Journal and Proceedings of the Institution of Agricultural Engineers

SUMMER
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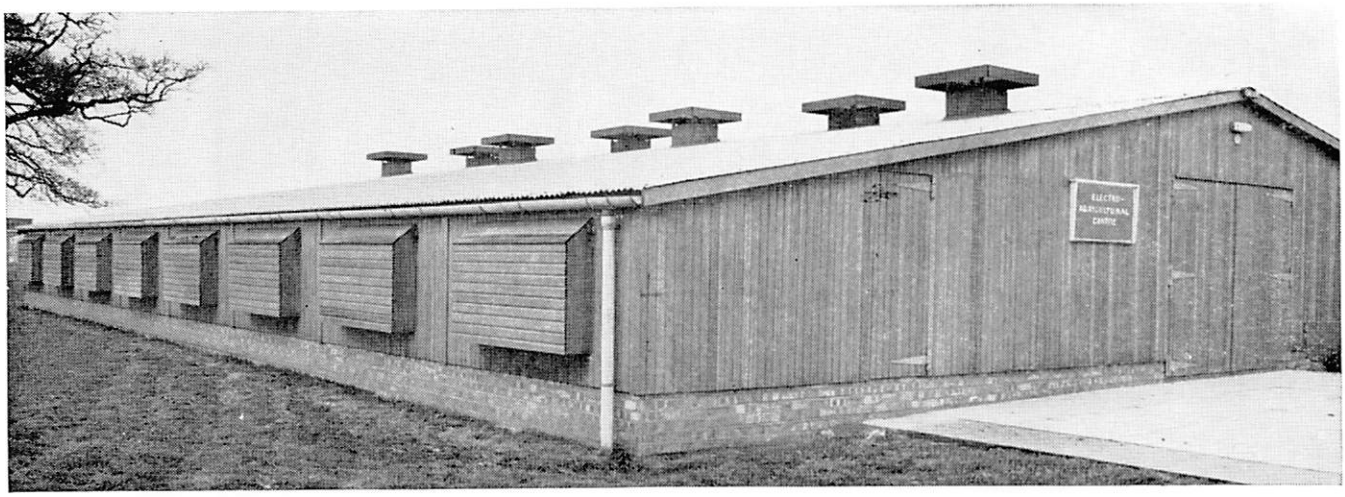

