a series of parallel sessions each preceded by a keynote speaker.
There will be back-up poster sessions and a choice of technical visits.