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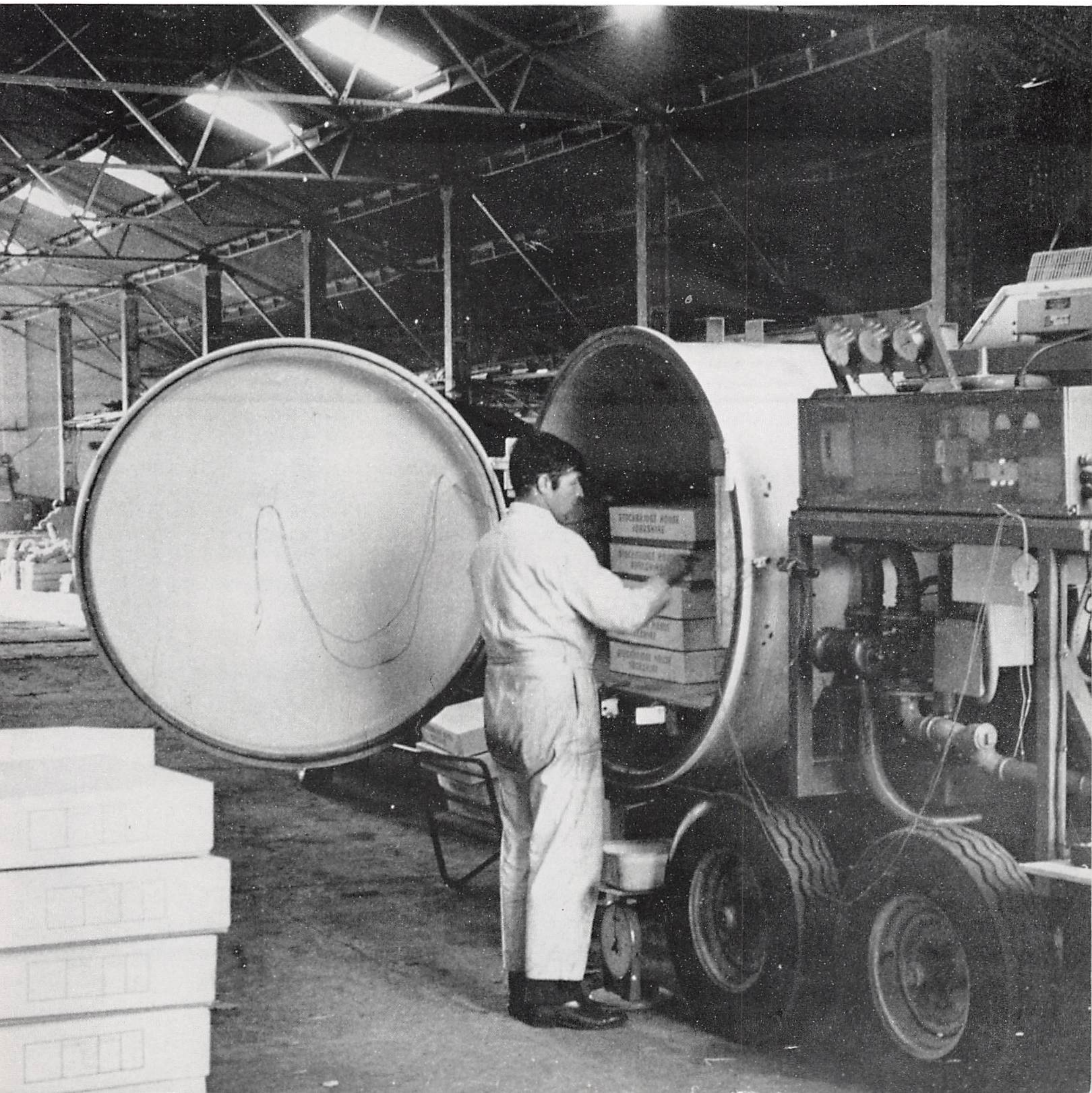

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CONTENTS

Front cover: Vegetables being placed in a freezing machine.

Note this date: 13th MAY 1975

THE USE OF ENERGY IN AGRICULTURE CONFERENCE FOLLOWING THE ANNUAL GENERAL MEETING VENUE: BLOOMSBURY HOTEL – LONDON

THE 1975 Conference provides a forum for analyses of the farming and agricultural aspects of this vital subject. A distinguished group of men associated with our industry but of different professions will discuss ways of reducing costs and contributing to worldwide economies. We are delighted that:

The Chairman will be PROFESSOR O'CALLAGHAN, Dean of Faculty of Agriculture, Newcastle University. Long before the 1973 crisis he was constructively drawing attention to the approaching problem; he was Chairman also of the 'Energy Working Group' of the MAFF and Agricultural Research Council Joint Consultative Committee.

PROGRAMME

10 00 – ANNUAL GENERAL MEETING.

11 30 – 'Energy Flow in Agricultural Systems' will be analysed by Gerald Leach. His considerations of the inputs of energy to produce staple foods, the useful outputs and efficiency of production when published in the 'Times' drew much attention to his ideas.

12 00 – 'Energy Sources' will be reviewed by G. E. Bowman NIAE. The prospect of better use of solar energy particularly in relationship to glasshouse crops will be dealt with.

12 20 – 'Economy in Use of Manufactured Fertilisers' will be discussed by Dr R. B. Austin of the Plant Breeding Institute. Substitution of crops and the prospects of transferring the nitrogen fixing abilities to other plants will be his theme.

13 00 – CONFERENCE LUNCH A distinguished guest will speak.

14 30 – 'Efficient Use of Tractors' will be analysed by J. Matthews NIAE, with particular reference being made to potential economies when cultivating soil.

14 50 – 'Straw and Grass – Problems in Using their Potential Energy'. I. Rutherford ADAS and Dr R. W. Radley NCAE, will discuss straw. T. C. D. Manby NIAE and G. Shepperson NIAE will discuss grass.

15 30 – OPEN FORUM The many questions not already raised can be discussed.

CLOSURE will be at 16 30 when TEA will be available.

Any suggestions or requests for further information should be addressed to the Conveners, T. C. D. Manby, Silsoe and Dr D. J. White, MAFF, Chief Scientist Group, Great Westminster House, Horseferry Road, London SW1P 2AE.

Agricultural and food engineering

by J A C Gibb

AGRICULTURAL engineers have never been in any doubt as to the contribution they can make to the production of food and industrial farm crops, in a wide range of activities including the design and production of farm machines and equipment, supervision of the use of such equipment on a large scale and the provision of advice on the selection of machines for specific tasks or systems of operation. From the earliest times in some territories, and more recently in Britain, agricultural engineers have also been vitally involved in the soil and water applications of engineering. Yet other applications have been concerned with buildings, environment control and farmstead mechanisation. But up to recent times these manifold activities have concentrated mainly on the production of food and fibres in farming areas. Little attention has been paid to those other processes which have, in the past, been carried out beyond the farm gate, in the conversion of food materials into the forms in which they pass to the wholesaler, retailer and housewife – engineering applied towards producing food rather than the raw materials from which foods are prepared.

During the last five or ten years various factors have contributed to new attitudes towards food engineering in some sectors of the agricultural engineering world, notably in the United States, but to some extent in Britain also. These include industrial developments, and particularly the vertical integration of the various links in the chain of production, processing, distribution and retailing of food, so that the ownership or financial control of the successive stages is brought within a single organisational grouping; changing demographic patterns; changes in transport methods; developments in processing and packaging methods and techniques; and other changes in levels of affluence and purchasing preferences of consumers. A further factor is the increasing extent to which food for animal consumption is already being processed on farms, providing a technical approach to processing operations which may offer parallels with some of the operations involved in the preparation of food raw materials for subsequent processing and human consumption.

For these reasons, the Institution decided to hold the 1974 National Autumn Conference on the theme "Developments in Food Processing", and the Conference was held at Shuttleworth College on 1 October. The intention was to explore further the trends mentioned above, and to bring together members of the Institution of Agricultural Engineers and some of those already concerned with engineering in the food industry. As will be seen from the papers reproduced on later pages in this issue of *The AGRICULTURAL ENGINEER,* the speakers were selected to provide a comprehensive outline of some of the possibilities in the food engineering field. In doing so it was hoped to establish a basis on which lasting relationships may be formed by the Institution with some of those bodies and individuals now working beyond the farm gate in the large and complex industry through which almost all farm-produced food must pass. In particular the need, and opportunity, for extending from the farm applications of engineering into the next tier of food engineering applications must be of concern and importance to the Institution.

Similarly, the possibilities offset by the Institution as a focus for those now engaged in the application of engineering in the food industry may also be significant.

All in all, it may be thought timely that an initiative of this kind should be taken. However, the Institution is by no means alone in seeking to identify and explore the connections between the primary and secondary stages of food production. At the 1974 Royal Show a small beginning was made with the introduction of an international Food Exhibition, and the Royal Agricultural Society of England has declared its intention to play a part in developing means of cooperation between the relevant representative bodies. The RASE is perhaps more concerned with the public relations aspects of food production than with the technical aspects of food engineering, but at least there is recognition of the relationship between the farming industry and the food industry which depends upon it.

J. A. C. Gibb OBE MA MSc FRAgrS FIAgrE MemASAE is Head of the Agricultural Engineering Section, Department of Agriculture, The University, Reading, and immediate Past President of the Institution of Agricultural Engineers.

The American Society of Agricultural Engineers has for some years taken seriously the question of Food Engineering, and has established a Food Engineering Division as one of its five technical divisions, on the same level as, for example, Soil and Water or Power and Machinery. Three of the nine committees which comprise the Division are concerned, respectively, with Standards, Food Processing and Food Handling, and a tenth committee on environment of stored products is administered jointly with the Structures and Environment Division. While it is no doubt true that the number of ASAE members active in the Food Engineering Division is smaller than in the other and older divi-ions, nevertheless these arrangements indicate a considerable scope for technical involvement and discussions in the food engineering field.

An interesting project now being planned by Professor J. T. Clayton and his colleagues in the Food and Agricultural Engineering Department of the University of Massachusetts is an international Congress on Engineering and Food, to be held near Boston, Mass., in the autumn of 1976. This will aim at bringing together as many as possible of the relevant professional, technical, governmental and commercial bodies, to consider a wide range of subjects. The Institution of Agricultural Engineers has received an invitation from Professor Clayton to be associated with the proposed Congress in some way or other, and our experience at our own conference on 1 October will be helpful in determining our response to this initiative, as well as to the more general question of further development of food engineering interests within the Institution.

Trends in the production and processing of farm produced food materials for human consumption

by Dr R Scott BSc PhD MInst FIFST

THE title of this paper can be taken in several ways, but for the present purpose it is intended (a) to show the trends in agricultural (including horticultural) production (b) to indicate when food processing is essentially a factory process and (c) to indicate where processing can be a farm operation even though it is only part of the total process before retail sale to the consumer.

While there are still viable farm processing units, many of these are indeed small scale factory processes and will for the present purpose be treated as such. There is no intention to belittle efforts in these enterprises which indeed often supply a useful need in remote areas. Farmhouse butter making (27 million litres per annum) in rural areas is an example, as is farmhouse cheesemaking (159 million litres) but where several farms combine to make up to say 18,000 litres of milk daily into cheese, this is more a small factory, needing equipment and services similar to the large cheese factory.

The main aim of this conference is to bring together those interested in human food production in which both farmer/horticulturist and processor play a vital role. Subjects like the use of soya bean for analog foods or the very new techniques of extracted leaf protein and fish farming are best left to specialist conferences.

Trends in food production and utilisation

It is pertinent to dip into the pages of history for a moment to see how trends have developed over the years.

Systematic agriculture received a boost when the Romans invaded Britain in the first century AD and left behind artisans practised in the methods and crafts of agricultural production which included, selection of livestock, cultivation of crops, planting and grafting of orchards and the use of herbs in foods.

Continuation of development in agricultural methods was to the advantage of the lords of the manors and to the landed religious orders. Methods of preservation of food by drying, salting, smoking and the use of honey in preserves are very old techniques. Perusal of the old writings shows how extensive the knowledge of these people was in the craft of food production but they had little science on which to build. Whereas today we use pure chemicals as additives to process, colour, thicken, mask or enhance flavour, they were practised in the use of herbs for such purposes.

The communities were self-contained and any complaint about food quality soon reached the person responsible for production. In the case of cheese alone, some 20 named varieties of cheese have disappeared over the years because of unacceptability.

We gather two lessons from the past. The first is that "quality" of produce is necessary for a viable industry. Secondly, that producers and processors continually require education in the methods of food production.

Dr. Scott is from the Food Science Department University of Reading.

This paper was presented at the autumn conference of The Institution of Agricultural Engineers at Shuttleworth College, Biggleswade, Beds, on 1 October 1974.

Today we could add a third necessity – continual reappraisal and advancement of these methods.

Apart from the necessity to preserve and store food from one harvest to the next we also learn, that, as a result of natural causes eg weather, famines and gluts of food, storage requires a much longer time than simply harvest to harvest. Thus a freezing winter may eradicate pests which might otherwise have ruined a harvest, whereas a warm winter would allow the pest to proliferate. Rainfall and sunshine can influence the quantity of harvest, while wind and humidity influence the quality of produce. We have these problems still with us.

One problem which the feudal people did not have, since the produce was marketed almost on the doorstep, is that changes in marketing have arisen from various causes.

The break up of large estates from 1460 AD, resulted in a proliferation of fairs, county markets, itinerant vendors and pedlars and wholesale "badgers" as intermediate salesmen. The increased number of small producers led to an extremely variable quality of produce. Some of the small, less experienced farm producers were pleased to migrate into towns to make a better living during the industrial revolution (circa 1790–1860) when the rural population declined and the town population increased many fold.

This process continued and created the necessity for longer storage life of foods, transport of perishable goods and a marketing chain from producer to consumer. The depletion of the rural population and enlargements of townships has continued to such an extent that at least half of our food today needs to be imported from abroad.

The industrial revolution replaced the homestead and cottage, as a place of work, by the factory. Capital plus technology became the new economic style in Britain. Agricultural produce while a necessity for the maintenance of life became of secondary importance to the new technologies, cotton, wool, steel and chemicals. This remains the accepted concept today, as an example, an energy wasting project like Concorde, produced for the few, has preference over food research to help feed the population, even in a socialist society. Indeed, a future conference might like to look at the limitation of food production caused by shortage of energy (not necessarily fuel).

Arising out of the new economic style, the earlier break up of estates from 1490 AD, continued up to the 1930s in sponsored smallholder schemes, this trend has now been reversed and farms are becoming larger and larger units. Indeed farming has become a business rather than a way of life.

Methods of farming have changed. The graveyards of farm machinery in the developed countries bear testimony to the changing face of agriculture.

Marketing of food has also changed. Indeed the decline in numbers of small shops and the rise of chain stores, supermarkets and hypermarkets has brought the subject of packaging into prominence.

Compared with the feudal times, a gap has developed between the farmer and processor (as representing consumer interests). This gap further widened by the Agricultural Marketing Acts of 1931, needs to be bridged in the interests of food quality as well as quantity.

To summarise, history indicates (a) changing situations in regard to movement of population, (b) the gluts and famines due both to natural and economic causes (c) the need for alternative food supplies to bridge world food supply situations (d) the changes in marketing of food and packaging and not least (e) the changing demands of the population for foods differing in character from traditional fare.

Agricultural production

About the time (1790–1860) when the necessity for extra food became urgent, pioneers in agricultural machines eg Jethro Tull in corn drilling – Viscount Townshend in cultivation and rotation of crops and Robert Bakewell for animal breeding, provided the impetus towards increased food production. Since that time agricultural production in Britain has become increasingly efficient and the envy of other countries.

We have only present agricultural production as a guide to the future. Hence table 1 is presented merely as a talking point towards the future.

Table 1 UK Agricultural and horticultural produce output

Year	1964–5		1967–8		1972–3	
Crops	000 tonnes	£m	000 tonnes	£m	000 tonnes	£m
Wheat	3629	93.9	3670	94.5	4373	155.8
Barley	4592	118.8	6073	146.4	5348	167.1
Oats	347	9.3	316	11.0	380	11.6
Potatoes	5473	78.6	5647	92.5	5650	118.3
Sugar beet	6218	42.8	6775	42.3	6118	48.9
Hops	13	8.2	11	7.0	9	8.8
Total value of all farm crops		363.5		408.0		530.7
Total value of horticultural crops		211.5		230.9		346.2
Livestock	*(000s)*	*£m*	*(000s)*	*£m*	*(000s)*	*£m*
Cattle	878	266	970	314	911	530
Sheep	260	84	261	87.5	230	128.3
Pigs	861	203	816	208	970	348
Poultry	374	89	478	106	645	167
Offal	161	6	168	7	140	13
Milk	*Mill. litres*	*£m*	*Mill. litres*	*£m*	*Mill. litres*	*£m*
	11 170	1786	11 870	1991	13 742	2918
Total agricultural output value	£1947 million		£2159 million		£2159 million	

Source: Ministry of Agriculture, Fisheries and Food Output and Utilisation of farm produce in the UK 1967–68 to 1972–73

Approximately half the wheat is used for human food while the remainder; 2,156,000 tonnes is used for stock feed. One should note that about 20,000 tonnes is wasted in distribution and this raises the question as to whether this is an acceptable loss? If the newer techniques of bread making (Chorleywood process) are used, can more English wheat be used instead of imported Canadian or American supplies?

The table also shows the beginning of increased prices. These increased prices set the economic structure and eventually may bring those other, more economic products into production.

The numbers of livestock continue to maintain the usual annual variations except for pigs and poultry, both of which show increases. These two areas alone are capable of rapid expansion if economic changes occur.

The changing economic climate has induced and will continue to compel changes in the type of food production. Indeed the impact of the EEC has still to be decided.

Tables 2 and 3 show the trends of vegetable and fruit production. The production of carrots and onions deserve mention especially in relation to storage facilities. The work proceeding at the Vegetable Research Station, Wellesbourne, is particularly timely in this respect. The increased production of brussel sprouts and frozen peas is indication of the trend in frozen food sales. Indeed the increase in tonnage of frozen and processed (canned) peas over direct market peas also show present trends.

Table 3 indicates the interest in strawberry and blackcurrant

Table 2 UK vegetable production (000s tonnes)

	1969–70	1972–3
Beetroot	105.7	87.9
Carrots	539.9	402.8
Parsnips	50.9	40.1
Turnips	141.1	114.6
Onions	88.1	132.0
Brussel sprouts	193.0	211.7
Cabbage	659.3	546.1
Cauliflower	274.2	313.7
Peas dry	51.2	60.7
Peas frozen or processed	185.0	197.4
Peas direct market	45.1	35.9
Beans broad	28.8	44.9
Beans runner	102.2	80.4
Total value	£183 million excluding wastage	

Source: Ministry of Agriculture Statistics

Table 3 UK fruit production (000s tonnes)

	1968–9	1972–3
Apples dessert	180	192
Apples cooking	134	148
Pears	65	48
Apples (cider)	36	21
Pears (perry)	5	3
Cherries	5	9
Plums	78	44
Strawberries	44	48
Raspberries	15	15
Blackcurrants	13	25
Gooseberries	12	9
Red and white currants	2	1
Blackberries	3	3
Total value million	£89	

Source: Ministry of Agriculture Statistics

Table 4 Other food crops UK (1972–3)

	000s tonnes	£000
Asparagus	1	420
Celery	63	3882
Leeks	26	2194
Rhubarb	44	2553
Watercress	5	1450
Under glass etc.		
Tomatoes	108	22 538
Cucumbers	34	4134
Mushrooms	55	18 471

Source: Ministry of Agriculture Statistics

crops. The former for the frozen and fresh fruit trade and the latter for juice extraction and jams.