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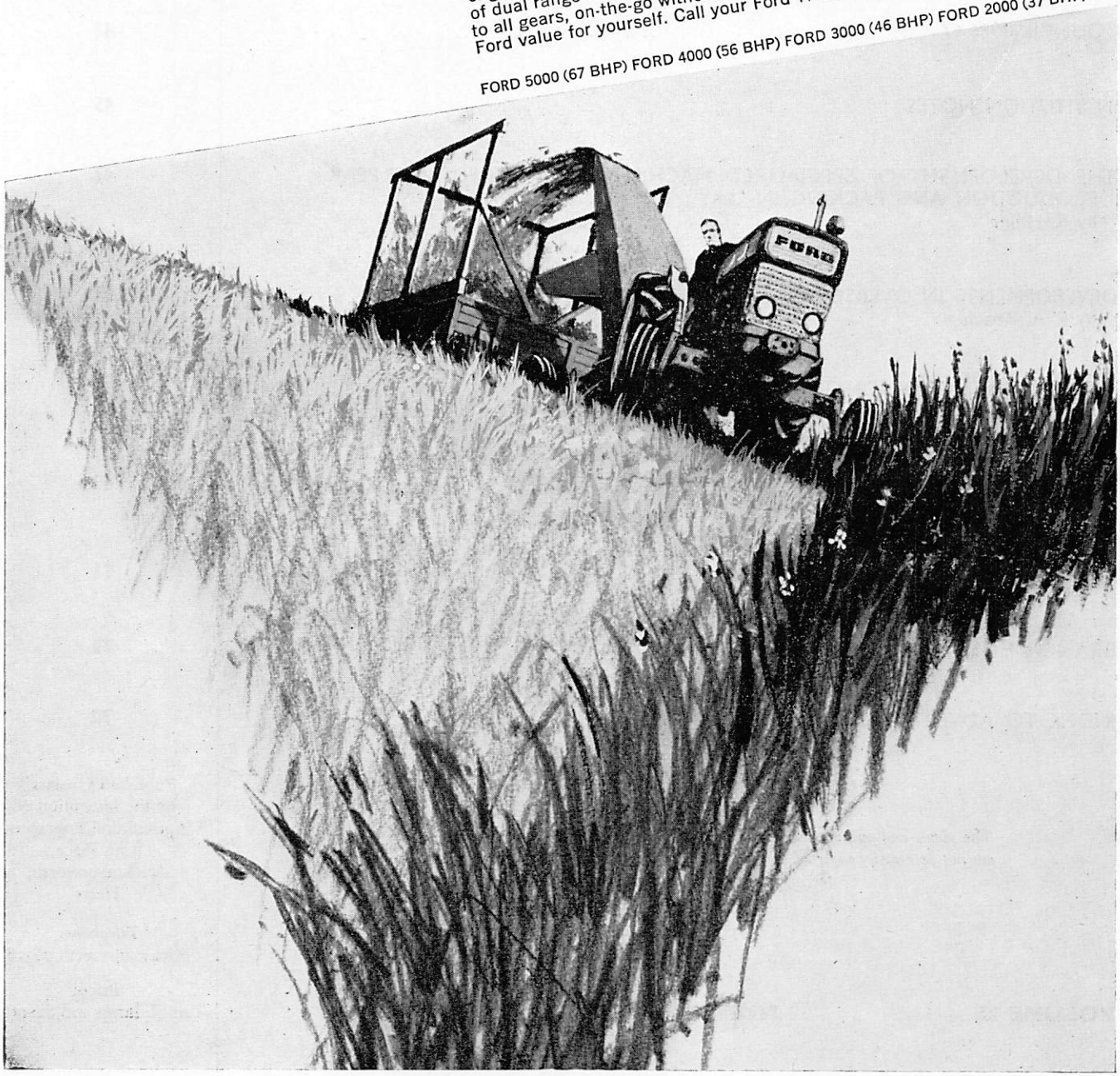

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INSTITUTION NOTES

Annual Conference

On 12 May, the Institution held what must surely be regarded as the most successful Annual Conference in its history. More than 180 members and guests made up the record attendance at this notable event, at which four papers were presented on the subject-theme of *Vegetable Harvesting and Handling*. These were *The Mechanization of Vegetable Harvesting* by J. C. Hawkins, *A Universal Vegetable Harvester* by W. Boa, and *Market Preparation and Packhouse Planning for Vegetables* by E. S. Devine, all three speakers being from the National Institute of Agricultural Engineering, Silsoe. The fourth paper, *Harvesting and Handling of Vegetables for Processing* was given by A. J. Gane of the Pea Growing Research Organization Ltd. The Conference was held in the Main Hall of The Institution of Mechanical Engineers, London.

All four papers, together with an edited transcript of the tape-recorded discussions, will be published in full in the Spring 1967 issue of the *Journal*.

Annual Dinner

On the evening of 12 May, following the closure of the Annual Conference, the Institution held its Annual Dinner at St Ermin's Hotel, London. The Guest of Honour was the Rt. Hon. John Mackie, MP, Joint Parliamentary Secretary to the Ministry of Agriculture, Fisheries and Food, who proposed the toast of 'The Institution'. The response was made by the President of the Institution, Mr J. H. W. Wilder, BA, MI AGR E, who was Chairman of the Dinner. Mr J. A. C. Gibb, MA, M SC, MEM ASAE, MI AGR E, Member of Council and Honorary Editor of the Institution, proposed the toast to 'The Guests', to which Mr F. W. W. Pemberton, MA, Honorary Director, The Royal Agricultural Society of England, replied.

Annual General Meeting

The Institution held its Annual General Meeting immediately after the first session of the Annual Conference in London on 12 May. Before proceeding to the business on the agenda, members stood for a few moments in silent tribute to the memory of the late Lt.-Col. Philip Johnson, Founder-President of the Institution, whose death was reported in the December 1965 issue of the *Journal*.