Table 4 shows the production of more specialist crops, such as asparagus, celery, leeks, tomatoes and cucumbers. The production of rhubarb, watercress and lettuce is receiving attention both in production and marketing methods which could induce more production. Mushrooms are also a possible expanding crop if present difficulties (cleaning and delay in ripening) are overcome effectively.

Table 5 is of interest since it shows the expansion in broiler chickens and turkeys. Both these are becoming very specialised in nature and not part of the general farm activity.

Table 5 Poultry meat and eggs UK production (000s tonnes)

	1968–9	1972–3
Fowls over 6 months	77.1	60.1
Fowls 6 months or under	379.3	480.0
Ducks	12.5	16.5
Geese	0.9	0.6
Turkeys	60.3	87.6
Value of poultry meat	£118 million	167.0
Eggs sold wholesale in shell (mill. doz.)	567.2	613.5
Eggs for processing (mill. doz.)	78.5	63.5
Total egg production	£1129 million	

Source: Ministry of Agriculture Statistics

Since potatoes for processing need special cultivation routines on the farm it is given separately on table 6. The expansion in canned new potatoes, in frozen chips, in crisps and in dried potato powders or granules is clearly shown. This is a trend likely to continue.

EEC impact on food production and consumption

Table 7 shows the changes as percentages in agricultural production in EEC countries in 1972–3. There is little difference between agriculture production and food production levels but when considered on a per caput basis these changes show the effect of population on food production figures particularly in Denmark and the Netherlands.

Table 6 Potatoes for processing (000 tonnes)

	1966–7	1969–70
Canned new UK	2	17
Canned new imported	15	6
Canned diced and soups	11	16
Chips	25	136
Crisps UK	278	296
Crisps imported	45	25
Dehydrated granules	23	80
% of crops processed	8%	12%
Total human consumption	4650	4620

Source: Potato Marketing Board

Table 7 1972–3 percentage changes in agriculture and food production EEC

	% change agriculture	% change food production	
	Total	Total	Per caput
Belgium	+5	+5	+5
Denmark	–4	–4	–5
France	+3	+3	+2
Germany	+1	+1	+1
Ireland	+3	+4	+3
Italy	+3	+3	+2
Luxembourg	+2	+2	+1
Netherlands	0	0	0

On the other hand table 8 shows the potential of *food consumption* in the EEC as a result of population increases. The proportion of processed and convenience foods in both the UK and the Netherlands shows a trend likely to continue.

Interesting figures on table 9 show the numbers of agricultural employees in relation to industrial employees in the EEC countries together with the employees in food industry.

The percentage of turnover in each country of the EEC expressed as a percentage of total EEC food turnover shows that Holland, Belgium and Italy are relatively small compared to Germany, France and the UK.

The trends in food consumption due to different standards of living vary widely. Belgium with an expenditure of Fr2490 per caput in 1969 was well above the UK expenditure where the equivalent was Fr1520. Germany spent 34% of household expenditure on food as against 25% spent in the UK.

In spite of the butter and now the beef surpluses in the EEC, the share of agricultural production against gross Common Market production fell from 13% in 1953 to 7% in 1969, thus indicating vast increases in manufactured goods over food.

On the other hand in the ten years 1962–72 the amount of processed foods increased from 45% to 80% of agricultural production (including, of course, wheat and sugar beet).

Drift from the land during the industrial revolution in the UK is now showing up in EEC countries, thus Germany had 41%, Holland 39%, Belgium 40% of farmers over 55 years while in France it is estimated that in 1980 the over-whelming farming population

Table 8 Potential of food consumption (EEC)

		Germany	France	Italy	Holland	Belgium	UK
Population	1970	61.6	51.2	54.6	13	10	56
	1980	65.2	54.7	57.9	14.7	10.4	59.3
As % of EEC + UK 1970		25	20.8	22.2	5.2	4.1	22.7
Proportion of expenditure on FOOD out of total household expenditure 1969		34	27	37.9	24.1	25.6	25.1
Proportion of processed and convenience foods out of total foods consumed		49.5	47.5	45.8	62	50	60.4

Source of statistics: G. Dardenne, Pro. Inst. Food Sci. and Tech. Sept. 1972

Table 9 European agriculture and food industries

	Germany	France	Italy	Holland	Belgium	Luxembourg	UK
% of employees in agriculture	9.6	15.1	21.5	7.5	5.2	11.6	2.9
% of employees in industry	49.0	40.6	43.0	41.3	44.8	45.7	46.8
Food industry work force (000s)	500	408	153	160	163	?	824
% of food industries turnover out of total EEC	26.14	22.12	7.8	10.63	5.74	?	27.57

Source: G. Dardenne, Pro. Inst. Food Sci. and Tech. Sept. 1972

will be elderly.

The regulations and directives, to come from the EEC will vary the conditions from time to time so that until the Community settles down forecasting the future is difficult if not impossible.

Consumer demands

Just as the farmers wife took over the processing of bread, butter, cheese, pig meat, fruits, beverages from the artisans of the feudal system, so the factory has taken over from the housewife and has filled the void between producer (farmer) and consumer (housewife) in spite of the changing patterns of production.

The changes include:

(1) A diminishing demand for bread and potatoes but a rising demand for biscuits and crisps.

(2) A demand for a greater variety of foods induced by holiday travel abroad and acquisition of new tastes.

(3) The balancing of food supplies when glut and shortages occur (Note: a severe winter caused shortage of greens and the void was filled by deep frozen foods, thus establishing a trend which has continued).

(4) A demand for frozen and dehydrated convenience foods — packets.

(5) A demand for complete meals in packets.

(6) Control of hygiene to prevent losses in foods.

(7) The need to control nutritional aspects of foods sometimes imposed by legislation.

(8) The need for attention to control food additives and chemicals used for animal treatment, or crop weeds and pests.

The processor has thus taken over responsibility for maintaining food quality and acceptability. This responsibility is often imposed by law, and is another reason why the farmer and processor must talk together.

Processing units

As the advances in knowledge lead to advances in processing techniques, capital cost of processing and quality control units also increase. The advances in medical knowledge have also led to the greater ease of pin-pointing human ailments resulting from consumption of food. Hence the public health aspect of food processing has increased in importance. Since food is distributed over a wider section of the population than formerly therefore gastric difficulty due to eating food affects more people. Briefly the requirements of a processing unit are:—

1. Power.
2. Water.
3. Effluent services.
4. Engineering services.
5. Roads and transport services.
6. Proximity to raw materials.
7. Labour supply.
8. Quality control service.
9. Marketing organisation.

It is often as a result of these aspects that farm processing has of necessity become a factory process.

Processing on the factory scale

Processing techniques on the factory scale throw constraints on the type of raw material which can be processed to give an article acceptance to the general public.

The preservation of food for long storage imposes on the food conditions which nature did not endow.

Since the food industry must inevitably be concerned (sometimes legally) with nutritional value of the food some of the constraints imposed by processing must be constraints also imposed on the raw materials. Thus some cultivars of peas are better than others for canning or freezing; similarly some varieties of strawberries are better than others in respect of colour or flavour; some meats are more acceptable than others and so on.

There must be adequate dialogue between the producer and processor. This gap as previously mentioned must be bridged in order to increase the quality of the consumer produce.

This country lacks adequate institutions capable of investigations into the difficulties concerned in bridging the gap between farm and processor, although some institutions like the Vegetable Preservation Station at Chipping Campden and BFMIRA at Leatherhead and others, although inadequately financed help in these investigations it is left for food processing concerns to institute their own research in spite, at the moment, of controlled profits.

Processing techniques

(a) Heat treatment. Nicholas Appert — the father of canning — in 1810 indicated the approach to preservation of food by heat treatment, Pasteur in 1861 added to the knowledge and although the principles expounded by these pioneers has been used in wine, milk and meat preservative very little farm processing using these techniques has been practised in the 20th century. Some small scale canning and bottling, mainly of fruits and cream have been practised but even these have migrated to the factory.

The higher temperature treatments; UHT process, has always been a factory process, requiring adequate control of the raw materials as well as the process.

Cornish and Devonshire or clotted creams are still produced in summer for seaside visitors, but factory methods are again replacing the farmhouse methods.

Processed meats from the slaughterhouse are also produced locally but again these products are more often factory produced.

It is only in the remote and rural areas where distribution is local that many of these processes are economic and viable.

(b) Canning of fruits and vegetables need techniques and experience not usually available at the farm. The need to obtain raw materials which will process satisfactorily however is important. The stage of maturity (eg tenderometer reading with peas) is vital for satisfactory quality of the canned product. Therefore there is a need for agreements (contracts) between the grower and processor in respect of variety, cultivation, maturity, application of pesticides, and fungicides etc. It is the closing of the gap between producer and processor which is vital from the quality point of view, although these contracts inevitably have economic (financial) implication.

(c) Curing, salting, smoking. Originally pork (bacon and ham) was dry cured by a slow laborious process but nevertheless still suitable for farm curing. Indeed the farm killed pig produced the best consistently good results where knowledgeable curing was practised.

Tank and injection curing of the Wiltshire style on a factory scale requires strict control.

Co-operation between producer and processor is essential for success in the bacon industry. Hence the need for agreements (contracts) between producer and processor on the question of feeding, weights of animals, etc.

The trend towards softer cures with less salt and nitrite also means a marketing organisation with a chain of cold storage from processor to retailer since the reduced salt content does not alone safeguard spoilage.

(d) Dehydration. The oldest technique for food preservation is dehydration. Removal of water from foods to enhance their keeping quality is not new to farmers. Grass drying, hay production, grain drying, from combine harvesters, etc., are well known farm operations. However, just as the farmer recognises that wrongly dried grain is spoiled so food for human consumption must be properly processed. This is a factory operation in which special facilities are provided for different forms of drying which include:

Spray drying.
Fluidised bed drying.
Freeze drying.
Infra red drying.
Puff drying.
Foam mat drying.
Vacuum drying.

Each process is better for specific types of food or for the uses to which the dried food eventually goes. Many of the end products require special packing to exclude air or moisture.

(e) Freezing. The development of the ammonia refrigerator by Linde in 1870 opened up the oceanic trade in meat (South America 1877) (Australia 1880).

Cold storage depots on land have been used for many years for storing food in bulk.

Although developed in 1914 the domestic refrigerator did not become popular till the 1930s when shop counter cold cabinets came into use to complete the chain of cold storage. Clarence Birdseye in producing the plate freezer speeded up the sale of frozen produced meats, fish, vegetables etc.

However, it was not until after the second war that liquid nitrogen became more freely available. In the early days this induced farm freezing of produce not necessarily suitable for the process and this was frowned upon by the general frozen food industry.

There is no doubt that when economic levels of usage are reached that farm freezing of produce, strawberries particularly, will expand provided that adequate preparation of the fruit is completed before freezing and a chain of frozen storage built up from farm to consumer.

Farm processing need not be the final process before the consumer stage. The use of blast freezers or in the case of peas, tank freezers as already practised in Yorkshire and the eastern counties can be of interest where too long a distance between producer and processor makes the non-cooled transport impracticable. Cooling and gas storage of fruit are well advanced applications of refrigerated storage.

Cold storage companies provide freezing facilities and subsequent cold storage for farm produce before sale to the consumer or processor.

Bulk or consumer packaging facilities are also available at some centres. Due to lack of appreciation of the needs of cold storage in respect of hygiene etc., some companies have had to impose "codes of practise" for their own protection. More control of the operations will be necessary as well as education for the processes before completely satisfactory operations become standard practise.

(f) Irradiation. The irradiation of foods for human consumption is rather limited both in application and because of legal permission.

The first full scale use may arise out of the treatment of pet foods.

Disinfection by irradiation of grain in larger silos has gained ground but other treatments which have been examined include meat and fish for extended shelf life, sprout inhibition of potatoes, control of fruit ripening, mushrooms, mould growth prevention on strawberries and other foods.

The strict control necessary make the operation impracticable for farm processes but some irradiated centres will process packaged goods for outside agents.

(g) Meat and poultry. With regard to meat the farmer is unlikely to be more than a producer of animals which go directly to the butcher, processor or factory. In remote areas for local consumption some farm processing may be necessary. The suggestion has been made that in remote areas (Wales and Scotland) there might be a local primary collecting and freezing centre and secondary processing plants near to consumer areas. The consumer demands for tenderness, flavour, leanness, juiciness and colour need to be recognised by the producer.

However, tenderising by the use of enzymes is best left to the factory processors, although on the farm antibiotics in foodstuffs for animals and hormone treatment need strict control.

The needs of the poultry industry, which is concentrated in a few areas, and are so well known that only mention is made at this stage.

(h) Packaging. The subject of packaging is so vast that only the bare mention is possible here. Modern methods of food processing require special packaging which extends from the string bag to paper bags — to plastic containers — to special plastic film sachets and bags — to vacuum packs and now to boil-in-the-bag techniques.

The use of moisture of oxygen or light proof packaging is often necessary to guarantee adequate protection and final quality of some produce. The consumer packets have provided fertile ground for the introduction of machinery.

Farm processing

As already mentioned farm processing may be complete and produce food for sale to the retailer/customer or the processing may be partial prior to tranship to cold store or processor.

Tables 10 and 11 indicate some of the processes which may be controlled on the farm. Many of these processes require engineering facilities well within the reach of the food engineer but slightly outside the activity of the agricultural engineer. There exist new challenges for designs of machines which are more efficient but there are opportunities for new machines. Thus strawberries harvested mechanically in the "white" stage to be subsequently ripened is a more recent challenge.

Energy is likely to be the limiting factor in food production in the not too distant future because of the world population increase needing massive quantities of food. Energy includes not only fuels, coal, and oil, but natural energy from the sun which not all the oil in the North Sea can provide.

Table 10 Farm processing

Produce	Operations	Newer techniques
For consumer or retail sales		
Fruit	Chilling, grading, packing	Vacuum chilling
Vegetables	Grading, packing, washing, grading, packing	Vacuum chilling
Lettuce	Water chilling or vacuum chilling, packing	
Potatoes	Washing, grading, packing, peeling, surface treatment, packing	
Mushrooms	Cleaning, grading, packing, cooling	
Poultry	Chilling, packing, freezing	Vacuum chilling
For sale to processor		
Fruit	Chilling, bulk packing, vacuum chilling	
Vegetables	Washed? Graded, packed	
Potatoes	Washed? Graded, packed	
Peas	Chilled or frozen in bulk	
Root crops	Cleaned, packed	
Onions	Cleaned, packed	
Cereals	Dried of combine harvested	
Cheese	Cool store 45°F	

Table 11 Farm processing for storage prior to sale to processor

Produce	Operation
Fruit	Refrigeration, gas storage, packed in treated wrap spray coated
Vegetables	Cooled, humidity, controlled storage
Root crops including potatoes and onions	Cooled humidity, controlled storage — treated with additive to control root growth
Cereals	Recirculated silos for moisture equalisation
Frozen produce	
Strawberries	Quick freezing in tunnel (liquid nitrogen refrigerant). Pre-packing often used
Peas, Beans	Chilled in bulk tanks for transport, frozen in bulk packs for cold storage
Poultry	Cleaned, chilled, packed in flexible film. Frozen.

Trends in food processing techniques and operations

by G Evans BSc MInstP

Introduction

MY initial problems in preparing this paper were (a) how to define the word *trend,* (b) to establish the width of coverage of techniques and operations, and (c) to determine what period of time the review should span. The *Short Oxford Dictionary* defines "trend" as "the general course, tendency to drift". In statistical text books it is "the general drift, tendency or bent of a set of *data* over a *long* period of time". Fowler in his *Modern English Usage* warns us "that it is a word, whether noun or verb, to be used by no-one who is not sure of both its meaning and its idiomatic habits".

Having digested all this, I finally ended up by accepting Humpty Dumpty's dictum "it shall mean exactly what I mean it to mean", and that is "the changes in food processing which I consider to be of sufficient importance and interest to an audience primarily composed of engineers and other professionals in the UK agri-business".

As for coverage, I have spread the net fairly wide, from meat to vegetables, powders to ice cream, and heating to freezing; I have considered the last 10–15 years as a reasonable time span.

(1) Trend influensors

I believe that developments in food processing evolve for the following reasons:—

(i) to meet identifiable commercial or consumer needs
(ii) to exploit technological/scientific discoveries
(iii) to counteract the effect of depletion or non-availability of raw materials.
(iv) to take advantage of increased consumer affluence.

There have been many statements in the recent literature to support the above. Cobern, Managing Director of Findus, believes that the social factors involved in consumer needs include "the demand and value placed on *convenience* foods by working married women", "introduction of speciality foods and ethnic dishes as a result of increasing holidays taken abroad", "tendency for younger generations to assign greater value to leisure time". At the recent IFST symposium Shaw, of Walls Meat Products Ltd, said "in a world where sources of protein, and red meat in particular, are becoming scarcer, applying technology to make a wider range of meat products and to *increase* the *utilisation* of available meat supplies is of social and economic value". A *Farmers Weekly* supplement stated "the development of meat and milk analogues was caused by a *shortage* of traditional products rather than a desire to put farmers out of business." Burt said "existing projections of world population and food supplies suggests that within the forseeable future there is likely to develop an increasing *deficiency of raw materials* used in concentrate feeds and that the deficiency will have to be made up by *improved utilisation of available materials".* Finally, in a May 1973 issue of the *Financial Times,* Professor G. R. Allen is headlined as expressing "A decade of food shortage fear".

Technological/scientific discoveries of the last decade include freeze-drying, microencapsulation, membrane concentration, cryogenic freezing and microwave energy. "Improved" technology includes heat sterilization and quick freezing; foods in flexible packaging is dramatically different from Appert's original vegetables in bottles. The original Clarence Birdseye plate freezer can now be classified as "low key" technology when compared with liquid nitrogen or Freon freezers or continuous spiral freezers. Affluence which is a frequently used and often misused word, is seldom accepted by all members of the community as having increased. However I believe that the trend (again that dangerous word) over the period covered in this paper has been an increase in consumers disposable income. This does not mean however that they buy *more* food but rather that they *demand better quality* and *greater variety.* A long range planning study by Ohio State University predicts that by the year 2000 USA citizens will use only 12.5% of their disposable income on food (cf. 16% in 1973). We continually read in the scientific and technical literature and popular press of the need for improved nutrition and natural (or nature identic) flavours. It seems that nutritional quality is, to misquote Nancy Mitford, one of the new "U" words. Convenience foods are not new — what is relatively new is the demand for *quality with convenience.*

I could continue in this way but I think this is sufficient to illustrate what I meant by "Trend Influensors".

(2) Materials shortages

It is not necessary to over emphasise to an audience so closely integrated with the agri-business that the imbalance between the supply and demand of many of our traditional foods and ingredients is likely to continue to increase. This imbalance is particularly acute for protein foods — hence the trend towards an increasing utilisation of non-conventional proteins and more effective utilisation of traditional proteins.

2.1 Oil seed proteins

The approximate contribution of traditional protein sources to human foods and animal feeds are shown in table 1, with the annual production per unit area of land in table 2.