Minutes of the Extraordinary and Annual General Meetings held in London 22 April 1965 were approved, following which the President, Mr J. H. W. Wilder, moved the adoption of the Report of the Council for 1965. In so doing, he drew attention to a number of major features of Institutional activity and development in that year, including the establishment and total reorganizaton of the headquarters and secretariat at Rickmansworth, the new pattern of mobility in the programme of national Open Meetings at vantage points around London, the revision of membership standards, the impending changes in examinations, the modernization of the Institution's publications and the economic challenge. He paid tribute to the acumen and diligence of those who had served on the Examination Board and the Council's Standing Committees and thanked the staff for their loyalty during a difficult year.

Mr T. Sherwen, Chairman of the Finance & General Purposes Committee, formally presented for adoption the Accounts of the Institution for the year ended 31 December 1965, together with the auditors' report. He said that the Council believed expenditure to be commensurate with the high level of activity in which the Institution had engaged but he warned that the rise in income from the growing membership was not on a par with rising costs. The resultant excess of expenditure over income had therefore to be seen as a challenge to be faced in 1966 by all who were in one way or another responsible for the Institution's financial well-being and good standing.

The Secretary announced the names of those comprising the Institution Council 1966-67 (see page 43 of this *Journal*) and the President welcomed those joining the Council for the first time, while at the same time thanking those whose terms of office would expire at the close of this Meeting, for their loyal service.

Future Institutional Activities

During the Winter Session 1966-67, there will be a comprehensive programme of open meetings, conferences, visits and social occasions, planned and administered under the joint aegis of the Council, the Papers Committee and the eight regional Branch Committees of the Institution. By the time this issue of the *Journal* is circulated, many members will already have received preliminary details of events scheduled for the early Autumn; in the near future, a pocket booklet will reach every member, giving details of all confirmed fixtures throughout the United Kingdom up to May 1967. Members everywhere are asked to do their utmost to support Institutional activities in their Branch area, not only through their own attendance but also by bringing along guests who may well prove to be suitably qualified, potential members of the Institution, in either corporate or non-corporate grades.

INSTITUTION NOTES *(continued)*

Branch Formation

The Council announces with pleasure its recent approval of the establishment of theWrekin Sub-Branch of the West Midlands Branch of the Institution.
Primarily intended for the benefit of members in Shropshire and Staffordshire, the new Sub-Branch will be staging a complete programme of winter sessional activities in that area. This development is confidently expected to lead to a growth of membership in the Sub-Branch area and this could lead, in due course, to a separate Branch being formed, as has happened in the past with other Branches in the network.
There continues to be a lively interest in the possibility of forming a Branch in the area covered by the counties of Bedfordshire, Buckinghamshire, Hertfordshire and Oxfordshire. Members in these counties are not currently within any existing Branch jurisdiction. A meeting is soon to be called for the purpose of drafting a concrete proposal and there is every hope that this will have positive results.

Forthcoming Conferences and Events

National Water Safety Conference 1966: an all-day conference on Tuesday 18 October 1966, at the University of London Swimming Pool, Malet Street, London WC1. All enquiries should be addressed to the Conference Officer, RoSPA, 17 Knightsbridge, London SW1 (Belgravia 8236).

Steel Congress 1966—'Steel in Agriculture' 25-27 October 1966 at Luxembourg. Enquiries should be addressed to the Steel Congress, E.C.S.C., Luxembourg.

The Royal Aeronautical Society announces that a joint all-day meeting between the Pesticides Group of the Society of Chemical Industry and the Agricultural Aviation Group of the Royal Aeronautical Society will be held on Wednesday, 15 February 1967 at the R.A.S. Lecture Theatre, 4 Hamilton Place, London W.1. The aim of the meeting will be to attempt to predict ways of making the operation of agricultural aviation more economical. Further details are still to be announced and enquiries should be addressed to The Royal Aeronautical Society, 4 Hamilton Place, London W1.