Table 1 Estimated contribution of various sources to world protein

Source	Contribution (10^6 tonnes)	
Cereals and grain legumes		72
Wheat	25	
Rice	12	
Maize	20	
Beans	8	
Peas, lentils and others	7	
Animal		
Meat, milk and eggs		20
Oil seeds		
Soybean, cottonseed, peanuts		20
Fish		3.5
Yeast		0.2
	Total	115.7

Adapted from WOLKNAK. B. Activities report No. 2 1972

Based on this data it is plausible to argue that production of oil-seed based protein is the more likely route for alleviating protein shortage and this is in fact one of the more *established trends* in food processing. As long ago as the early 1950's, research groups in many parts of the world, particularly in the USA and Britain, were actively developing techniques for the extraction, isolation, and concentration of oil-seed proteins — mainly from groundnuts and soybeans. The protein concentrates were converted to meat

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This paper was presented at the autumn conference of The Institution of Agricultural Engineers, at Shuttleworth College, Biggleswade, Beds., on 1 October 1974.

Table 2 Protein production per unit of land surface

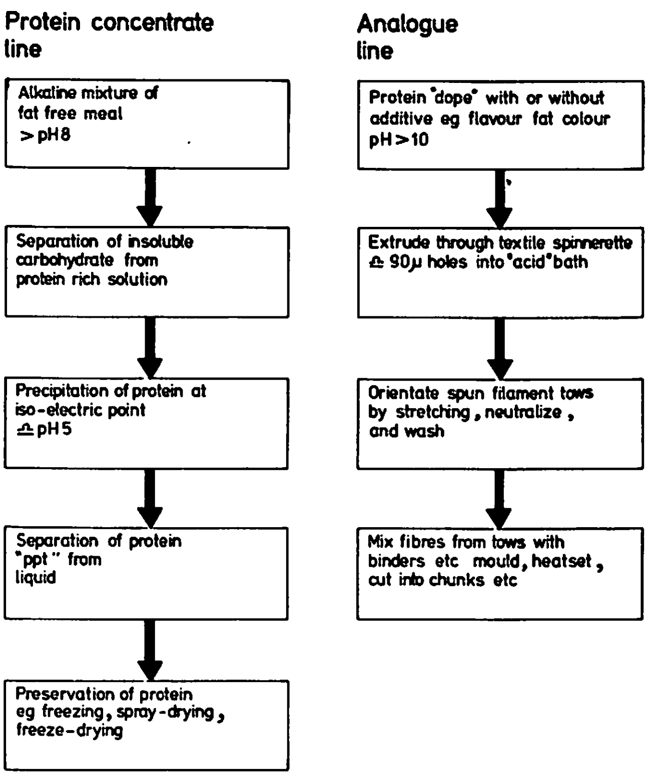
Protein source	Average yield/ha	Protein kg/ha
Soybeans	16.3 litres	560
Maize	43.4 litres	358
Wheat	17 litres	202
Milk	3140 kg	112
Beef	269 kg	67

See Dimler R. J. Soybean Digest Nov. 1970 p.17

and dairy type food analogues. The Boyer technique which was probably the most advanced, was based on the formation of continuous tows of filaments by extrusion of highly concentrated pure soya protein through "textile" spinnerettes into an acid bath. The tows were mixed with fats, flavours, and binders to form meat analogues of reasonably good quality. The analogues did not meet with immediate commercial success however — they were more expensive than the natural product, and had certain quality deficiences (eg texture and flavour).

Despite this early set-back, there are now many commercial meat analogues on the market. For example in the USA, General Mills market Bac'os (flavour like bacon), Pepro's (flavour like spicy pepperoni) and Saus'os (flavour like mild sausages). Courtaulds in the UK recently launched Kesp — a high quality spun product based on the field bean *(Vicia Faba)*. The basic flow diagram of most of the spun fibre processes is outlined in figure 1.

Figure 1 Basic flow diagram for soya protein based meat analogue



2.2 Non-spun protein products

Some products are based on "texturing" fat-free soya meals or flours by the simultaneous application of shear and heat ie extrusion cooking. The ensuing products, in the form of chunks, are usually used as meat extenders eg to increase the meat-like appearance of soups; Arkady TVP and Texgran are typical examples of such products.

2.3 Single cell and fungal proteins

The press frequently refers to non-conventional proteins based on bacterial or fungal fermentation or single cell proteins as *synthetic* or novel: the implication is that they are artificial or *made* from some *basic* elements — this is far from the truth. They are produced by a biological process. That they are novel is also questionable — food yeasts have been known for at least 30 years and certain algae have been staple diets in some communities for many centuries. What *is* novel, however, is the recognition and utilisation of certain substrates to support growth, for example the use of hydrocarbons in the petroleum industry to support bacterial growth, and the use of industrial wastes from the paper industry to support the growth of filamentous fungi.

2.3.1 Petroleum based proteins

British Petroleum are probably the main producers of animal feed proteins from petroleum stocks. In the Lavera (France) Plant they use a refined oil containing 10% paraffin. The paraffin is consumed by the yeasts, and the oil returned to the refinery after separating out the product, which is then purified and dried before marketing. Estimates made in 1972 by Reynolds of actual or projected protein production using such processes are shown in table 3.

Table 3 Estimated protein production from petroleum stock

Country/Company	Production kg/yr x 10^6
UK	
British Petroleum — Grangemouth	1.8
Imperial Chemical Industries, Billingham	<0.5
France	
British Petroleum, Cap Lavera	13.6
Japan	
Kyowa Hakko Kogyo, Bofu	0.9
Dai Nippon Ink, Chuba	5.4
Italy	
Ital protein, Sardinia	<0.5

Abstracted from Reynolds D.G. — Business Communication Co. — Engineered Protein Foods 1972

2.3.2 Bacterial fungal protein

Fermentation process based on industrial wastes are under development in many parts of the world. In the UK Rank Hovis McDougall recently revealed details of a process for growing filamentous microfungi from a strain of *Penicillium Notatum* using the starch waste from the Kesp process. The Louisiana State University ferment Cellulomances sp. bacteria and Alcaligenes faecalis on sugar cane begasse cellulosic waste. The Pekilo process of the Finnish Government uses a sulphite by-product from the paper industry. Tate and Lyle make a syrup from the carob plant *(Ceratonia Siliqua)* to grow a fungal strain.

2.3.3 Single cell proteins

The unicellular algae contain 40—50% protein of reasonable nutritive value though the protein is usually deficient in sulphur-containing amino acids. Some species are consumed extensively in Japan and the filamentous green Spirulina is traditionally harvested in Lake Chad.

Theoretically all these algae need for growth is water, sunlight, carbon dioxide and essential elements. It was recently estimated that a lagoon the size of Essex could provide all the world's protein needs, and that one the size of a football pitch would yield *44 tonnes/annum* — equivalent to 100 steers. However many unresolved technical/commercial problems have delayed the full exploitation of unicellular algae. For example shallow lagoons are essential to allow adequate light penetration. Need for prolonged sunlight restrict areas of potential exploitation and high CO_2 levels demands expensive capital investment. Harvesting is technically difficult and the harvested crop needs extensive and costly processing to convert it into a palatable product. Pilot plant processes for Chlorella or Scenedesmus have been developed despite these drawbacks.

2.3.4 Other protein sources

Fish, manure, grass/leaves and animal blood are a few other sources being evaluated. Blood is an interesting possibility — recovering all the blood from UK slaughterhouses would yield about 14,000 tonnes of protein (table 4).

Table 4 Estimated "blood" protein from UK slaughterhouses

Species	No's killed x 10^3	Average weight kg	Extractable blood kg x 10^3	Protein kg x 10^3
Cattle	3466	550	85,784	7721
Pigs	15,176	90	47,805	4302
Sheep	15,156	36	24,553	2210
		Total	158,142	14233

A process based on the use of 6 x 10^6 tonnes cow manure would produce as much protein as the entire USA soybean crop. The key factor is that 20% of the cow intake is not digested, and that bacteria, which acts as digestors (rather than enzymes as in pigs and humans) are excreted in large quantities *as single cell proteins:* new bacteria are continually cultured in the cow's four stomachs. The manure is mixed with water and certain chemicals to form a slurry. The fibre is then filtered out, impurities removed and the ensuing bacterial slurry sterilised and dried to a powder. The fibre goes to silage.*

(3) Structuring and restructuring

More effective utilisation of existing raw material resources either for alleviating shortages or for improving quality is one of the major objectives of both the Food Industry and the Agri-business. Structuring and restructuring is one of the major process trends in achieving these objectives. The concept is not completely, of course, new — bread and pasta are obvious examples of long established structured products based on a process of breaking down grain to a basic unit, adding and mixing functional ingredients, followed by heat setting coupled with shaping either before or after heating. The essential process steps in practically all restructuring processes are shown in figure 2.

3.2 Meat and fish

The meat from a substantial proportion of slaughtered beef cattle and (retired) milking cows is of relatively low quality, and a considerable quantity of useable meat adheres to bones at the butchering stage. The recovery and upgrading of such meat is of considerable commercial value, hence the increasing trend for deboning processes and structuring techniques for comminuted meats. The USDA are currently drafting a proposal for using red meat recovered with meatbone separation equipment — quoted yields are between 11% for rib back bones to 38% from chuck.

In one structuring process low grade portions are flaked, combined with other meat chunks or ingredients, and the mass extruded into logs and then diced. On the other extreme British Patent No. 1327762 describes a process in which a paste of *finely comminuted* meat containing a proportion of separate fibre bundles is extruded and then heat set prior to slicing and dicing.

An earlier British Patent (No. 952204) described the preparation of a cooked meat product from a heat set comminute whose formulation was adjusted to give precise ratios of fat, protein, and water.

The Iowa Beef Processors Inc. upgrade meat trimmings from a 50:50 lean to fat ratio to 80:20 lean to fat ratio using a novel photoelectric colour sorter technique.

**It is as well to stress that a problem still exists in gaining consumer acceptance and legal permission for these alternative proteins.*

Figure 2 Essential steps in restructuring

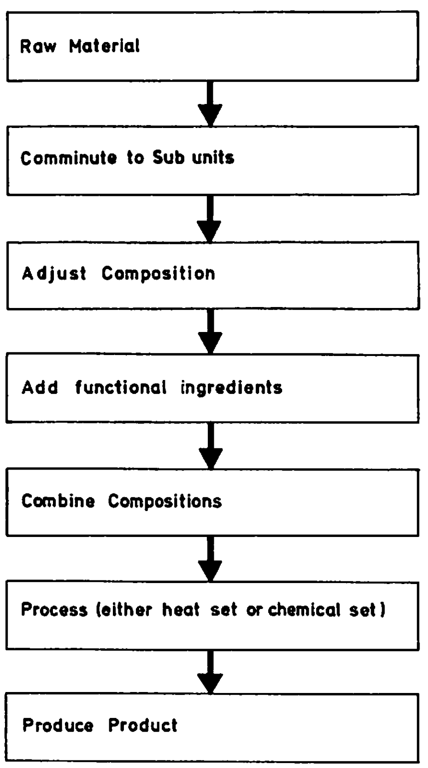
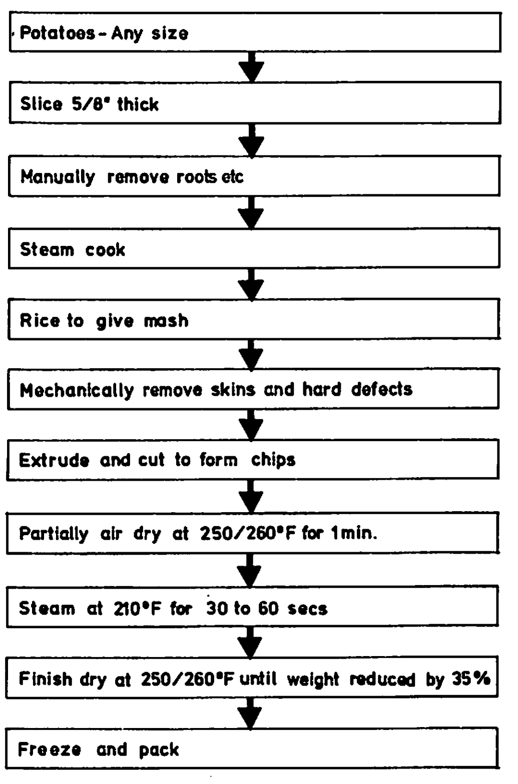


Figure3 Restructured potato chip process as developed by WRL (ref. Food Processing Sept. '73)



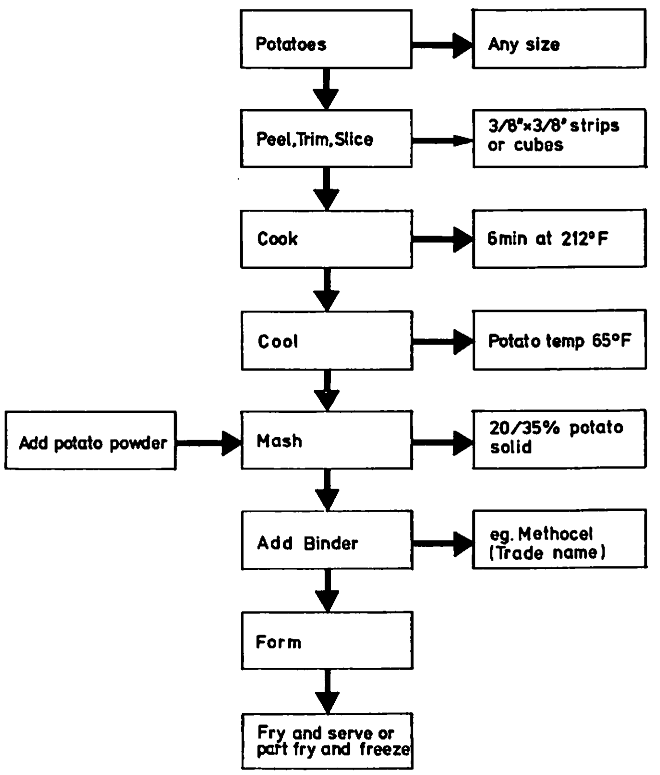
Structured fish processes however are usually based on mixing fish fibres with gelling agents, eg alginates, followed by extrusion or moulding.

3.3 Vegetables

The same basic principles apply to structured vegetable products. For example figure 3 is the basic flow diagram of a process for making structured potato chips: the process was developed by the Western Regional Laboratory of the USDA. It is claimed that such chips can be fried in about 60 seconds at 185°C and that the oil content can be regulated – the preferred level is for best quality is ½ to ⅔ that in conventionally made chips.

An alternative process figure 4, is based on cooking sliced potatoes, followed by rapid cooling to below the gelatinisation temperature prior to mashing. An edible cellulose binder is added and the mash is then partially dehydrated and finally shaped and fried.

Figure 4 Structured french fries from potato mash
(Extracted from B.P. 1 176 897



A reformed onion process depends on forming an extrudable slurry of onion pulp into rings which are then covered with an alginate solution. The rings are subsequently dunked in a setting liquid containing, for example, alkaline earth ions.

3.4 Fruit

Harvesting of soft fruits is becoming more and more expensive because of shortage of labour for harvesting. One consequence is an increasing risk of the fruit becoming over-mature and hence unacceptable for marketing. The market also expects fruit like strawberries and raspberries to be of a well defined and uniform size. Over mature and under-sized fruit do not command a premium price and are usually either left in the field or converted to pulp – with a consequent increasing loss to the grower and an increasing deficiency in the market.

This is a classical situation for restructuring and there are clear process trends in this direction. For example Irish patent 301/73 describes a process for products resembling soft-centred fruits like gooseberries or cherries. Sweetened fruit pulp is mixed with an equal quantity of an alginate or pectate sol. The ensuing slurry is extruded into a bath containing calcium ions. The extrudate is cut into discrete lengths just as it enters the bath such that the pieces form spheres due to surface tension effects. The calcium ions react with the alginate to form a hard skin. The resultant spheres are heated to 70–100°C after about 10 mins to quench the calcium/alginate reaction.

(4) Advancing technologies

Technology, like Topsy, evolves and grows continuously. It is difficult to define scientifically or identify precisely "new" technology. The introduction of some long established scientific principles into actual (or potential) and relatively sophisticated commercial processes is now a significant trend. Some processes are introduced because of environmental lobbies eg to reduce pollution or upgrade or re-cycle wastes; others to meet increasing consumer demand for improved quality; a few because of the successful engineering development of an essential stage of a process.

4.1 Microencapsulation

In many instances either during processing or preparation prior to eating or even during eating, it is desirable to release components that will react with the rest of the food to give desirable product attributes. For example in structured foods we need a controlled release of flavours during cooking and eating, in animal feedstuffs we need to protect the stability of added vitamins, in certain reaction processes we need a controlled release of acidulents or leavening agents.

The technology of microencapsulation has expanded rapidly in recent years to fulfil some of these needs. Although many processes have been developed eg mechanical extrusion, electrostatic precipitation, polymerisation, and vacuum deposition; spray drying and coacervation are undoubtedly the most advanced.

4.1.1 Spray drying

Well over 6.81×10^6 kg annum of spray dried encapsulated flavours are now used in the USA with probably a similar quantity in Europe. The first step in the process is the dissolution or dispersion of the wall material in a solvent (usually water). An emulsion of flavours or essential oils in the suspension/dispersion of wall material is spray dried, using a high pressure nozzle or atomising disc to form droplets of the emulsion in a stream of hot air. Ultra rapid evaporation ensues, because of the drop's high surface area to volume ratio, such that the product core temperature does not exceed the wet bulb temperature in the drier until practically all the water has evaporated. If an emulsion solid level of more than 40% is used then less than 10% of the volatiles are lost during drying. The most widely used wall materials are:–

Vegetable gums – gum arabic (acacia), gum tragacanth, guar gum etc.
Starches – including modified or pregelatinized starches.
Dextrins
Proteins – including gelatin, hydrolized gelatin, soya protein, caseinates.
Cellulose – esters and ethers.
Sugars – sucrose, dextrose etc.

4.1.2 Coacervation

This process consists essentially of three stages.

(a) *Formation* of three imiscible liquid phases – a liquid manufacturing vehicle phase, a core material phase, and a coating material phase.
(b) *Deposition* of the liquid (polymer) coating around the core material – induced by the reduction in total interfacial energy.
(c) *Solidification* of the coating, usually by thermal, chemical cross-linking, or desolvation techniques.

Methods used for stage 1 include:–

(i) *Direct addition* of insoluble waxes or immiscible polymer solutions or insoluble liquid polymers to the manufacturing vehicle phase.

(ii) *In situ production* by dissolving a monomer in the liquid vehicle and then polymerising the monomer at the interface.

(iii) *Phase separation* by inducing physical or chemical changes in a polymer solution — for example by reducing temperature, action of dissimilar polymer pairs in a common solvent, addition of salt. Coating materials include natural and synthetic polymers such as aminoplasts, carboxymethylcellulose, cellulose acetate phthalate, ethylcellulose, gelatin, and gelatin-gum arabic. Coating thicknesses vary from 1 to 200 microns — equivalent to between 3 and 30% of the total weight. The core material is released by application of external forces, heating, dissolution in an appropriate solvent, biodegradation, or diffusion of, say, water through the coating.

4.2 Concentration

Liquid food concentrates, for sale as such as for conversion to powders/granules by spray or freeze-drying, have been produced for many years. Considerable flavour volatiles are lost during concentration and drying hence the ensuing produce quality is worse than that of the original material. Process routes have evolved to overcome some of these quality deficiencies eg flavour stripping and add back techniques. Most of the losses are attributable to thermal or phase change effects hence the considerable attention paid in recent years to concentration techniques involving little or no phase changes in the product. Two such developments worthy of mention are reverse osmosis and freeze concentration.