Agricultural Engineering Symposium: a four-day symposium from 11-14 September 1967 organized by the Institution of Agricultural Engineers, at the National College of Agricultural Engineering, Silsoe, Bedford. Preliminary information appeared on page 3 of the Spring 1966 issue of the *Journal* and further announcements will be made from time to time. Enquiries should be addressed to the Honorary Organizing Secretary, Agricultural Engineering Symposium, The Institution of Agricultural Engineers, Penn Place, Rickmansworth, Herts.

City and Guilds of London Institute

The City and Guilds of London Institute announce that they have conferred Honorary Membership of the Institute on Mr Alexander Hay, OBE, NDA, FDD, HON MI AGR E, in honour of his work for many years as the representative of The Institution of Agricultural Engineers.
Mr Hay has been particularly active in connection with part-time education for agricultural workers and with farm machinery and agricultural engineering courses. This has included the Chairmanship of the City & Guilds Advisory Committee for the 260, 261 and 270 Certificates.
A member of the Examination Board in Agricultural Engineering (appointed by the I AGR E Council), Mr Hay was Board Chairman from its inception in 1950 until 1962. He was elected an Honorary Member of the Institution in 1952.

THE DEVELOPMENT OF SPECIALIZED MACHINERY FOR APPLE AND PEAR PRODUCTION AND PACKING IN U.K.

by

R. HILLER*

Presented at the Spring National Open Meeting of the Institution at Wye College, Kent on 24 March 1966

One of the author's earliest memories is of a line of men carrying knapsack sprayers on their backs, working slowly through a young orchard. In those days of the early 1920s pruning was done with a knife, grassing down of ungrazed orchards was in its infancy, apples were picked into wicker baskets called pothampers and there was little, if any, grading of the fruit. Quality was very variable. In the middle 1920s petrol-engine driven fruit tree sprayers made their appearance. Because of the weight of the machines steel pipes were laid on top of ground, down the rows of trees, and insecticides or fungicides were tapped off at various points down the pipe. At this time big advances were made in spray chemicals and for the first time it was possible to produce fruit of consistently high quality. Elementary grading was started, and fruit was taken from the orchard and packed in separate packhouses. From then on progress was steady and continuous, growers produced more and better fruit year by year, and by the late 1930s Cox's Orange Pippin had established itself as the best apple in the world. Large orchards were planted all over the southern half of the country. Permanent underground piped spraying systems were installed. Growers were quick to seize on new labour saving machines. Factory buildings, especially designed and built as fruit packing stations, began to appear in all the fruit growing areas. The war called a halt to further planting and building of packhouses but technical advances continued. After the war there was an enormous spurt in planting; by 1948 growers were talking of over-production and were looking far more closely at cost-reducing methods and machinery. By 1964 there were 160,000 acres of commercial apple orchards in the United Kingdom plus another 37,000 acres of old farm orchards. There were also 17,000 acres of commercial pear orchards. In 1964 the estimated crop of apples was 600,000 tons, or 48 million 30 lb boxes—very nearly a box per head of the population. The value of the apple crop was estimated for at £24 million. The pear crop was another 60,000 tons, with an estimated value of £5 million. Due to increased competition from U.K. plantings and foreign imports, only the highest quality fruit, well-graded and packed, can now show a profit to the producer.

Before we examine modern orchard techniques I must make one point to which I shall return later. Only half of the cost of production of a bushel of apples originates in the orchard. The other half is spent in the packhouse and in transport to market.

In a modern orchard selection of the right root stocks produces trees smaller than in the past. A favourite method of planting is called the hedgerow system, in which there is a wide space between the rows but the trees are allowed to grow together in the row. Trees are often not more than 5 feet in height and are seldom allowed to exceed 10 feet, normal spacing being 24 feet between the rows and 12 feet between the trees. Most, but not all, dessert apple plantations are grassed down. Most pear and culinary apples are grown on cultivated land. The grass under the trees is never grazed, but is mown frequently and is allowed to rot. In cultivated orchards, normal arable farming implements are used. There seems little difference in cost between an arable orchard being cultivated and keeping a grass orchard mown.

The Year's Work

We will now look at the year's work in a typical modern orchard. The best time to start our year is, I think immediately after the previous crop has been picked, Thus, my year commences on the 1 November. The grower is waiting impatiently for the leaves to fall in order that he can commence pruning. This is the longest and most expensive single operation of the year and provides him with his biggest labour peak for his permanent staff. Pruning is still done by hand with secateurs. Pneumatic secateurs are being tried and we shall probably see further development with power operated pruners, but the operation will still be hand controlled. The cost is high. Last year with small trees in a hedgerow system orchard, which is the cheapest pruning we do, it cost us £15 per acre. On older, larger trees pruning costs double this figure. The total cost of pruning the nation's commercial apple and pear orchards is therefore in the region of £3½ million. One of the problems we have to face is the difficulty in recruiting skilled pruners, for this operation requires great skill and experience. When pruning an orchard is finished, the cut prunings are either swept up with buckrakes and burnt on the headland, or are pulverised with a shredder which is an adapted forage harvester. Pruning generally takes from leaf fall until the new leaves appear and very frequently an orchard will have to be left for a year unpruned, because there is too

* A. H. Hiller & Son Ltd.

much leaf to continue. Pruning is the primary labour peak. In February one or two men will have to break out of pruning to apply the fertilizers. Manuring will vary considerably but will generally consist of a compound granular fertilizer. This is applied with a spinner type distributor. We are now in mid-March. You will note that no spraying has been done during the winter. Winter spraying is no longer necessary. Modern insecticides do the job quite as well in the spring and summer at lower cost. However, as soon as green leaves show the spraying season starts, the date varying from mid-March to early April. Probably the biggest engineering advance in the last twenty years, so far as fruit growers are concerned, is in the design of spraying machines. Most modern fruit tree spraying machines consist of a tank holding up to 200 gallons of spray chemicals and water, a pump giving pressures varying from 50 to 300 lb/in^2, precision machined jets in very hard steel and a large fan to carry the spray to the trees. There are two distinct types of spraying machines. One type is designed principally to apply concentrate sprays, and one to apply washes at high volume. Which type of machine the grower chooses depends on his particular conditions, and his own personal preference. A modern sprayer applying the wash at high volume, should spray over two acres per hour. A machine spraying at low volume will probably spray over three acres per hour, depending on conditions and orchard layout. The number of spray applications per season varies from orchard to orchard. Plantations suffering from mildew have to be sprayed at seven day intervals, while other orchards more resistant to both mildew and scab, may only be sprayed five times during the season. Thus, over a period of twelve months, orchards are sprayed from five to twenty times. If we take an average of 7 applications per year we get an annual sprayed acreage of 1¼ million acres. In the past this sort of programme would have been impossible, but with modern machines, although at times labour resources are strained, a good fruit grower will only be prevented from completing his spray programme by conditions of very bad weather or, dare I say it, mechanical failure. April also sees the start of the mowing of grass orchards and, in cultivated orchards, other weed control methods. In many orchards today, herbicides are sprayed either in circles round the trees, or more frequently in strips down the rows. This is done for two reasons. It is impossible to cut grass right against the tree butt; the dark damp conditions caused by these grasses and weeds is the perfect condition for the fungus disease collar rot. Also in winter uncut grass is conducive to mouse damage to the bark of the tree. The other reason is ease of mowing. If a strip is kept clear of grass the machines do not have to reach so far under the branches of the trees. This greatly reduces damage to the trees, not only from the machines hitting low branches but also hitting the trunk of the tree, with dire results both to the tree and mowing machine. Of course, the same advantages from herbicides apply to arable orchards as to grassed down orchards. The herbicides are applied with a standard ground crop sprayer fitted with a specially designed boom. The grass mowing is done in a variety of different ways. The fastest is the gang mower, similar to the ones that are used on golf courses. These machines cover a very large acreage in a day, but they will not work in wet grass or long grass. The second type of mower is the vertical axis rotary mower. This machine will cut both wet and long grass but it is much slower than the gang mower, and a lot of time is wasted changing blades. The third type, only just appearing in our orchards is the transverse horizontal axis rotary flail-type. This machine will cut wet and long grass and requires less maintenance. It is much slower than the gang mower, but makes up for this in no loss of time from rain or dew—a very important factor in our climate.