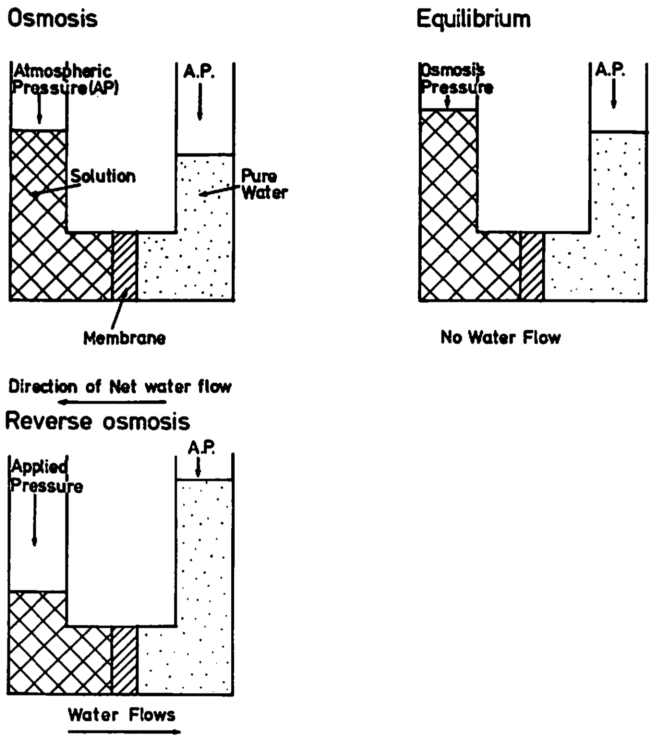
4.2.2 Reverse osmosis

Osmosis is a biological phenomenon of all living organisms. If two liquids, one a solution such as common salt or sugar and the other pure water, are separated by a semi-permeable membrane such as cellulose acetate, then water will flow through the membrane into the solution. If increasing pressure is applied on the solution side the water flow will eventually stop — the pressure at zero flow is known as the *osmotic pressure* of that solution — for 3.5% common salt solution (sea water) and pure water it is about 2410kN/m^2. If the pressure is increased further then water will start to flow in the *reverse* direction ie the solution is concentrated. This is the basic principle of *reverse osmosis (RO)* or hyperfiltration (figure 5).

Reverse osmosis has been studied in research laboratories for over 100 years. It's commercial development was retarded because of lack of suitable and reliable membranes with acceptably high flux rates. Since about 1966 the situation has changed considerably and many manufacturers are now offering fairly large RO systems. The choice of membrane depends on the bond strength between the solvent and the membrane material.

Equations developed by Lonsdale to describe the flow of permeate through the membranes show that (i) the solvent flow rate will increase with applied pressure if the solute concentration remains constant, and (ii) solute permeation increases with rise in concentration but not with pressure.

Figure 5 Basic principle of Reverse Osmosis (from Food Trade Review Nov. 1970)



As the solvent passes through the membrane the concentration of the solution will increase at the membrane wall until eventually it is so high that flow will cease. This effect, known as *polarisation*, must be reduced if flow is to be maintained: this is usually achieved in practice by creating turbulence at the wall.

Although energy is used for pumping the permeate through the system, to overcome the osmotic pressure, and to maintain turbulence, no *phase or temperature* change occurs at the concentration step.

Some companies offering reverse osmosis systems are listed in table 5. Some applications are listed in table 6.

Whey is a by-product of cheese manufacture and contains about half the original milk solids, including most of the original lactose, some protein, amino acids and salts, together with about 94% water. The material has a high BOD, which causes an effluent disposal problem. Reverse osmosis can be used to extract the protein and lactose and the ensuing product can be spray dried. The BOD of the residual water is very much lower than the original whey liquor hence greatly alleviating the effluent problem.

Table 5 Reverse osmosis systems

Pressure containment	Description	Manufacturer
By porus tube itself	Lined with high flux membrane	Aqua-Chem, Aerojet 1 American Standard, Havens, Babcock and Wilcox
Tubes contained by external pressure shell	(a) High flux membranes outside porus support tubes (b) Micron filaments self supporting low flux membrane	Foss Chemicals Du Pont
Cylinder inside external sheet	Spirally rolled high flux membranes and spacers	Gulf General Atomic
Stack in external shell or between end plates	Stacked flat sheets of high flux membranes and spacers	Aerojet General, Wurstack, Amicon, Dorr-Oliver, APV

From Food Trade Review Nov. 1970

4.2.3 Freeze concentration

Reducing the temperature of a solution below its eutectic point precipitates water in the form of ice crystals thus concentrating the remainder ie here is a concentration process avoiding quality

Table 6 Some uses of reverse osmosis in the food industry

Product	Advantages
Fruit juices eg lemon, apple	Flavour retention, sweetening
Whey, skim milk	Reduced effluent problems. Recovery of valuable by-product
Egg white	Improved concentration of heat sensitive material — glucose reduction possible

degradation associated with thermal effects. *Freeze concentration,* known for many decades was used commercially just after the last war — notably in Spain and America for concentrating citrus juices. It was not a commercial success because of the relatively low yield caused by loss of mother liquor entrapped in the ice crystals. A modified process evolved by Thijssen and developed by Grenco claims to have overcome this deficiency and hence has re-generated interest in the potential use of this technique for concentrating heat sensitive solutions.

There are two essential stages in this technique — crystallisation and ice crystal/mother liquor separation, the former being the more important. It is based on the scientific observation that spherical ice crystals above a critical size will grow uniformly in a slightly supercooled regime, (about 0.02^{o}C). Crystals below the critical size will melt and transfer their latent heat to the mother liquor and hence maintain the supercooled regime. The "small" crystals are continuously added to the crystalliser; they are suspended in a mixture of fresh feed and mother liquor from the crystalliser. The mixture is cooled in a scraped-surface refrigerated heat exchanger.

An aliquot of the grown crystals is continuously fed into a wash column separator; mother liquor is removed from the top. The ice crystals move to the bottom under hydraulic pressure, and heat is then applied to melt the crystals. It is claimed that solutions can be concentrated to more than 30% total solids with a yield better than 99.9%.

4.3 Thermal preservation

Heat sterilised foods in sealed containers were first introduced commercially by Appert in 1804 in the form of bottled products. The technique continuously evolved until the present day canning industry was established. Canning has undoubtedly played a major role in the development of mass produced long shelf life foods. In conventional processes a substantial proportion of the product is overheated (especially for cans larger than A1), since heat is conducted through the bulk to the centre. In recent years the trend has been to evolve more rapid and more uniform heating systems in order to improve the quality. The slope of bacterial lethality rate

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curves of products subjected to heat is steeper than the corresponding chemical/physical reaction rate curves — consequently using ultra fast heating at relatively high temperature results in adequate bacterial kill *before* any substantial change in the major product attributes eg colour, flavour and texture. Early developments concentrated on agitating the contents of the can — eg by rotating cages holding a number of cans. The concept of sterilising the products *before* filling into cans was introduced in the early 1920's. It is only in recent years however that the concept has developed into large scale commercial processes.

4.3.1 Clean room concept

In the early 1950's Smith and Ball introduced the concept known as the "clean room" process. The basic premise was that *all* process operations should take place in a *pressurised* and *relatively* clean (microbiologically) room. This eventually developed into the "Flash 18" process (figure 6). A large pressure chamber at 138kN/m^2 gauge houses the canning equipment and process operators. The product liquid phase is rapidly heated in a scraped surface heat exchanger and the particulates eg chunks of meat, in a stirred boiling tank. The two streams are then combined and fed into pre-sterilised cans. The cans are sealed on conventional filling/sealing equipment using pre-sterilised lids, then cooled and packed. This process is particularly valuable for large catering size cans eg A10.

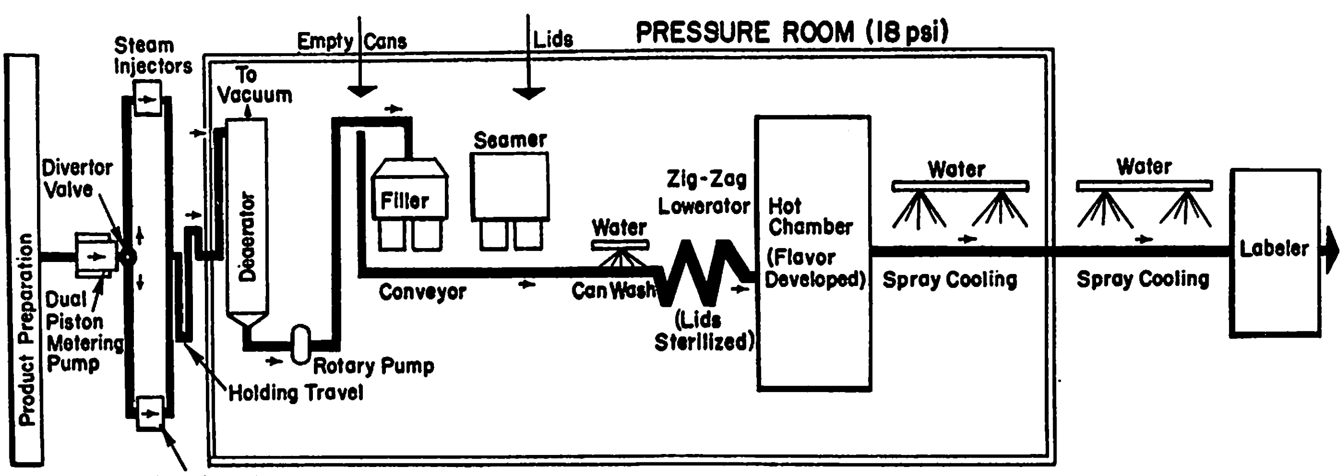
4.3.2 Aseptic canning

An aseptic canning process for liquid products was developed by the Martin-Dole Co.; the process involves heating the product rapidly either in a scraped surface heat exchanger or by steam injection: the product is then filled into cans in a sterile canning chamber using steam pre-sterilised cans and lids. The seamed cans emerge through a continuously steamed interlock gate system.

4.3.3 Microwave energy

Microwave energy is the term applied to the physical manifestation (usually heat) associated with the absorption (or attenuation) of electromagnetic radiation of 900 MHz and above. Since it is absorbed in the body of the product, thus avoiding surface heat transfer restrictions, very high heating rates are possible. Its applica-

Figure 6
Schematic diagram "Flash 18" process



tion in food processes has a chequered history since first proposed in the 1950's. The *trend* is towards wider applications in processes which need *controlled* and *rapid* internal heating – for example for the sterilisation of foods in flexible plastic bags, pasta drying, mold inactivation of pre-packed bread, sterilisation of pre-packed bacon, thermal proofing of doughnuts. The use of domestic microwave cookers may indirectly influence process trends in so far as products and packages must be tailor-made to be compatible with the properties of the radiant energy. For example "lean" buns used for hamburgers and hot dogs had to be re-formulated to give controlled cooking; breaded fried chickens require close control of crumb levels and oil quality.

4.3.4 Quick freezing

Quick frozen foods are now a major factor in our lives and have a considerable influence on both the food industry and the agribusiness. In the formative years products were packed in wax paper cartons, placed on metal trays, then frozen in plate frosters. These were batch operations with high labour costs. The trend has been towards continuous low labour operations, more rapid freezing usually before packaging or before bulk storage for subsequent packaging. Ultra rapid freezing techniques now exist whereby products are frozen by *direct* contact with natural liquid gases eg nitrogen or carbon dioxide or manufactured liquid gases eg Freon (dichlorodifluoromethane). Continuous indirect systems are based on mesh belts travelling spirally upwards and downwards on two drums with cold air (less than –30°C) blowing through the belts and around the product.

4.4 Dehydration

A survey of trends in food processing would be incomplete without some reference to dehydration. The image of poor quality associated with dried foods during the last world war has now virtually disappeared. Good quality dehydrated foods are available in ever increasing quantities and variety – for example vegetables, fruit, desserts, snacks, beverages, soups and even complete meals. The main trend is towards quicker (or even instant) rehydration either in cold or hot water. Freeze drying, hailed some 15 years or so ago as the panacea for most of the ills of dried foods, is now finding its niche in the good quality beverage powder and dairy product market. Instantising techniques are continually being used and extended to a much wider product mix than skim milk.

(5) Concluding remarks

This survey is obviously not exhaustive. For example I have not included the trends towards continuous bakery processes, (eg the Chorleywood bread process), continuous pasteurisation/sterilisation of flexible and semi-rigid containers (eg Tetrapack), continuous culturing of milk products (eg for yoghurt, dairy desserts), or upgrading of cereal wastes (eg alkali treatment of straw). Advanced developments – in a technical rather than scientific sense – include cell culturing of "new" plant varieties, immobilized enzyme for continuous fermentation processes and for sugar conversion systems (eg for converting glucose to fructose), fish farming, continuous meat processing techniques (eg co-extruded skin/meat sausage manufacture), intermediate moisture content or lowered water activity products. In conclusion I believe that the major *trend* is towards the *creation* of *new* products by the isolation or breakdown of ingredients to basic identifiable units (eg protein, fat, water) and then re-building the units in a controlled process to give a desirable and product with *built in* properties (be they organoleptic, nutritional, stability or flexibility). It may be many decades before the industry operates like the chemical or petrochemical industries but I see this *trend* as being with us already.

Acknowledgement

I wish to thank the directors of Unilever for allowing me to write this paper. The opinions expressed are entirely my own. Many of my colleagues have contributed and in particular I acknowledge the help given by Mr Gerry Allen who collected and collated so much of the information.

Selected references

Proteins

Imrie F. K. IFST Symposium March 1974.
Amer. Oil. Chem. Soc. 51 (1) 1974 (Special issue).
Wolknak B. Activities report No. 2 1972.
Dimler R. J. Soybean Dig. Nov. 1970.
Reynolds D. G. Engineered Protein Foods – Business Communication Co., Stanford 1972.
Gardner B. (Editor) Supplement to *Farmers Weekly* – 15 June 1973.
Callihan C. D. and **Dunlap C. E.** – USA Environmental Protection Agency 1971.
Foster C. F. and **Hughes D. E.** – Symposium on Waste Recovery and Recycle Inst. *Chem. Eng.* May 1974.
Hashick W. *Food Trade Rev.* Jan. 1974.
Anon – Novel Protein Intelligence Unit Bulletin No. 1 – MAFF July–Dec. 1972.
Blair R. and **Toles G.** *Farmers Weekly* Feb. 8 1974.

Structuring

Patent App. NE 7309172 7/1/74.
Shaw R. IFST Symposium March 1974.
Altschul A. M. and **Hornstein I.** – *J. Agr. Food Chem.* 20 (3) 1972.
Irish Patent App. No. 301/73 (27/2/73).
Netherlands Patent App. 7306 441 (9/5/73).
U.S. Patent 3 650 766 (21/3/72).
British Patent 1 176 897 (7/1/70).
British Patent 1 327 762.
British Patent 952 204.

Technologies

Bakan J. A. *Food Technol.* (USA) Nov. 1973.
Graves R. E. *Cereal Sci. Today* 17 (4) 1972.
McKernon W. M. *Flavour Ind.* Dec. 1972.
Friedlander H. Z. and **Rickles R. N.**, *Chem. Eng.* Feb, March, April, June 1966.
Harrison P. S. *Food Trade Rev.* Nov. 1970.
Assinder I. Applications of Microwaves to Food Processing – Loughborough University Course 10–13 Sept. 1973.
Schiffmann R. F. J. *Microwave Power* 8 (2) 1973.
Daly P. N. – *Food Technol.* (USA) Sept. 1971.
Mauter R. L., **Tremblay M. R.** and **Chadwick E. A.** – *Food Process.* 33 (1) 1972.
Keefe R. T. and **Goldblith S. A.** – *Food Technol.* (USA) 27 (8) 1973.
Goldblith S. A. – *Food Technol.* (USA) Jan. 1972.
Thijssen H. A. C. Dachema Monogr. 1969 63.
Ziemba J. V. *Food Eng.* March 1964.
Hersom A. – AFST Symposium March 1974.
Timbers G. E. *Food Can.* March 1974.
Farmakis D. – *Quick Frozen Foods* 35 (8) 1973.
Vieth W. R. and **Venkatasubrahanian K.** *Chem/Tech.* Nov. 1973.

General

Weetall H. W. *Lab Equip. Dig.* March 1974.
Keith W. R. *Chem Tech.* Nov 73.
Burt A. W. A. – *J. Sci. Food Agri.* April 1973.
Allen G. R. *Financial Times* May 10 1973.
Anon – *Food Technol.* (USA) Dec. 1973 p.46.
Kendall R. M. *Chem Ind.* (London) Feb. 1974.
Coburn M. – *Grocer* March 1974.
Bone D. *Food Technol.* (USA) 27 (4) 1973.

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Food preparation and processing operations on the farm

by A O Roberts CEng MIMechE AIFST

Summary

PERHAPS a layman would conjure up a picture of the farmer's wife preparing food for the casual workers in the hayfield when he read the title of this paper.

We are discussing a much more sophisticated manufacturing unit, products from which could be marketed worldwide.

Traditionally we have looked upon the farmer as the primary food producer providing raw food products in field condition with the local blacksmith providing implements from the plough to the harvesting machines.

The picture has changed considerably. Nowadays the farm unit is often an appreciable size self-contained food factory in which products are grown, processed, preserved and packaged ready for the housewife to place in the refrigerator or deep freeze. In order to accomplish this, it has been necessary to break down prejudices from the established larger food processors who hitherto had acknowledged the expertise of the farmer on the land, but now the farmer was intruding on processors expertise. After all, a food processing hall requires different standards of hygiene than the farm yard!

The farmer/grower "bought in" the expertise in the form of experienced technologists and now we find very acceptable conditions.

Quick freezing was selected as the most suitable system rather than canning or dehydration, because there was an established market for the frozen material in bulk, and the equipment required was convenient to purchase, operate and maintain.

The products handled are conventional crops such as those shown in table I with the potential of those in table II, which are familiar enough to the farm scene.

This paper is not concerned with the other farm products, which are also processed, shown in table III, and the author certainly suggests that the farm freezing unit avoids the "popular" frozen products shown in table IV!

I	II	III	IV
Peas	Onions	Meat	Pizzas
Broad beans	Beetroot	Chicken	Waffles
Green beans	Swedes	Turkey	Sausage rolls
Potatoes	Turnips	Duck	Mela Stregeta
Sprouts	Celery		Bomba Sophia
Broccoli	Cabbage	Milk products	Strawberry ice cream
Cauliflower	Mushrooms		
Carrots	Spinach		

There is still a great deal of scope for fruit and vegetable growers in onions, mushrooms, cucumbers, strawberries, raspberries, gooseberries etc.

Emphasis must be made, that the grower/processor has to recognise and adhere to the high standards required when processing foods. The product must be protected from any practices resulting in poor quality which would create disrepute. Membership of trade associations with research facilities and technical service is most essential.

The equipment is available to ensure first quality product. This can only operate satisfactorily with good management and supervision and organisation.

The scope of this paper is "Preparation and processing of food products on the farm" which encompasses, harvesting, cleaning conditioning and preserving. Packaging and storage are dealt with in another paper.

Harvesting

This is included, although it may be considered that ever since man existed he has been involved in harvesting and this is nothing new. Modern harvesting methods with the contributory ground preparation and plant breeding are important facets of any preparation and processing unit.

The crop must be harvested fast at its optimum maturity, with minimum damage and in clean condition, leaving all unwanted materials in the field and enabling the factory unit to start with raw materials that are worth processing. It is a fallacy to believe that the factory can "improve" poor raw materials and it must be recognised by the grower that he must uphold the standard of product into his own factory, that is demanded by the larger processor.