As mentioned earlier, standard scuffles, discs, harrows, etc. are used in cultivated orchards. If weeds get out of control, which often happens towards picking time, rotary cultivators are used extensively.

Towards the end of May, those of us lucky enough to have irrigation laid on to our orchards start looking at our soil water deficiency tables. This is the most important time of the year. If our fruit blossoms have escaped spring frosts and have set, the middle of May to the middle of June is the time when cell division takes place, and it is the number of cells that governs the size of the fruit. Therefore, we do not let our soil deficit fall below three inches at this time. Irrigation is applied by low angle rotary sprinklers throwing the water under the trees. We do not distribute the water over the trees because if we did, we should encourage the fungus disease scab.

June, July and August are spent spraying, mowing and irrigating. We finally arrive at harvest time, with, we hope, after all this work, a good crop of high quality apples and pears. The crop is normally picked with casual labour; this operation constitutes our second labour peak. Some varieties are picked over two or three times, others are cleared at one picking. In either case the method is the same, the fruit is taken from the tree, placed in a picking bucket or bag and then emptied into a tray or bulk bin. This operation costs from about £2 to £5 per ton depending on the size of the trees and the size of the crop. The smaller the trees the less step-ladder work there is to do and the lower is the picking cost. During this picking operation the big danger is bruising. Supervisors are constantly trying to stop pickers handling the fruit in such a manner that bruises result, but for all our efforts a percentage of fruit is blemished. In my own plantation we even make the pickers wear white cotton gloves. The gloves themselves do little to prevent bruising, but the psychological effect of wearing them does make the pickers more careful.

After picking, the fruit is transported on trailers or fork lifts fitted to tractors to the packhouse for immediate sale or to cold or controlled atmosphere storage.

Storage and Packing

We have now completed the year's work in the orchard. However, only half of the cost of production has been expended. The storage, packing and transport to market costs us as much as we have spent growing the fruit. The packing of apples and pears is normally done partly by

permanent staff and partly by staff engaged just for the season and constitutes our third and final labour peak. Although we have our own packhouses and stores it does not matter whether the packhouse or stores are privately owned or a co-operative undertaking, the same principles apply. Upon arrival at the packhouse some fruit will be transferred to cold or controlled atmosphere storage for packing and selling later in the season. In 1962, 415 fruit farms had cold or controlled atmosphere stores, holding 158,396 tons of apples and pears—over 25% of the total crop. Another 777 growers stored 44,000 tons in stores off their farms, mostly in co-operative packhouses. Since then a further 20,000 tons of storage space has been built each year; thus by 1966 there is storage for 282,000 tons or nearly 50% of the total crop. It is not my intention to deal with storage techniques in this paper. Suffice to say storage conditions are now so good that we can keep our apples and pears until the next crop from the southern hemisphere arrives in this country. There is little point in storing dessert apples and pears after this date. The culinary variety Bramley, however, which is not grown in the southern hemisphere must be stored very much longer; in fact until early cookers arrive the following season.

Packhouse techniques and procedures vary in detail but the broad principles are the same. After arrival in the reception department the apples are tipped on to a belt which feeds them on to a cull-eliminator, which removes the apples which are too small for domestic consumption. These small apples go to the cider mills. From the cull-eliminator the apples pass to a cleaning machine to remove dust, leaves, etc. From the cleaner the fruit passes to the grader proper. The next operation is to sort the fruit for quality and colour. There are three principal types of sorting tables. One is a roller table similar to those used for sorting potatoes. With this type the apples are sorted into three lanes, for first, second and third quality. Any fruit below third grade is removed and goes for cider. This type of sorting table is called the subtraction system and is very rapid, but not as accurate as the second type, which is the flow and return belt. With this design each apple is removed from the belt and placed on one of three feed belts to the sizing machinery. Greater accuracy is achieved with a flow and return belt, because each apple is handled individually, but more labour is required than on a roller sorting table. The third system is to take the apples by hand from the orchard boxes and place them direct on the feed belts. This method is the most accurate of the three and also causes less bruising. It is, however, also the slowest method. Up to now we have been dealing only with apples. Pears—because they will not roll properly—are sorted straight from the boxes on to the feeder belts to the sizing sections. Apples and pears are separated into their various sizes by one of two methods, the first by determining the diameter of the fruit, the second by determining the weight of the fruit. Again, the first method is the quickest but is less accurate than the second. The method of determining the diameter is generally either by the fruit travelling between diverging belts or travelling under cushioned rollers, set at different heights down the line. With weight graders the fruit travels in a cup passing over counter weights which will release the cup and let the fruit drop out when the fruit weighs more than the counter weight. The fruit drops into a bin according to its size, from where it is either wrapped by hand or is placed in a cell-pack similar to an egg pack. After packing the boxes are check weighed and marked with variety, grade and size before finishing up in the dispatch bay.