As well as quality, quantity must be available at all times to keep the factory operating efficiently. Nowadays harvesting machinery is capable of doing this but it is a big investment to be considered in conjunction with the factory equipment.

Pea plants are pre-cut and left in windrows in the field for the pea combine harvester to travel along, pick it up, thresh out the peas and throw back the waste materials on to the field. These machines are large to cope with the plant bulk but recently I have seen varieties of pea plants growing that have no leaves — a considerable reduction in bulk to be handled by the viner. Perhaps we shall see more of this type of plant development. Also systems exist to strip the pods from the pea plant and thus exclude the stalk etc from the threshing chamber. A lot of work is needed in this area all of which must still ensure a good material being delivered to the factory gate.

Broad beans are harvested in a similar way but green beans (or french beans as some prefer to call them) are harvested by stripping the pods from the stalk which remains in the ground. There has been a dramatic development in the growing and harvesting of this vegetable. The dwarf type has been grown in rows about 76 cm apart down to about 40 cm to allow weed control access and row-type harvesters to operate. These machines move along the rows taking in two or more rows but they are labour intensive and relatively slow. Improved weed control chemicals have allowed closer planting of the beans, producing higher yields per hectare, and the development of harvesting machines that travel along or across the rows at a fast rate taking in a 3 metre swath improves

It is essential that all members of the Institution of Agricultural Engineers keep the Secretary informed at all times of any change in their address.

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the economics a great deal and produces a more uniformly mature product for the factory to process.

These points highlight the requirements of the factory. The same principles apply to the other products that the farm processing unit will be expected to handle. The agricultural engineer has a very important contribution to make to the successful operation of these factories.

The building

Not a converted cow-shed, but a purpose built food hall of hygienic construction. This is a subject in itself with good published information available[1]. Almost a clinical approach is required with smooth interior walls without ledges that could harbour undesirable debris and pests. Adequate potable water, and a drainage system leading to acceptable effluent disposal facilities. A steam raising plant capable of meeting peak requirements. The electrical installation of standards suitable to withstand the rigours of almost continuous high pressure washing down — not intentionally of course!

This building will probably incorporate cold storage facilities for short term storage of raw and finished material.

Cloakrooms and washing facilities for the factory personnel, kept in clean condition are essential, as is a canteen or eating room separate from the processing hall.[1 and 2].

Preferably the site should be away from existing farm operations but with good access for transport vehicles for raw and finished materials.

Staff

Since the venture is likely to be of a co-operative nature, a separate company will be formed with directors from each of the participating growing groups. In this case the company operation will be of a familiar pattern with a managing director and production manager responsible for producing the goods — and showing a profit.

However, *quality* is of prime importance and a trained quality control man is necessary. He would preferably be responsible directly to the managing director who should respect his judgement on daily matters. He is the person responsible for assuring the buyers that the product is of a satisfactory standard.

All personnel should be dressed appropriately for a food factory, usually with white overalls and suitable covering for the head.

The equipment

The conventional systems available for preserving food products are:—

1. Dehydration
2. Canning
3. Quick Freezing

Dehydration requires bulky equipment and the market for the product is rather limited.

Canning or thermal processing does not give the advantages of storing in bulk. It has the disadvantage also of having to take in empty containers and lids and storing these. The cost of doing this is not to be disregarded.

Quick freezing provides all the advantages for the grower/processor, whose prime interest is to establish a system which will preserve his products in bulk and accept it at all times without hampering his harvesting operation.

The freezing unit is compact and is often available on lease. It is reliable without too many moving parts. The product from the freezing unit can be collected in bulk boxes (polythene lined) of about 1200 kg capacity which are readily transported by fork lift truck and stacked in the cold store. The product is very marketable in this form without further attention by the grower/processor.

Freezing units

Although it is not in logical sequence for this paper, let us look first of all at some details of the freezing systems available[3].

These fall generally into two categories:

1. Refrigerated air at minus 30 to 40°C recirculated through a low temperature heat exchanger and ducted through the product as it passes along a mesh type conveyor or a trough in which the product is fluidised.
2. Cryogenic freezing which is the application of gases (at minus 196°C for nitrogen), which have been stored at high pressure, directly onto the product as it moves through a chamber on a mesh type belt. Nitrogen, carbon dioxide or freon are used. Advantages are claimed for each with various application methods.

The first system requires an "engine room" with high capacity compressors with associated power units and heat exchangers but it is independent of 'external' supplies of refrigerant.

The advantage of the second system is that, in place of the self contained refrigerating unit needed for the first system, only a high pressure gas storage arrangement is required which does not have any 'moving parts'. The storage vessels are recharged regularly from mobile tankers belonging to the gas companies.

There is also a major advantage claimed for the Freon system. (At the time this paper is being written Freon is not yet "allowed" in the UK for food freezing. This is a formality and should be generally permitted by the Autumn 1974).

This system has a bath of liquid Freon gas into which the product is tipped. This gives instant freezing after which the product emerges on a sloping mesh belt to give drainage of liquid. All vapours from the bath are recirculated through a heat exchanger to reliquify. This, it is claimed, gives good operating economy without excessive losses of gas.

Product preparation machinery

Back now to the products and handling systems[4]. Inevitably this paper will omit mention of some products, but equipment for the more common vegetables will be described.

It will be expected that the vegetables will arrive in bulk from the field, in tipping trucks or 500 kg tanks. A bulk reception area is required. It may even be necessary to have a cold room to hold some products in chilled condition.

The bulk receiving hopper will have the facility to discharge the product at variable and controllable rate to the processing line.

A check will have been made of the quantity or weight of product arriving at the factory. A weigh bridge will enable this to be done or alternatively a continuous weigh belt can be incorporated in the line preferably after dry cleaning and before washing — which would show an increase in weight due to the water present!

Dry cleaning is important since the waste material can be carried away and dumped without causing anyone any anxiety. Wet material after a washing operation, is more difficult to handle and dispose of as effluent.

Peas, broad beans, green beans*

The smaller and lighter unit weight vegetables such as peas, broad beans and green beans pass though an upward draught of air from a fan. This removes lighter waste such as skins, leaves etc. Suction systems are also very efficient for this operation. A riddle system takes out large waste pieces and allows small stones, gravel etc. to separate out.

Washing of these products also has the purpose of removing stones and any light floating waste such as poppy heads and straw that has reached this stage.

There are a number of destoning systems, all associated with density separation in water or brine. Any stones can cause havoc to cutting equipment and cause production stoppages.

Peas and broad beans are ready for blanching after washing but green beans must have any clusters broken up and the ends cut off (snibbing).

Blanching is the operation of immersing the product in near boiling water for a short time (about 1 minute for peas and 4 minutes for green beans) mainly to inactivate enzymes on the surface of the vegetables which could cause spoilage even after freezing. It also gives a hot water wash, and improves the product colour. **See Appendix 1 for flow line.*

After blanching it is desirable to give the product a fresh water wash on a vibrator. This will remove sugars and starches released in the blancher, and also any splits and skins that may then be present.

Cooling the product to about 16°C helps to reduce the refrigeration load later. It also minimises snowing up of the freezer and consequent "down time".

Inspection after blanching and cooling is essential to give a final check to the product before freezing. This is the last visual separation of unwanted and foreign material before freezing. It is also easier to inspect whole product before cutting. Green beans are mostly cut in one way or another before freezing and blanching makes the cutting operation easier.

Carrots, potatoes, root vegetables*

Heavier root crops are tumbled in cage type reels to remove adhering soil or clay and to separate out small stones etc. Washing is

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**See Appendix 1 for flow line.*

**See Appendix 2 for flow line.*

subsequently done in similar reels with high pressure water sprays on to the product which is inter-rubbing to dislodge soil.

Root vegetables must be peeled. This is done either by chemical caustic dipping which burns off the skin or by steam peeling in which the product is subjected to high pressure steam for about ¾ minute which loosens the skin.

Brush washers are very effective to clean off any adhering skin after any system of peeling.

Inevitably some trimming will be necessary to remove blemished product. This is done usually by operators stationed on each side of a wide conveyor.

Following this the product goes forward to cutting or to freezing in the whole condition.

**See Appendix 2 for flow line.*

A particular mention for carrots. Attempts have been made to cut the tops off carrots in the field during harvesting. For various reasons this has not been successful. It is a big problem and many companies have invested a great deal of money to make a machine for factory use. This usually is directed towards the smaller roots which need size grading. A successful machine could help to cut the present estimate of over £1,000,000 year spent on carrot topping only! If topping equipment does not come available soon the carrot pack could deminish appreciably.

Why do it at all? Well, the top is unsightly because it is discoloured and often harbours soil and grit.

For dicing or slicing the larger carrots are preferred because they produce a lower percentage of outer faces and less small pieces.

Potatoes seem "a natural" for the grower/processor. In most instances these are converted into chips (or french fries). However the smaller processor should be wary of the market, since there are very large commercial companies with high capacity equipment and specialist knowledge. Indications are that there may be over production soon, with the consequent clogging up of cold store capacity. However the processing stages should be included in this paper. These are indicated on the flow line in Appendix 2.

It will be seen that blanching or conditioning forms an important step (often with the addition of sugar) followed by deep frying in hot oil before freezing.

Brussel sprouts*

This is an important commodity for the UK grower and is popular in the frozen condition.

Harvesting has been rather laborious in poor working conditions but mechanical harvesting is not too far away now and the hand trimming of the butts which made the product rather costly to produce can now also be achieved mechanically.

Here again a great deal of investment has been made by the larger freezer companies to develop machinery.

A sprout is difficult to orientate to present the butt to a trimming knife without causing excessive wastage and bruising. The varieties play an important role in successful mechanical handling, but close grading for size is essential to prevent over-trimming.

Various systems are available each with advantages. Essentially the sprout must be supported firmly in a trough whilst a knife system does the trimming.

After trimming, the sprouts are water blanched cooled and frozen. Separation into three size grades is usually necessary for the final pack, but this is achieved before trimming. On a small installation with limited blanching capacity, storage of the trimmed graded sprouts must be allowed for. In any crop there will be an unpredictable fall out of grade sizes to be dealt with.

Broccoli, cauliflower*

These are rather delicate products which are hand trimmed and sorted, followed by washing on a conveyor. Water blanching is normally used followed by cooling and freezing.

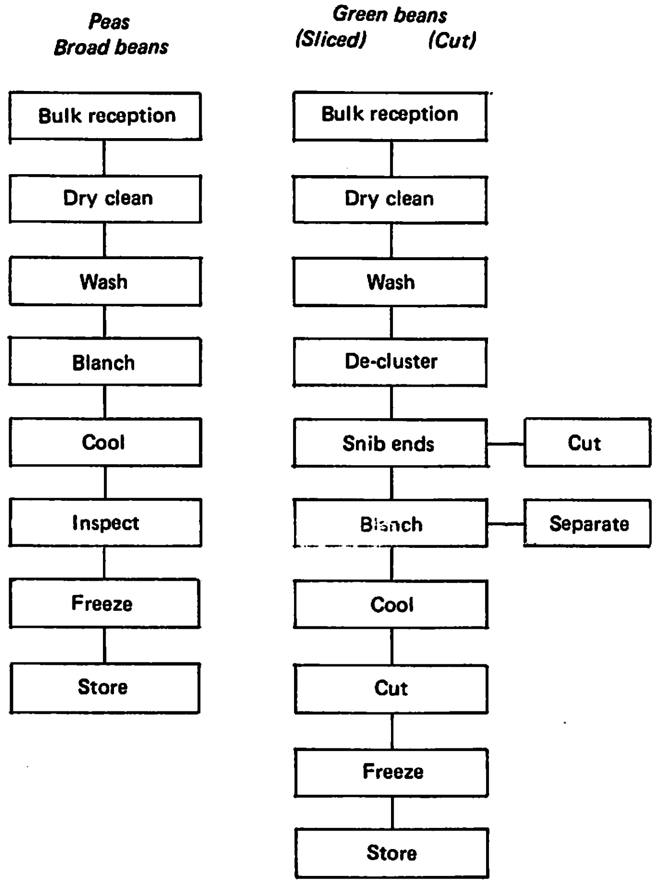
In order to retain the fresh light colour of cauliflower, a low strength solution of acetic acid is used in the blancher. The blancher must then have suitable materials of contact.

Final Comment

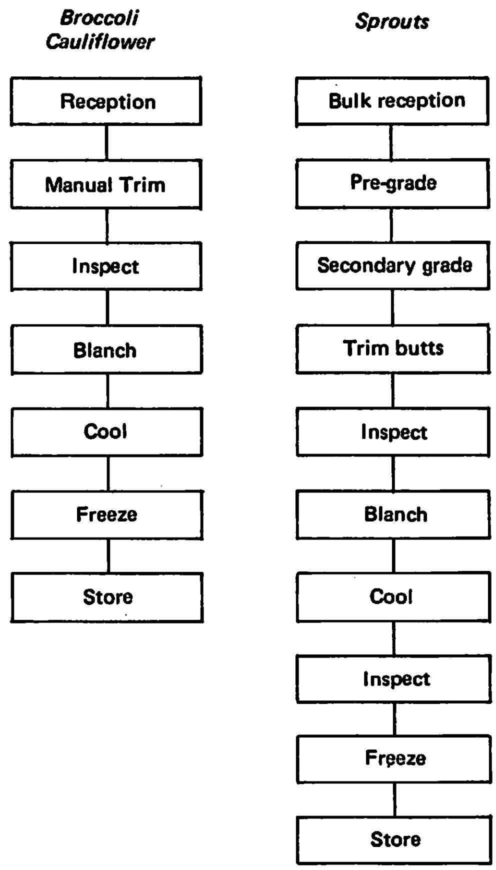
This paper has probably only just touched the fringes of the potential still available in farm freezer units. It has however given an insight into the 'factory side operation' for the appreciation of the agricultural engineer. Collaboration between the field operation and the factory is bound to improve efficiency. After all, "Why import it — when we can grow it — and process it.....

**See Appendix 3 for flow line.*

Appendix 1

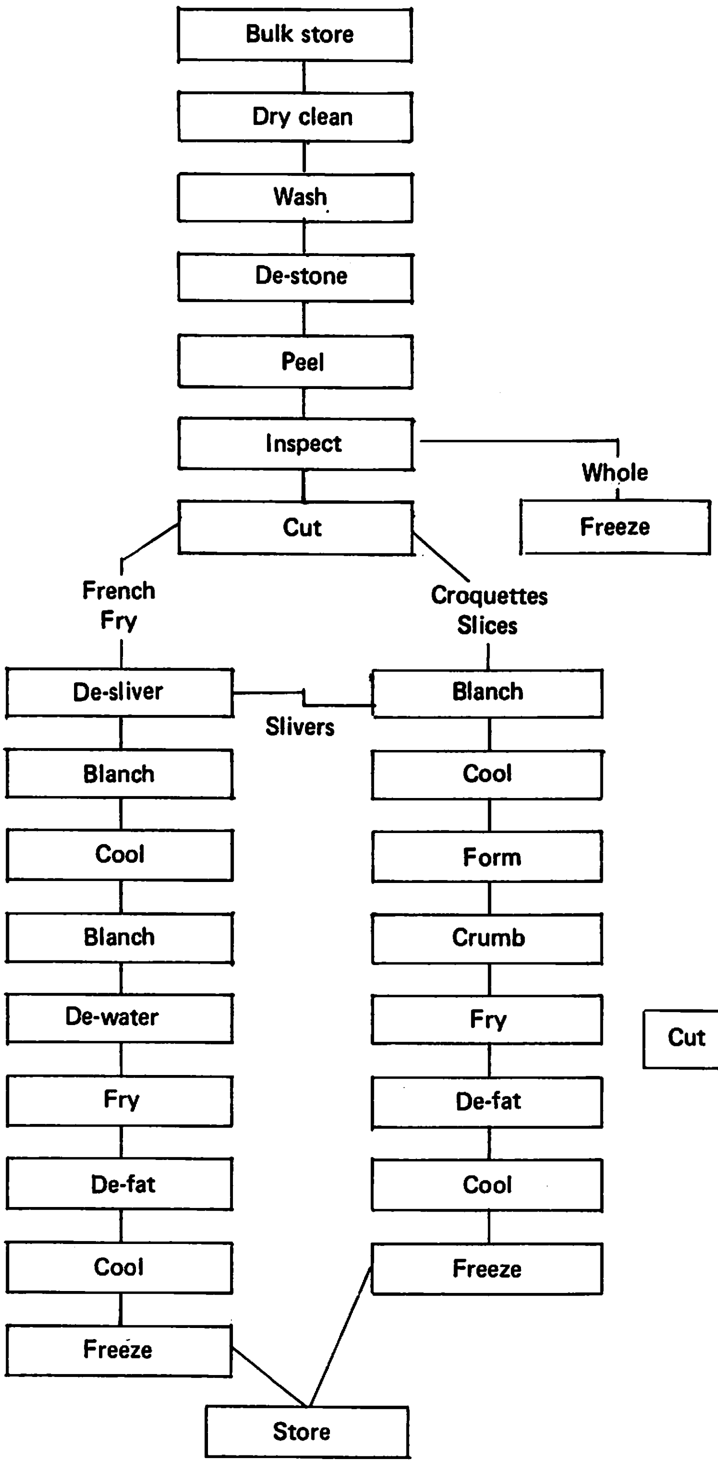


Appendix 3

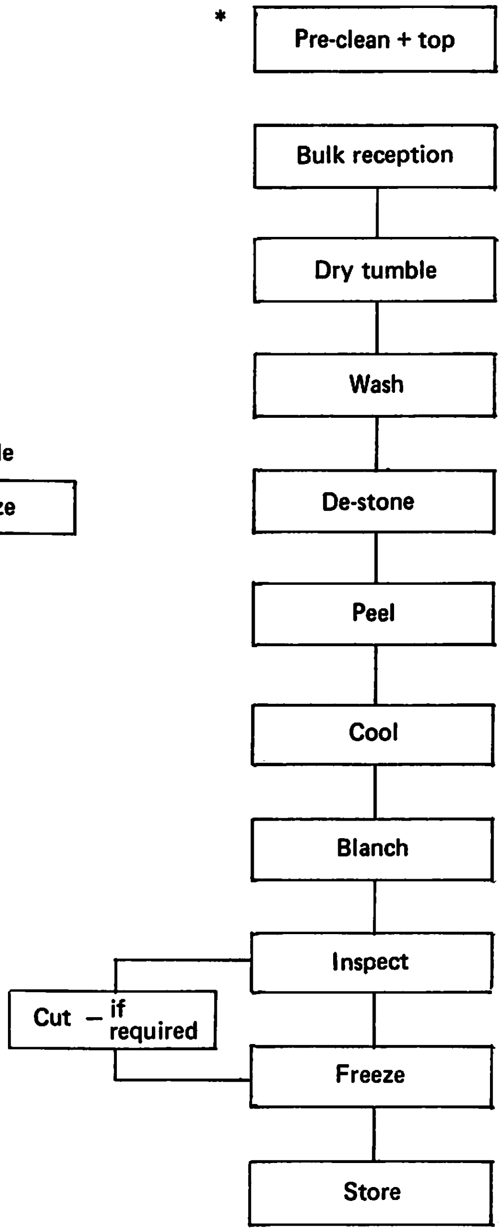


Appendix 2

Potatoes



Carrots



* *This is usually done in an out-station. It includes pre-washing and size separation Larger sizes are preferred for dicing.*

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References

1 (i) *Proceedings of Institute of Food Science and Technology* (UK) Vol. 7 Number 2 (June 1974)

(ii) **BFMIRA** Leatherhead — Food Factory Design.

2 Post Process Sanitation. Tech. Manual No. 1. Campden Food Preservation Research Association.

3 Paper C 131/72. **D. W. Everington** — Conference "The Mechanical Engineers Contribution to Process" Engineering in the Food Industry — IMechE (1972)

4 Paper 128/72 — **A. O. Roberts** — Conference "The Mechanical Engineers Contribution to Process" Engineering in the Food Industry — IMechE (1972)

Packaging and transport of locally processed food products

by F A Paine BSc FRIC MInstP and R R Goddard MInstPkg

Summary

HISTORICALLY the producers of food took their surplus to the local market and sold it directly to consumers. No packaging was involved other than the re-usable boxes, baskets or sacks used to carry them. With the growth of national distribution centres, the increase in the size of agricultural units, and greater specialisation the trend has been for produce to pass through intermediate stages where the bulk loads are broken down and the produce sorted, washed, graded and packed.

Some of these operations can be carried out on the farm itself where appropriate, and it is then possible to sell the produce directly to the consumer, or to deliver it in ready-to-sell packs to local retailers.

If this operation is to be profitable the additional costs incurred in grading, packaging etc must be less than the increase in price obtained. Moreover, there must be a viable market for the outgraded material. Any packaging operation must therefore be technically and economically correct, and of such a standard as to ensure that a bond of goodwill is maintained between the producer and his (no longer anonymous) customers.

The transit hazards and storage conditions in a local distribution system should be fairly easily determined and be generally less severe and less variable than those occurring in distribution on a national level. This should allow pack specification to be compiled more accurately, and in some respects performance requirements can be reduced. This will lead to economies in packaging costs, and may help to make smaller operations profitable.

Principles of packaging

Before examining the specific range of products involved in this industry it is worthwhile to run briefly through the basic principles which apply to all packaging operations.

The packaging operation is the physical movement of the product in the correct mix, weight, number or attitude into the pack; or the forming of the pack around the product.

The location of the packaging operation must be decided for each situation, taking into account all of the factors. Carrying out the packaging operation at the earliest possible stage in distribution has advantages in reducing multiple handling, and in providing product protection. The disadvantages are likely to be an increase in bulk, and a reduction in the rate of harvesting. The optimum must therefore be selected.

In performing the packaging operation the usual principles of work study can be applied — minimum handling, in-line operations etc. and the appropriate degree of mechanisation employed. Such operations as weighing, counting and grading can all be mechanised to very high levels, or can be performed manually. The same is true of filling the product into the packs and closing them. Here also an optimum rate for carrying out the operation must be sought, ensuring that high cost equipment and labour are used at an economic level. For most small-to-medium operations there are suitable items of semi-automatic equipment available, often with a great deal of flexibility built in, allowing several different products and/or pack weights to be handled on the same packing line.

The pack itself has certain functions to perform. The most acceptable definition of these is in the four words "containment, protection, communication and service". This is sometimes expanded to include some reference to costs, but problems then arise of defining the minimum acceptable performance. In addition, it must be remembered that the selling function (part of communication) will have to be paid for, and any extra cost above the minimum must bring in additional sales (and profit).

Expanding the four prime functions:—

Containment means simply that the pack must hold together a suitable amount of product or a number of items (which may be similar or different). The performance requirement is usually one of the appropriate strength characteristic to resist spillage in transport with properties such as tensile, burst, and impact strength, tearing and puncture resistance of the pack material being specified.

Protection includes a wide range of requirements, and is related to the sensitivity of the product to distribution and environmental factors. These potential hazards encountered between farm gate and consumer may be chemical in nature eg attack by water, oxygen and/or light, biological eg deterioration by moulds or attack by insects and animals, or physical eg drops or impacts, superimposed loads and vibration from vehicles. The problem may not be due to outside influences entering the packs, but the loss of volatile constituents from the product can also lead to problems such as short weights due to drying out. Conversely, other produce may need access to air, and in special instances such as fresh meat, the rate of access of oxygen must be controlled within specific well-defined limits.

Biological hazards may be caused by self-spoilage or by contamination from outside the pack. Most farm produce comes into the first category, and deterioration may be accelerated by environmental factors of heat, light access to oxygen etc. or retarded by cool cabinet storage etc. during sale.

The best way to prevent attack by insects and animals is to eliminate the possibility of them reaching the packed produce ie by close attention to storage areas and generally good housekeeping. It is generally considered uneconomic to pack low cost foodstuffs sufficiently well to prevent attack by determined animals. Some claims are made for materials having insect-repellent treatment, but these are not extensively used, and there can be problems of acceptable treatment levels. With some produce there is the likelihood of insects being present in the produce when harvested, and these should be eliminated prior to packaging.

The physical hazards may be fairly constant and well defined as in a limited distribution system by own transport, under close supervision; or they may be quite variable in nature as in postal distribution or rail handling. In the first situation it is fairly easy to arrive at a pack specification which is adequate but not excessive. With the second it is less easy. It is necessary to allow for a higher level of hazard to meet the greater variability, and this means that perhaps 95% of all packs will be strong enough to meet conditions they will never experience simply to prevent damage in the remaining 5% which will normally suffer them. In general really abnormal shocks (accidents) should not be catered for, as this leads to over-packaging which is costly.

Communication. As well as informing the customer or the consignee of the contents, weight, quality and origin of the goods, the pack also has a part to play in establishing confidence in the product by

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the use of a brand name. For most agricultural products the best identification is the sight of the produce itself. Visibility ensures that the customer can see:—

1. That the produce is of the right quality;
2. has been graded correctly;
3. is free from dirt and other matter;
4. is uniformly sized etc.

Transport packs permitting such visibility since they transmit light do not protect light sensitive produce adequately eg potatoes turn green on exposure to light and would best be packed in opaque packs. Only if the customer can 'trust' the opaque packs will he be prepared to accept quality without seeing the produce. The importance of this aspect is perhaps slowly changing, eggs are generally bought now without inspection, but would strawberries be if similarly packed?

Service. There is an element of this in every pack which is not always apparent. In the simplest form it is the presentation of a single item or the appropriate amount of a product in the most convenient form for the consumer to use. There are however products and packs where this aspect is the most important feature eg aerosols for hair lacquer.

Summing up the requirement of the pack

The choice is dictated by the specific needs of the product, the anticipated shelf life, the type of distribution system and the market at which it is aimed. It is essential to recognise those properties of the pack which provide these requirements so that the most cost-effective system can be selected. By being aware of the function and purpose of each component and aspect of the pack, it becomes easier to make modifications when circumstances change, and to assess whether any new materials or package development can be used with advantage.

The pack or packaging material should be specified to the supplier, giving the fullest possible information about the intended use. Each clause in a specification should relate to some significant aspect of the performance required, and no clauses included unnecessarily. Too often, in the past, requirements have been included in specifications because they are easy to measure or are traditional when the material is used for another purpose. Another important aspect of specifying packs or materials is the range of variability which is acceptable. This should be realistic and take account of the possible manufacturing tolerances, and of the importance of accuracy to the user. Very tight tolerances, if specified, will cost money in that more stringent inspection and probably a higher rejection rate will result.

Let us now consider some specific agricultural product and the particular packaging requirements:

Grain and cereals. In the main these are handled almost exclusively by large producers in bulk, under contract. There could be a market for small quantities for 'health' shops and there may well be some reversion to self-sufficiency in the future. These products are not particularly difficult or demanding, and the storage conditions are often more important than the packs themselves.

Meat and poultry. These are expanding areas, especially following the recent growth in deep freezer ownership. The UK sales of deep freezers have been steadily increasing, especially over the last five years or so. Figures quoted are:

1968	57,000
1969	132,000
1970	200,000
1971	350,000
1972	530,000
1973	850,000*

** including refrigerator/freezers*

The total number of deep freezers in use in the UK at the end of 1973 is estimated by Birds Eye at 1.9 million — or 10.5% of the UK households.

As the emphasis tends to be on bulk packs these are primarily functional in nature. Simple plastics film bags feature very widely, and so long as the freezer conditions are maintained and the film is suitable for the low temperatures, few problems arise. It should be remembered that low temperature storage leads to dehydration of unwrapped meat although the quick freezing process itself should lock moisture in as ice. 'Freezer-burn' is the result of local rapid dehydration caused during the quick freeze process where a hole exists in a film or foil wrapper. When very cold packs are removed from a deep freeze condensation takes place over all surfaces. Plastics film bags are usually unaffected by such effects, but other materials can give problems (cans rusting, and cartonboard becoming soggy). In the main meat and poultry are 'catch-weighed' at the time of sale. Primal cuts of meat are frequently vacuum packed and heat sealed into bags made from laminated material, often nylon/polythene.

Vegetables. These are a large range of products differing widely in their requirements. Root crops are usually the least demanding, although the tendency now to sell washed produce can result in too much water being trapped with the product in the pack. This can lead to mould growth where the pack is not ventilated, and suitable equipment to dry the crop sufficiently before packing should be installed. Typical packs are polythene bags, perforated to allow ventilation, and a wide range of net materials made from cotton or plastics.

Leaf vegetables are more demanding, some being sensitive to crushing and bruising, and all are susceptible to wilting. For the latter rigid trays allowing a circulation of air are most commonly used, while for products like cabbage conventional cotton net bags continue to serve. The degree of trimming carried out on brassicas particularly cabbage, broccoli and cauliflower, varies considerably. The aim with cabbage should be to provide the consumer with no waste if the produce is prepacked in a film material, and to provide one layer of removable leaves if packed without a barrier. Some leaves should be left on broccoli and cauliflower as this provides protection.

Trimming and packaging can be done in the field, which means that only saleable product has to be transported and it is protected from the moment of cutting. The trays used are often re-usable wooden ones although wax coated fibre-board is finding some acceptance. Another new material of use here is plastics "corrugated" which is water resistant and can be re-used. It is more expensive than the board however, but has advantages in certain situations and could be returnable and packed flat.

Vegetables provide some special problems which make them different from most manufactured products. Among these are the following:—

Lack of uniformity in size, shape, weight and variety in the products. Short harvesting season, the useful life after picking differs from variety to variety but in some instances is only a matter of days.

Produce is still 'living' during the marketing period, respiration and transpiration continue, oxygen being consumed and carbon dioxide produced in the process.

Fruit. Also a widely differing range of produce, most however, being susceptible to bruising and crushing. The method of packaging and the protection necessary depends upon the use to which it will be put. Bulk material, for manufacturing into other products require less protection, and will not be considered further, the main interest being in fruit for dessert and other household use.

Hard fruit — apples and pears — are often packed, after grading, into corrugated board cases separated by shaped layer pads made from pulp fibre or foamed polystyrene. Such packs are usually reserved only for top grades and longer journeys. Most local deliveries can be reasonably packed in open top trays holding ten pounds or so of either size graded or jumble packed fruit. There is a fair sized market for such packs particularly in 'grower areas' both at the farm gate and at pack houses. When pre-packs are required as retail units the most favoured system for hard fruit is a shallow tray in paperboard, moulded pulp, or foamed polystyrene covered with a clinging film of stretch pvc. This is a very effective pack functionally, and the appearance can be very attractive. The unit of sale is normally a number (four to six apples) but if closely graded for size this also equates to a weight unit. Two major problems, related to one another, exist. Both result from the out grade situation. To establish 'confidence' in a pre-pack all fruit should be top quality. There is a great tendency to lower the standards for outgrading in the belief that this will give greater profitability. In the long term it does not. It only destroys confidence in the packer's standards whether the packer is a pack house or a fruit farm. The second problem is how to use the outgrades profitably. Processing for purees and cider etc. have limits and jumble packs stated to be outgrades give a low return. The solution lies in relating the top graded price to that obtainable for the outgraded produce. Soft fruit for retail is packed into punnets which have remained constant in style for many years, during which the material of construction has changed from peeled wood to moulded pulp and carton board, to the currently used plastics which are either injection moulded in skeleton form or thermoformed from thin sheet into punnets with some ribbing to improve rigidity. The more traditional materials are still used however. Individual punnets are frequently used as the basis for a modular system where a number fit exactly into a shallow tray fitted with supporting ends or corner posts which is used as a returnable bulk pack.

Eggs. A product for which the packaging remained unchanged for many years, the bulk container of 'Keyes' trays and the six egg retail pack are too well known to need description here. Slight variations exist in the design of the '6' packs and the material of construction, once exclusively pulp fibre, may now alternatively be foamed polystyrene or thin sheet polystyrene. These packs meet the needs of the large 'factory' producers, who use grading and filling equipment designed to handle them. The smallholding or farm-gate trade in eggs has existed for many years, and shows no sign of slackening, probably the reverse.

For the smaller operators without the constraints of equipment, a very wide range of pack styles are possible, and PIRA has studied examples from all over the world. At the moment however, with the bulk manufacturing techniques available the present hinged lid six egg pack in moulded pulp is probably the most economic available. The thin polystyrene six pack is more expensive, but since the filled packs interlock, some savings arise in bulk transport costs.

The market for egg packs is a large one and many studies for alterations to the present pack have been made, so far without notable success.

Dairy Produce. Butter, cheese, cream and milk are generally packed in large scale operations by factory methods, although there is scope for small integrated producer-supplier operations, particularly for cream.

Appendix 1

Sources of information or advice on packaging. There are several organisations concerned with the packaging of foodstuffs, and a number of standards relating to packs for specific foods exist. The British Standards Institute have a Packaging Standards Committee which co-ordinates the efforts of all of the specific committees involved in producing individual Standards. There was, until recently, a committee dealing exclusively with standards relating to the dairy industry, but the packaging aspect of this has now been taken over by the general packaging committee. There are a number of standards relating to packs for specific products eg bags for potatoes, trays for tomatoes, and crates for broccoli. These, and many others are listed in Sectional List SL15. Other standards of interest may be found in SL31 (agricultural, dairying and allied interests).

Another body issuing standards is PIFA, the trade association of manufacturers and converters of plastics films. These are more general, and quote the prospects which should be expected of plastics films and packs made from them.

PIRA, the research association for the paper and board, printing and packaging industries can provide information on any aspect of packaging or the other associated industries. This service can take various forms including literature searches, answers to technical and economic enquiries, and carrying out studies in any defined area as required. Regular publications are issued, covering literature references to technical aspects of the three industries individually, and to marketing matters related to all of them collectively.

PIRA also have laboratory facilities where wide ranging tests can be performed on materials and packs. A wide range of performance tests can be carried out on filled packs, simulating in the laboratories conditions which may be encountered in various systems of transport.

Small rooms are available where climatic conditions can be controlled, producing similar conditions to those prevailing in any part of the world. Packs and products may be stored in these rooms, and certain tests may also be carried out in them.

Where there appears to exist a need for research to be carried out in a specific area of packaging which would clearly be of interest to a number of organisations or companies, then PIRA will propose a detailed project and carry out the work on behalf of all interested parties.

The addresses of these organisations are:—

British Standards Institution, 101 Pentonville Road, London N1 9ND.

PIFA, c/o Peat Marwick Mitchell & Co., PO Box 121, 301 Glossop Road, Sheffield S10 2HN.

PIRA, Randalls Road, Leatherhead, Surrey.

Appendix 2

Suggested Further Reading.

BS 1133 — The Packaging Code — BSI.
Principles of Food Packaging, R Heiss, FAO.
Fundamentals of Packaging, ed. F A Paine, Blackie.
Packaging Materials and Containers, F A Paine, Blackie.
Modern Packaging Encyclopaedia, McGraw Hill.
The Packaging Directory (of Suppliers), Tudor Press.

Developments in food processing

Edited summaries of discussion

Mr J S Robertson (National Crop Production Engineer — Horticulture, ADAS, Cambridge) congratulated Dr Lewis on Dr Scott's paper, but said that some of the statistical information it contained must be treated with reserve. For example, in table 2 the production of brussels sprouts in 1972–73 appeared to show an increase of about 9% over 1969–70. In fact there was a glut in 1972–73 and the effective increase was not as high as indicated. Similarly, the figures in table 8 relating to potential expenditure on food consumption were taken from 1972 when UK membership of the EEC was not yet affecting the then low level of food prices. One would expect much scope for increased expenditure in the UK on food.

Mr A J Gane (Director of Research, Processors' and Growers' Research Organisation, Peterborough) endorsed Dr Scott's plea for greater co-operation between organisations in the food industry. Research and development should not be left solely to the processors and growers organisations, by whom research had been supported jointly for the last 30 years.

Balancing food supplies on an international scale was very important, and everything possible must be done to avoid imbalances between surplus and starvation in the future.

Mr J Gibson (Eastern Electricity Board) asked for information on the proportion of farm-produced foods preserved by cool chamber methods of refrigeration. (No answer was offered by the speakers or anyone else present).

Mr C E G Morris (National Union of Agricultural and Allied Workers) recognised that although a variety of food treatment processes were potentially available for use in developing countries their application was likely to be limited owing to high capital costs. He asked how this problem might be overcome.

Dr Lewis suggested that methods of protein production from waste materials represent opportunities to produce protein with a minimum of technology and hence at less cost.

Mr G Evans commented that his company was commercially based and therefore interested in making products that people would buy. He suggested that the reduced availability of certain products would in future mean that more effective ways of using these basic products would have to be found. This could involve the use of non-conventional proteins and modern technology to produce food which people would be prepared to buy. Gaining acceptance of such food is likely to be a major difficulty in developing countries.

Mr R E Goldsmith (Weasenham Farms Ltd) said that sending dried milk to developing countries might not be the best form of aid — it was better to encourage them to develop their own means of food production. Referring to the high protein production of soya beans, he asked how soya beans could be grown in less favourable climates, as in Scotland, for example. Finally, he asked what was the relationship between the cost of the raw food material and that of the finished product. Was it not the case that the more processing was involved the higher would be the final cost? Mr Evans replied that future protein shortages were most likely to be resolved by the production of non-conventional protein, which could be grown and processed more quickly than protein from animal sources.

Dr R W Radley (NCAE) observed that the UK and western Europe appeared to be heavily dependent upon imported supplies of vegetable protein. He asked whether the food industry had formed a collective view on what sources of such protein should be developed and what were the implications for the UK cropping plan.

Dr Lewis replied that a varied source of supply was desirable to provide an adequate nutritional mix, especially of amino-acids.

Mr Evans added that the international companies were considering this question, and the production of rape seed, sunflower seed and soya beans in western Europe was under investigation. Even in Brazil soya bean production was now beginning. High levels of protein production per hectare were vital.

Mr J Harding (Findus Ltd) said that we could hardly be described as desperately short of food when high levels of loss were tolerated and large amounts were thrown away. There was considerable scope for savings in the conventional production of food — for example, a loss of 20% of the crop from the back of the combine-harvester might well take place. In the past it had been easier and cheaper to buy food from other countries rather than to make these economies. There was plenty of scope for increased production of conventional foods, and in Western countries people both wanted and would be prepared to pay for more expensive foods, such as beef.

Mr J V Fox (President I Agr E) asked if food processing operations did not in fact use more energy that the food itself contained. For example, was it not wasteful to use petroleum as a feedstock for protein production?

Dr Lewis replied that fortunately this was not so, as it was necessary to de-wax crude oil in any case, and it was from the wax by-product that the microbial protein was produced. This process and the refining of fuel oils were complementary and not competitive.

Mr J S Robertson (ADAS) said that large quantities of carrots were dumped because they were damaged or diseased. He asked if the sound parts could be recovered and reconstituted, and for information on the stage of development that carrot toppers and brussel sprouts re-trimmer had reached.