This is how we do things in 1966. We can now turn to the more interesting half of this paper. What are we going to do in the future and where must we look for changes? Please remember my three labour peaks—pruning, picking, and packing—the three Ps.

The Immediate Future

I think we must divide the future developments within the apple and pear industry into two parts—the immediate, and the more distant future say in ten to fifteen years hence. In the immediate future we can foresee fairly clearly the way the industry will develop. Obviously we must try and reduce costs as well as increase the quality of the fruit. The tendency towards smaller trees will continue. This type of plantation might well have quite a short life, say fifteen to twenty years. In arable orchards there will be increased use of herbicides, and we may see zero cultivation become established practice in pear and culinary apple orchards, as it is now in blackcurrant plantations. Thus, we shall require ground crop sprayers especially designed for orchard work. They must be efficient, quick and reliable. We shall also require machines to apply granular weed killer. However, as more fruit growers install irrigation I think the tendency will be for more orchards to be grassed down. Thus we shall need really good fast mowing machines which will cut both wet and long grass as well as making a neat job under normal conditions. I think the flail type of mower shows the greatest opportunities for development into a good orchard mower but it has a long way to go yet. It is a most regrettable fact that with the exception of spraying machines, most of the equipment offered to fruit growers today is designed for another purpose, either for farming or public services, and then adapted for orchard usage. When one considers the home market and the export potential this fact always amazes me. Our spraying machines are good and are still improving. I think, however, they may become less important to us. Fruit growers are hoping to see the development of systemic fungicides. If these are developed the number of spray applications per annum will be drastically reduced. However, we must not place too much store by this, for just when one has lulled oneself into a pleasant state of false security, nature has a way of landing us a back-hander. We must anticipate continued advances in spray chemicals which will enable us to improve our quality. The speed of spraying may become more important; already we can set frosted Conference pear blossoms artificially with gibberellic acid, and I now hear that French workers have a break-through with artificially

setting frozen apple blossoms. If artificial setting of frosted blossoms becomes standard orchard practice obviously great speed of application of a setting agent after the frost will be essential.

Pruning

The first of our labour peaks—pruning—must receive much more attention than it has in the past. Potter of East Malling is working on biennial pruning, which reduces labour requirement by 30% to 40% over a two year period, but I am not sure, with the ever-increasing demand for larger and higher quality fruit, that any other than the best of our orchards will be able to adopt this system. Pneumatic pruners have been on the market for some time, but up to now they have been too heavy, resulting in operator fatigue. New models are now on the market which are much improved and will soon replace the hand secateur in many orchards. The pneumatic long arm for doing the top of the tree is still far too heavy and with some models too clumsy. Even with small trees, one cannot reach all one's cuts without a long arm. It is essential that this model of the pneumatic pruner be improved. Operator fatigue must be reduced to a minimum or the whole system is hopeless. All pneumatic pruners must, of course, be powered from an air compresser coupled to the power take-off of our standard tractors. We shall also have to look at hydraulically powered pruning and picking platforms; to use the American name, the 'Mechanical Monkey'. These again should be fitted to the rear of the tractor and powered by the hydraulic system. The platform should rise and swing and be controlled by the operator on the platform. It is also necessary for the operator to be able to move his tractor to the next working position without leaving his platform. Having seen the hydraulic wonders of the modern trench digging machines built round tractors, I cannot believe that this is beyond your powers of ingenuity. The home and export demand for a platform as described would be very great. If a skilled pruner were equipped with pneumatic secateurs and able to work off a hydraulically powered movable platform his output of work would be greatly increased.