Mr Roberts replied that carrot tops had to be removed if carrots were to be acceptable to the consumer, who also preferred small size carrots. Larger carrots had to go for processing. It was sometimes difficult to conform to EEC regulations on the description of carrots. Several millions of pounds has been spent on research on topping without producing an acceptable solution, unless carrots of a standard size could be grown. Regulations now prevented the employment of housewives in the evenings to undertake manual topping, because their children were not allowed on factory premises.

Machines for separating and trimming brussels sprouts had been developed, but only of size which would be economic on a factory scale. They worked best with pear-shaped sprouts which had an identifiable stem by which they could be handled. Recent developments in plant breeding had led to spherical sprouts, which were less easily dealt with.

Replying to a further comment by Mr Robertson on the possibility of using the main stem of the sprout plant as a point of reference, and thus avoiding the need for retrimming. Mr Roberts said that because conditions in the field were often very bad it was normally better to remove sprouts from the field in a semi-trimmed form.

Mr Gane pointed out that plant breeders had become increasingly competent in "biological engineering" as a means of developing new types of plants, and could do so quite quickly. Mr Roberts agreed with this comment, and added that at Chipping Campden an advisory panel had been set up to examine the problems of achieving suitability of plants for mechanical harvesting.

Mr J Gibson (Eastern Electricity Board) requested further information on the extraction of protein from organisms growing on animal wastes. He asked what kind of animal waste was to be used in this way, whether any equipment for this purpose was available and to which classes of livestock such protein might be fed, and whether or not reverse techniques had been tried on farm waste.

Mr Evans answered that protein extraction from livestock wastes had been attempted only in the USA, and he could not say with what kind of waste. Reverse osmosis membranes for many different purposes were being developed in a number of countries and he did not envisage any special technical difficulty in producing a membrane to handle farm waste.

There might be economic problems, although these would be reduced if there was a vigorous industrial demand for membranes for this purpose. Reverse osmosis techniques could become widespread in the future.

Mr J A C Gibb (University of Reading) asked for further information on the possibilities of reconstituting the usable parts of damaged or diseased materials. If these techniques became widely available there would be important implications for the design of harvesting systems.

Mr Goddard replied that separation of different fractions by colour was already used in vegetable dehydration processes.

Mr Evans emphasised that diseased materials could not be accepted for such treatment, but other defects and mechanical damage could be catered for and unwanted fractions such as potato eyes could be picked out. Drum drying techniques for some crops were particularly suitable for use in connection with such selective techniques. However, carrots presented greater difficulties and the problems had not yet been solved. It had been stated that 40 – 45% of the carrot crop was not used, but this did not mean it was necessarily unusable.

Mr Robertson said that this figure was probably excessive, and that 30 – 35% was more realistic. The effects of cutworms, carrot fly and damage due to both harvesting and packhouse equipment meant that it was difficult to reach EEC Class 1 standards. It was true that in the UK carrots were over-supplied, which led to considerable waste of food material and growing effort. Work on damage to carrots was being carried out jointly by ADAS and the NIAE.

Mr Gane said that processors' standards were very high and together with the housewife's desire for uniformity, they contributed to high wastage.

Mr A J Walters (FMC Corp. (UK) Ltd) asked what proportion of effort when designing packaging materials was directed towards pollution control.

Mr R R Goddard recognised that pollution and packaging did not always go together. He stated that the avoidance of pollution was normally included as one of the objectives in pack design. recycleable or disposable materials being used where possible. There were limits, however, which are often economic in form. New material was frequently cheaper than recycled material for glass containers. About 40% of paper in the UK was already recycled and this figure could be increased to 60% or even 80%, given adequate motivation and reward for collection. Biodegradable plastics had been studied but Mr Goddard felt that this was treating a symptom and not a cause, since the facility for recycling was lost in such an approach. Laminates had great versatility in packaging but were not recoverable due to the mixture of materials.

Mr P G Finn-Kelcey (consultant) said that if losses of material from harvesting machines could be used by means of a re-structuring process it would have considerable implications for machine design.

Mr Gane agreed that this would be true if the lost fraction could be collected and handled, but very often this was not the case, and the material remained on the field.

Mr Evans added that salvage and re-structuring were often possibilities where the point of rejection was at the processor's plant.

In reply to further questions by Mr Finn-Kelcey and Mr Roberts on the harvesting of crops such as strawberries and tomatoes, and the once-over harvesting of grapes, Mr Gane said that the combination of freezing, canning and jam-making processes offered the best possibility of full utilisation of the various fractions of these and other crops.

Finally, Mr Gane referred to the wide range of possibilities in food processing which merited further discussion in the future, and the need for a sense of urgency in this connection.

National farm safety year

by C V Brutey

NATIONAL Farm Safety Year was brought about as a direct result of a suggestion from the farmer members of the East of England Agricultural Society. Whilst there have been safety regulations in agriculture for the past 18 years and figures for fatal accidents have certainly dropped significantly, it was nevertheless felt that safety is more a matter of attitude of mind rather than regulation and that an extra push was needed to supplement the statutory requirements administered by the MAFF safety inspectors.

The "Year" is being organised for the Royal Society for Prevention of Accidents by a small Working Party consisting of a Representative respectively from the farmers, farm workers, machinery trade and ROSPA. The "Year" started on 16 October last, concurrently with the beginning of European Farm Safety Week and will end with the Royal Smithfield Show in 1975. It is the avowed intention of the organisers not to overcrowd the already very full agricultural programme and to utilise existing events where practicable.

How can agricultural engineers and, more particularly, members of the Institution help in this respect? There are many ways, both long and short term. The long term is undoubtedly the more important and engineers responsible for design can probably contribute to a greater extent than any other individual, by not merely bearing in mind the question of safety when designing equipment, but more particularly, giving the fullest regard to those requirements of comfort, health, vision, ease of access and other ergonomic considerations that have an underlying bearing on safety in the long term.

But what of the short term – the "Year" itself? No doubt branches will have already fixed their programmes for this winter but the "Year" does go on into at least the first half of next winter. There must be many ways of introducing safety into the programme of branch meetings in a way that is interesting and constructive. The engineers are probably at an advantage over other sectors of the Agricultural Industry in this respect as their interests range over a far greater range of disciplines, in many of which safety factors are involved and could usefully be the subject of discussion. Better still, why confine the discussion to our own members on such a vital issue. Would this not be a splendid opportunity to invite at least selected farmers and farm workers to branch meetings to discuss this essential issue with the benefit of gaining the users views and opinions at first hand.

Colin Brutey is the Machinery Officer of the National Farmers Union.

Reprint Service

CHANGES have recently been introduced in the reprint service offered to members of the Institution. The Editorial Panel has now made arrangements with University Microfilms Limited, St. John's Road, Tylers Green, High Wycombe, Bucks., for *The AGRICULTURAL ENGINEER* to be placed on microfilm from which enlarged copies of articles or papers can be obtained. Those members wishing to obtain copies of articles should now address their requests direct to University Microfilms Limited who will make a charge for this service at the rate of S3 each for articles and 8c. per page for complete issues. Charges will of course be made in sterling, the equivalent being obtained by conversion at the rate current at the time of placing order.

At the present time only Volume 28 is available under this service but it is planned to place earlier volumes of the Journal on microfilm in the future.

A few back numbers of the Journal are still in stock at Institution Headquarters and will be made available to members upon application. Once Institution Journal and paper supplies have been used up it will no longer be possible to offer members up to six items a year free of charge and post-free through University Microfilms Limited.

Slatted floor sheds for beef cattle

by V A Dodd and H J Doyle

Summary

RECENT developments in slatted floor sheds for beef cattle are described. Design data for stocking density, feeding arrangements and pen shape are given together with illustrations of shed types based thereon. The forms of construction for both superstructures and substructures are described. It is concluded that slatted floor sheds offer considerable advantages for beef cattle units in excess of 100 places particularly in the areas of flexibility, water pollution control, labour requirements and manure management, in addition to being comparable in costs to other housing systems.

Introduction

Dodd (1971) reviewed the trends in buildings for beef cattle. At the time development was concentrated on three types of buildings viz loose housing using straw for bedding, cubicles and slatted floor sheds — the last being generally confined to units in excess of 300 places.

At the present time straw bedded sheds tend to be mainly concentrated in areas of mixed farming in which straw is freely available and on farms where labour is not a critical factor. In beef cattle units in excess of 100 places based on cubicles, whether as kennels, unroofed or installed in a shed, the following disadvantages have become apparent:—

(i) cost of providing manure storage facilities to comply with present day water pollution control regulations

(ii) necessity for frequent bedding of cubicles to ensure 'clean' cattle and

(iii) apparent difficulties associated with altering cubicle widths to cater for wintering cattle over different liveweight ranges.

Walker-Love, Laird and Forsyth (1968) reviewed previous research on the performance of cattle housed on slatted floor and straw bedded sheds; on the basis of an experiment they concluded that there is no significant difference in the health and performance of beef cattle whether housed on slatted floor and in bedded sheds. Mulvihill (1973) reported that cattle of initial liveweight approx. 240 kg on slatted floors gave the same performance in liveweight gain as similar animals on bedded cubicles, both roofed and unroofed. The results for fattening cattle, liveweight 450 kg, indicated a lower liveweight gain in slatted floor sheds but this was not reflected in carcass weight.

The main developments in recent years in cattle housing in Ireland has been associated with slatted floor sheds and there are now many variations in operation; this paper describes the recent developments in design and form of construction of such sheds.

Design data — density and feeding

The essential difference between shed types is in the feeding arrangements and indeed feed space requirements largely dictate shed layout. Where feed, whether as silage alone or silage plus supplements, homogeneously mixed, is offered *ad libitum* 300 mm of trough length per animal is considered adequate for fattening cattle. In sheds where supplementary feed is offered distinct from silage, 600 mm of trough length per animal place is required.

The design stocking density for slatted pens is 2 m^2 per fattening animal place. Thus, pens are normally either 3300 mm or 6600 mm wide. Figures 1—6 illustrate the variations in pen shape and feeding arrangements and the relevant measurements are shown in table 1.

V. A. Dodd and H. J. Doyle are from the Farm Structures and Environment Department, Economics and Rural Welfare Centre, An Foras Taluntais, (The Agricultural Institute), Dublin 4.

Table 1 Measurements for slatted floor pens

Fig No	Pen width	Feeding space/animal silage mm	Feeding space/animal meals mm	Floor space/animal m^2
1	3300	600	600	2
2	6600	600	600	2
3	6600	300	300	2
4	6600	300	600	2
5	7800	250	600	2

Shed types illustrated in figures 1 and 2 are considered suitable for units in the range 100—200 places. Figure 1 illustrates a shed which is particularly suitable for smaller units on exposed sites, the silage being dumped onto the feed alley with a tractor cum front loader, supplementary feed being distributed manually on top of the silage. In this shed no feedtroughs are available. The shed as shown in figure 2 is considered suitable for well sheltered sites for 200 place units, a central windbreak being required in exposed locations; this can be formed of timber or concrete and should be a minimum height of 1250 mm.

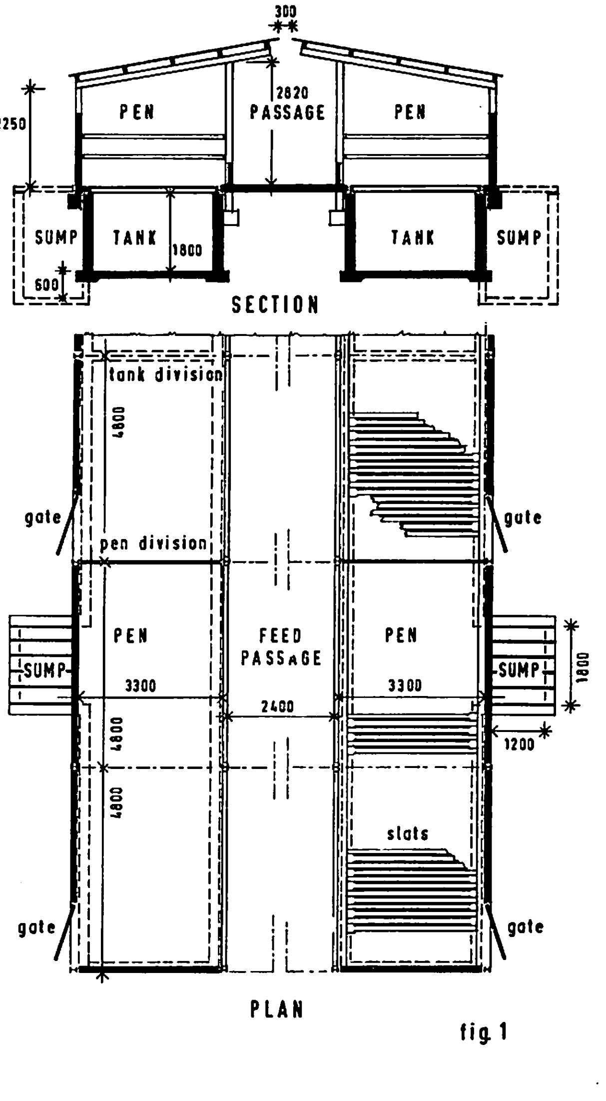


fig 1

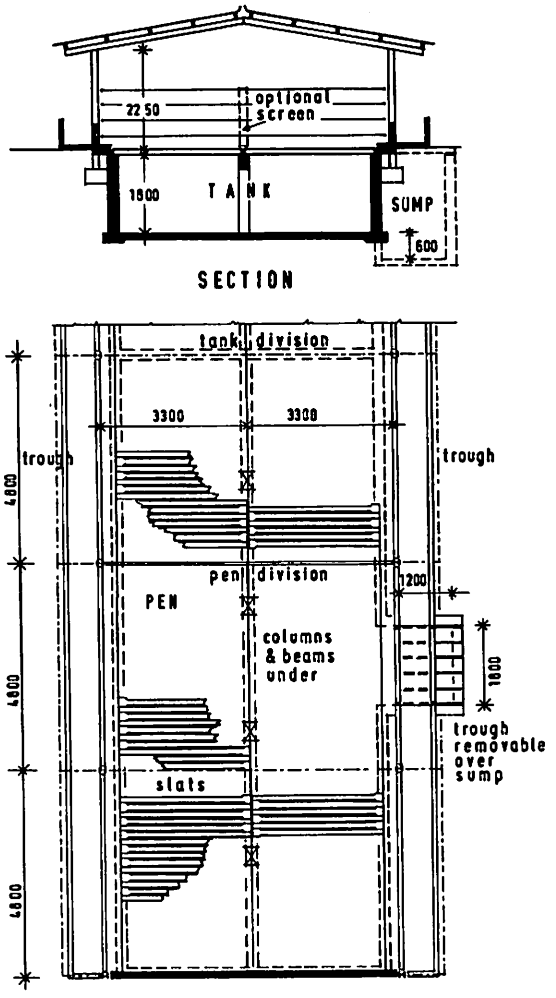


fig. 2

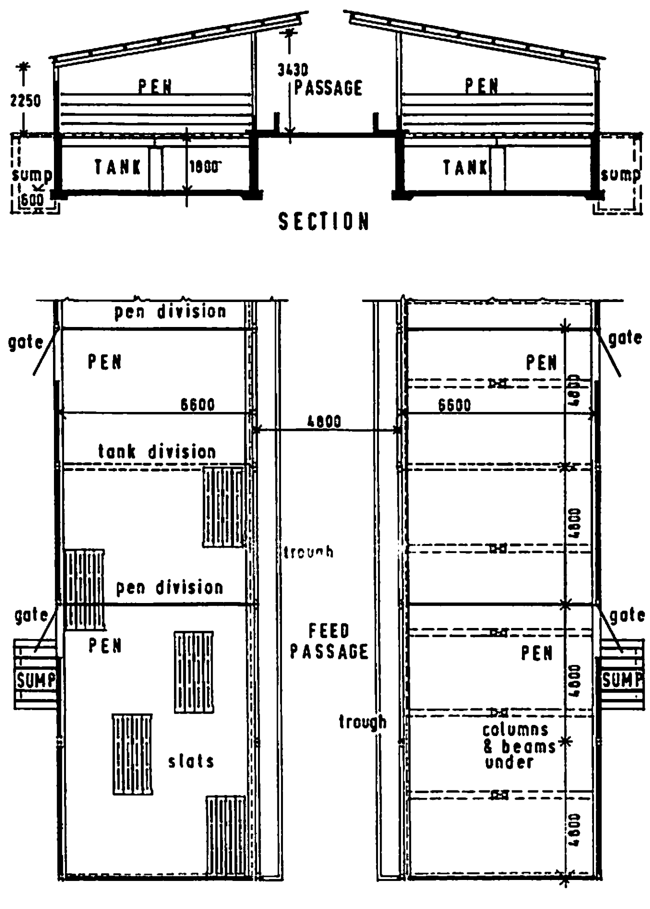


fig. 3

In sheds exceeding 250–300 places there is a distinct trend towards feeding silage and supplements simultaneously in the same trough using a self unloading forage wagon and for this situation the shed type illustrated in figure 3 is suitable.

On farms where initial development is in the range 150–250 places but where there is potential for future expansion a compromise solution as illustrated in figure 4 is frequently adopted; in these sheds the troughs along the outer walls are used for supplementary feed only, the side cladding comprising infill panels capable of being raised and lowered.

The shed as shown in figure 5 incorporates supplementary feed troughs within the building, placed transversely to the silage feeding alley. In this layout, therefore, silage and supplementary feed are offered distinctly; supplementary feed is distributed manually and silage is dumped along the feed alley.

This shed type is considered applicable for units less than 200 places in which the labour requirements of distributing supplementary feed are not critical.

Slats

Slats are invariably formed of precast concrete units designed to carry a live load of 400 kg per linear metre of slat. The normal arrangement is to provide 35–40 mm slots and 125 mm slats. They may be cast as individual slats or in groups of two to four slats and are usually made in lengths of 2500–3500 mm. In the past, the practice in 6600 mm deep pens was to lay the slats transverse to the feed alley and support them on a central spine wall. Present day practice, howèver, is to eliminate the spine wall and to support the slats on a series of beams and columns; with this arrangement the slats can be laid parallel or transverse to the feed alley. The beams should be designed for a live load of not less than 1.5 tonnes per linear metre of beam.

In 3300 mm deep pens the slats are laid transverse to the feed alley and the floor area is 100 per cent slatted. In the case of the 6600 mm deep pens several variations can be provided with 60–100 per cent of the floor area slatted, hard standings being provided varying from 300 mm to 1200 mm in width. The significance of the proportion of floor area slatted has not yet been established in terms of animal performance but it is generally accepted that, with hard standings exceeding 600 mm, the cattle are very dirty.

Superstructure

The superstructure of present day sheds is simple in form, steel frames at 4800 mm centres being used. Roof cladding is uninsulated 24 gauge corrugated iron or asbestos cement sheeting. In the case of the former, the steel frames are formed from 152 x 89 mm (16.5 kg/m) rolled steel joists with 150 x 75 mm timber purlins; the corresponding sections used with asbestos cement cladding are 178 x 102 mm (21.1 kg/m) rolled steel joists with 178 x 75 mm purlins. The roof pitch is normally ten degrees and the height between slat level and underside of portal at the back of the pen is 2250 mm. This roof pitch provides adequate height in the feed alley for tractor and front loader in the case of the layout shown in figure 1 and for the forage wagon in the units as shown on the other layouts.

Side cladding when used should be formed of either 150 mm blockwork plastered or 150 mm thick mass concrete. The side cladding is normally built to a height of 2000 mm, a 250 mm gap between the cladding and the eaves providing ventilation. A ridge gap of 300 mm minimum is desirable.

The feed alley width should be a minimum of 2400 mm in the case where no feed troughs are provided and 4800 mm with feed troughs (measured between columns).

In the past, with the slat direction being transverse to the feed alley it was not feasible to fix the superstructure to the substructure both being erected independently of each other, as shown in figure 6. Problems of unequal settlement could arise unless care is taken with the placing of back fill; in poor conditions the columns are

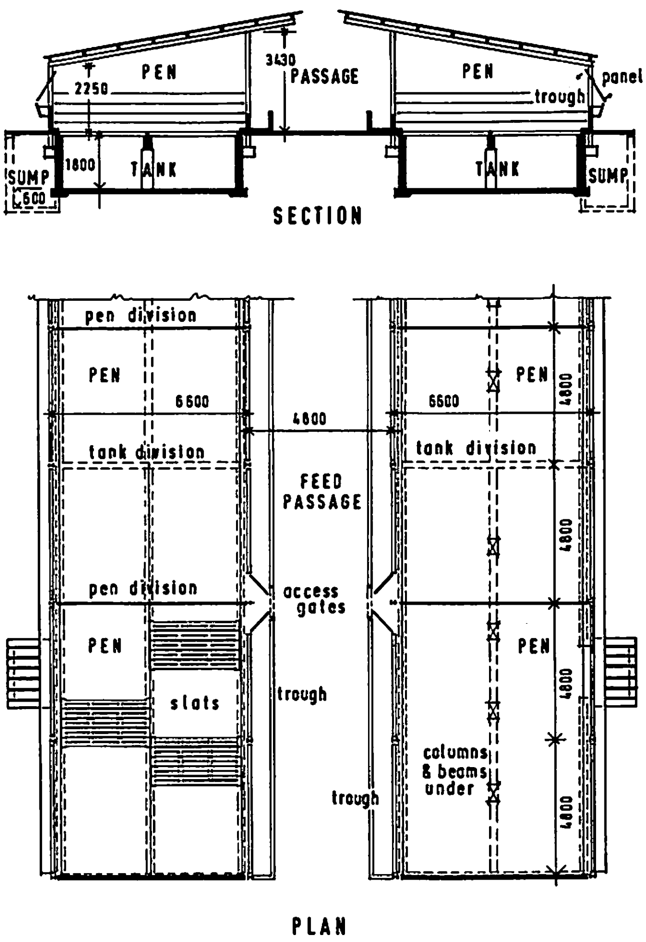


fig. 4

carried down to the formation level of the substructure. The present day trend of laying slats parallel to the feed alley permits a combined form of construction as shown in figure 3, with consequent economies in building costs and improved stability. It must be pointed out, however, that for this form of construction to be practical more accuracy is required that heretofore in the construction of the substructure.

The optimum number of cattle per pen is not known but is considered good practice to limit pen sizes to approx. 30 places. Gates 2000 mm wide, sheeted, are usually provided at 9600 mm centres on the back of the pen.

Pen divisions can be formed using four strands of 10 mm wire rope strained between the portal stanchions.

Feed trough walls should be a minimum thickness of 100 mm and be of mass concrete and formed as shown in figure 6. Feed rails can be timber poles approx. 100 mm dia. or 20 mm wire rope; height adjustment is desirable.

It is considered that drinking bowls should be provided at 4800 mm centres (viz on the stanchions at the pen fronts), the supply line being located as shown in figure 6. A nominal degree of artificial lighting is desirable.

Substructure

Manure storage is provided under the slats. It is customary to provide for a storage period of 120 days based on manure production of 28 litres per place per day. Thus for 3300 mm and 6600 mm pen widths the depth of storage required is 1800 mm, assuming 100 per cent of the pen floor is slatted. The floor slab is normally 150 mm thick and the walls 225 mm thick reinforced as shown in figure 6. Substructure walls of concrete blockwork even if strutted and plastered as shown in figure 5 are considered unsuitable in all but very dry sites in which a low water table level exists. In the past one of the major problems associated with slatted floor sheds was the absence of adequate manure handling machinery. At the present time, however, suitable machinery is available such as submersible centrifugal pumps or augers which are used to agitate the manure and pump it to manure wagons; an alternative manure handling system based on a high capacity helical rotor type pump mounted under a manure wagon is also widely used. In order to ensure efficient agitation and a homogeneous manure, it is recommended that partition walls be constructed at 14.400 m centres thus dividing the substructure into distinct compartments each provided with a desludging sump, the floor level of which is 600 mm below the main tank floor level.

An alternative method of emptying manure from slatted sheds is by means of a mechanical scraper. The scraper is powered by an electric motor (3 hp) and is operated with a pvc-coated wire rope. With this arrangement it is necessary to restrict the depth of storage beneath the slats to 500–600 mm and to provide additional manure storage facilities outside the building.

Discussion

The main advantages associated with slatted floor sheds are considered to be:

(1) Low labour requirements (two men per 1,000 animal places).
(2) The cost per animal place is competitive with other forms of housing.
(3) Water pollution control problems are eliminated.
(4) It is the most suitable form of manure storage facilities consistent with utilisation of manure for crop production. The nutrient content of the manure with this system is predictable owing to the absence of dilution water and, therefore, can be incorporated into a fertilising programme with a degree of confidence not normally attainable with other systems of cattle housing.
(5) A high degree of flexibility is provided in terms of feasibility to vary group size and feeding regimes for different groups of cattle.
(6) It is considered that as the use of forage wagons in conjunction with precision chopped silage increases, the feed space requirements of 300 mm per animal place may be reduced, resulting in an increase in the pen depth.
(7) The increased cost of steel may result in a trend to use

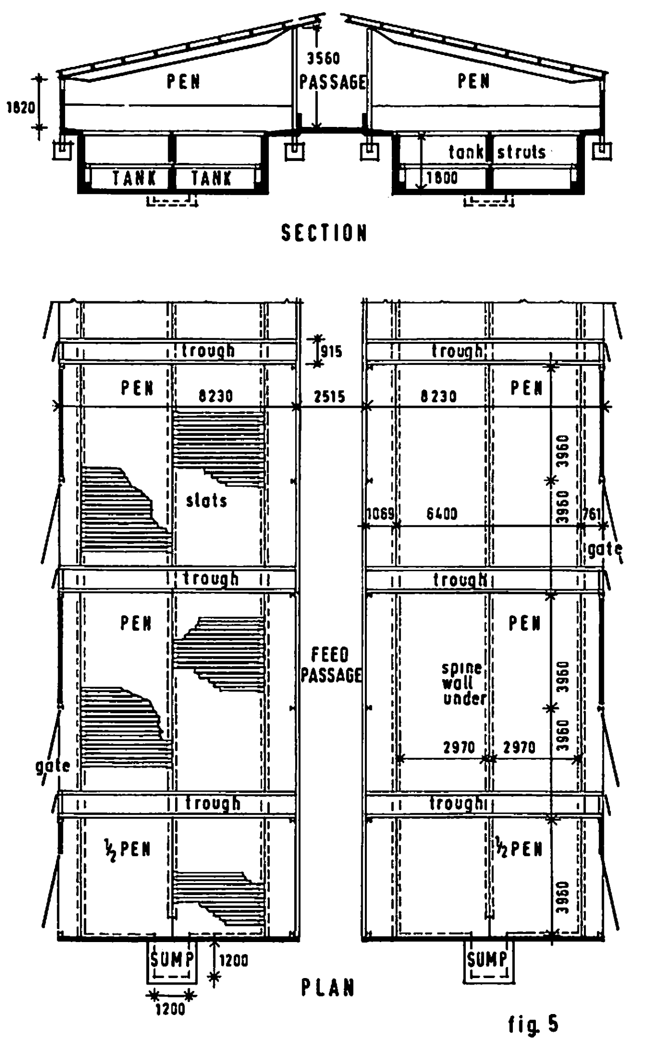
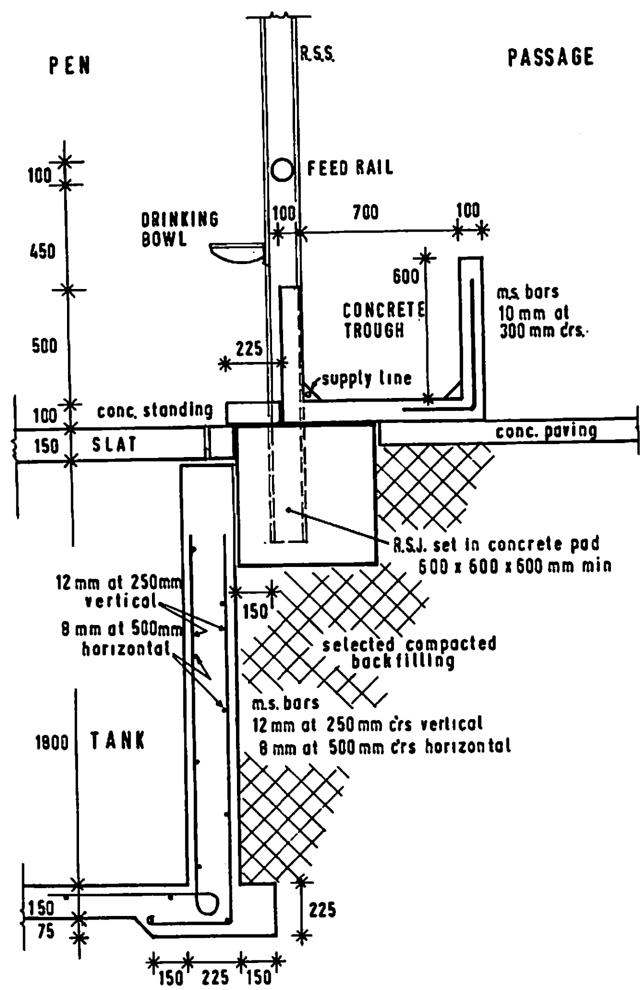


fig. 5



SECTION THROUGH TANK & FEED TROUGH
fig. 6

precast concrete portals for the superstructure. In addition, increasing on-site labour costs associated with constructing the substructure in reinforced, cast in-situ concrete may stimulate the development of a system of construction for the substructure based entirely on the use of precast concrete elements.

Acknowledgements

The authors wish to thank Dr T Walsh, Director, The Agricultural Institute, for permission to publish this paper. Acknowledgements are also due to the members of the Animal Management Department, The Agricultural Institute for their co-operation in the development work on buildings for beef cattle.

References

Dodd, V A, 1971. Trends in buildings for beef cattle production units. *Ir. Vet. J. 25. 243–253.*

Walker–Love, J, Laird, R, Forsyth, R J. Slatted floors for beef cattle. *Scottish Agriculture.* Winter 1967/68.

Mulvihill, T A, 1973. *An Foras Taluntais* Personal Communication.

Honorary Fellowship for Mr Theo Sherwen

AT the Annual General Meeting on 7 May 1974 Honorary Fellowship of the Institution was conferred on Mr Theo Sherwen and the citation was read by the President:—

"Mr Sherwen is a Fellow of the Institution of Agricultural Engineers whose service to the Institution and to the agricultural engineering industry is of the highest order. In his earlier years he worked with the late Harry Ferguson and was responsible for a number of facets of the design of Ferguson tractors and equipment, including that of the first hydraulic tipping trailer and the automatic hitch on the tractor by which the trailer is coupled. These developments were followed in due course by the automatically coupled manure spreader and the high lift loader. These items of equipment combined to form an inter-dependent system of machines for loading, transporting and spreading manure, and introduced a design concept on which many other types of implement have since been based.

For the major part of his career, Mr Sherwen has worked as an independent consultant, specialising particularly in hydraulics and related mechanisms. In this capacity he has been connected with many important companies having interests in agricultural tractors and machinery. His work is distinguished by a notable elegance of design and originality of concept.

Mr Sherwen was a distinguished President of the Institution from 1967–69 and he has contributed to the technical proceedings of the Institution through a number of papers on aspects of hydraulics, on the role of the inventor and on innovation in design for agricultural engineering.

In his capacity as a Fellow of the Institution of Mechanical Engineers, Mr Sherwen has also played a most important part in linking the endeavours of the Institution of Agricultural Engineers with those of other engineering bodies. In particular, until very recently he has been the Institution's representative on the relevant committees of the Engineers' Registration Board, and he was very much concerned in the formative work which led up to the establishment of the Board and to the Institution's position as one of its founder members."

Members of the Institution may wish to be reminded that Honorary Fellowship is the highest distinction the Institution can confer. It is awarded for outstanding service to agricultural engineering and is not necessarily confined to members of the Institution. Not more than one award is made each year.

Nominations may be sent in strict confidence to the Secretary, by 1 January each year, either by individual members or through branch secretaries, for consideration by the Executive Committee. Because the Institution guards most jealously the standard of Honorary Fellowship, nominations should only be made of persons who can meet the most rigorous criteria. They should be accompanied by an appropriate citation in each case. A note outlining the criteria for the appointment of Honorary Fellows can be obtained from the Secretary.

AROUND THE BRANCHES

Yorkshire

THE Yorkshire Branch's first meeting of the season, at Holmfield House, Wakefield, on 12 September was on "The Big Bale System", the subject being ably handled by Mr M. Williams, Forage Equipment Product Manager, Howard Company Ltd.

With the aid of films and slides, Mr Williams explained that many companies were involved with a "Big Package System" as the Americans called it. The two main systems were:— the instant hay stack, of three to eight or more tonnes, made by filling large covered trailers and the large round or square bale of about half a tonne using a baler-like machine.

The round bale system, developed in the USA, from the old Allis Chalmers' baler, was said to have a faster ground speed than conventional balers and to bale up to six tonnes/hour with a 1.5 m wide bale of 1.8 m diameter, density being controlled by the belts. The large square bale was pioneered by two Gloucestershire farmers and developed by the Howard Co. It was an all new 2½ tonne machine with pto powered pick-up reel, feeder arms, a packer and three knotters, producing 2.4 m wide bales of up to 711 kg. The square bale seemed easier to handle, stack, and feed, each being built up of manageable bundles. Maximum moisture content for round bales was 20 to 25% and square bales was 33 to 35% (though 45% had been successfully handled). Drying square bales cost about the same as for conventional bales.

In conclusion, Mr Williams said that though, in its infancy, "The Big Bale System" was on its way with two to five manufacturers involved in the UK market.

BRANCH PROGRAMME

South Eastern Branch

Acting Secretary	N. Oldacre Writtle Agricultural College, Writtle, Chelmsford, Essex (tel: Chelmsford 420705).
December 12	Day visit to Ford Motor Company Ltd, Tractor Division at Boreham House and Basildon. Details will be circulated by Branch secretary.
1975 January 15	Investment in Fixed Equipment on the Farm. Speaker: P. M. Gorton (Land Economics Section, ADAS, London), Writtle Agricultural College, 19 30h.
February 10	Farm Scale Grass Drying. Speaker: R. V. Falkingham (ADAS Taunton), County Hotel, Chelmsford, 19 30h.

COUNCILS & COMMITTEES

Other appointments

Institution representative National Agricultural Safety Committee ROSPA	Mr E. Sudrom
Engineers' Registration Board — Technician Board	Mr C. V. Brutey
CIGR representative and correspondents Section 4	Mr P. Wakeford

SECRETARY'S NOTES

THE Secretariat would be very pleased to hear from members who have recently changed their appointment. Such notifications will be passed on to the Editor of *The AGRICULTURAL ENGINEER* who will make every effort to publish the information as it becomes available.

County boundaries — England and Wales

TO ensure that the Spring 1975 and subsequent issues of the Journal are correctly addressed, English and Welsh members resident in an area involved in the change of county names are requested to complete an IAgrE updating card (which will be sent to them with the annual subscription notice) and return it to the Secretary, showing details of their new address, by not later than 1 February 1975.

ERB updating cards

Members who are registered with the ERB are especially asked to complete the updating cards (printed black), as the occasion arises and send it to the Secretary, IAgrE for annotation and passing to the Board.

These cards should not be confused with the IAgrE updating cards which are used for entirely separate administrative processing.

IAgrE annual subscription notices — 1975

THE IAgrE annual subscription notices — 1975 were programmed to be posted to all members by not later than 1 December 1974.

If any member has not received his notice by 15 December 1974 he is requested to advise the Secretary promptly.

All subscriptions are due on 1 January 1975.

IAgrE updating cards

IAgrE updating cards (printed green) are being sent with the annual subscription notice to all members. All members are asked to make use of these cards, as the occasion arises, and send them to the Secretary. These should not be confused with the ERB updating cards, which are used for entirely separate administrative processing.

Journal addressees

THE attention of all members is drawn to the fact that addressed envelopes are prepared for despatch to the Journal printers *five weeks before posting date* ie first day of February, May, August, and November. Journal posting dates are the fifth day of March, June, September and December.

It is regretted that changes of address received after the former dates cannot be incorporated until the following quarter.

Overseas members

Lists of members in individual countries are in the course of printing. It is proposed that in the New Year national lists will be sent to each overseas member. New lists will be posted either with the Spring issue of the Journal, or the Annual General Meeting notice.

Secretariat: End-of-year audit and holidays

THE Secretariat will be closed for all day-to-day business from cease-work on Friday 20 December 1974 until the morning of Monday 6 January 1975. This period is intended to cover statutory holidays and annual audit work.

Normal working hours of the Secretariat are 08 30 — 17 00.

Technician Engineer (CEI) and Technician (CEI)

CERTIFICATES of Registration are now available at the cost of £3 (including postage and packing) which is payable with order.

Application forms can be obtained from the Secretary of the Institution.

UK members travelling abroad

The Institution's membership covers 69 countries. Any UK member travelling abroad is invited to apply to the Secretary for a copy of the membership list for the territory(ies) he is visiting.

We are sure that overseas members will welcome the opportunity of meeting members from the UK.

Printed lists should be available early in the New Year.

West Midlands Branch Secretary

THE new Secretary of the West Midlands Branch of the Institution is Mr C. L. Powdrill, Warwickshire College of Agriculture, Moreton Hall, Moreton Morell, Warwickshire.

Johnson Medallists

AT the Institution annual luncheon held on 7 May 1974 Johnson Medals were awarded to two former students of The West of Scotland Agricultural College for their outstanding levels of achievement in the National Diploma in Agricultural Engineering Examinations held in 1973.

Nigel Ford and James Anthony (Tony) Horsfield also had the distinction of having started their academic studies along similar lines, both having taken City and Guilds courses 260 and 261 Part I at Doncaster Technical College.

Before going on to the West of Scotland Agricultural College at Auchincruive, Nigel studied further at Lackham College of Agriculture while Tony took more advanced studies at Lincoln Technical College, both taking their Full Technological Certificates with recognised apprenticeship training.

At present both have appointments in further education as assistant lecturers at East Riding College of Agriculture and Cheshire College of Agriculture respectively.

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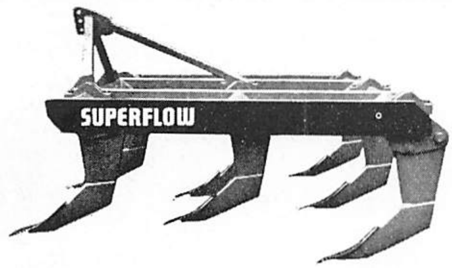

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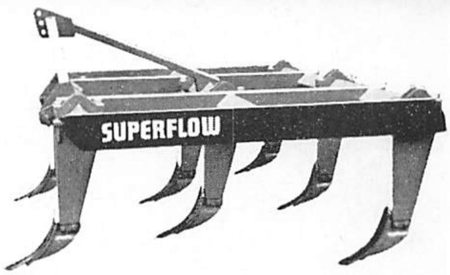

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