We also require better pruning shredding machines. Far too much time is wasted raking prunings into the centres of the rows where our present machines can get at them. The shredder must either deal with the prunings where they fall, mostly under the tree, or a side delivery rake must be designed to move the prunings mechanically into the centre of the row. Requirements for irrigation equipment may change drastically. If our chemists produce a systemic fungicide for scab, we would then apply irrigation water over the tree rather than under it. If over-tree irrigation becomes possible, much bigger sprinklers could be used, and a larger area covered between sprinkler shifts. The chief advance in design we are looking for in the irrigation field is the reduction of the labour requirement. We have good pumps and pipelines, ingenious and efficient couplings and fairly good sprinklers. But the labour requirement for orchard irrigation is far too high. It may be that this problem requires some fundamental re-thinking. Is a system using long lengths of rigid pipes with mounted sprinklers, requiring movement between trees, the most efficient for orchard use?

Whether we water over or under the trees the problem is the same. Long lengths of tube are very difficult to handle among trees. Difficult handling means slow handling, with resultant high labour costs. One thing is quite certain—orchard irrigation is going to increase enormously. In 1963 only 6,440 acres of commercial orchards were irrigated regularly out of a potential of 200,000 acres. The ever-increasing demand for larger and larger apples will make irrigation essential. Until recently, growers on porous soil, without a natural supply of water, were prevented from adopting irrigation. In 1963 there were only 428 man-made reservoirs on all agricultural and horticultural holdings. Now, however, with the introduction of butyl rubber and certain plastics as reservoir liners, anybody who can trap his land drainage water during the winter can build a reservoir and install an irrigation system.

Picking

Now let us look at fruit picking, our second labour peak. For the next 10 years this operation will be performed by hand. Our trees, being smaller, will be easier to pick but we shall still have to use step ladders. Step ladders need re-designing to allow great stability without the necessity of pushing a leg through the middle of the tree and knocking off half of the apples in the process. They must be comfortable to stand on and be so constructed that the picker can use both hands to pick the fruit instead of having to use one hand to hold onto the ladder. Finally the steps must be easy and quick to move. On older larger trees our mechanical monkey could also be used for picking the tops. Any branches that the picker could not reach from her short step ladder would be left for the mechanical monkey to pick. In this manner the mechanical monkey would be able to cope with a large number of trees in a day. Bulk bins will replace trays in our orchards, but there is still much design work to be done on them, and I feel sure that the perfect bin has not yet seen the light of day. Bruising must be reduced to an absolute minimum. Most picking is done on piece work. Unless the closest supervision is kept on the pickers, they drop the fruit into the bin, bruising every apple. If extra supervisors have to be employed, half the labour saving advantage of bulk bins is lost.

I hope to see a simple bin filler designed. The filler would empty the picking bag, or buckets, gently, lowering the fruit into the bin. Bin ventilation must be improved. It is very noticeable that Cox's stored in bins come out of store much yellower than those stored in trays. We must also have a simple powered bin mover for orchard use. When we are picking trees over, picking young trees or just a light crop you cannot fill a bin without moving it

around the orchard. We cannot afford a tractor driver with a forklift truck to do this moving. The pickers must be able to move their own bins without undue physical effort. Transporting the bin from orchard to packhouse is no great problem. There are several bin transporters already on the markets; these machines will undoubtedly continue to develop.

Packing

We now finish up with, I hope, unbruised fruit in the packhouse and face our third labour peak, the packing of the fruit.

At present the only satisfactory method of emptying a bulk bin without additional bruising is by water flotation. The bin is lowered into a tank and the apples float out. The fruit is taken by a powered roller type conveyor out of the water and then dried. This system seems, to say the least of it, very wet. We must find a method of emptying bins without bruising the apple and without submerging them in water and subsequent drying.

Some cull-eliminators and cleaners are satisfactory but others cause additional bruising and sorting tables require further development. Flow and return belts are too slow, therefore, ways must be found to improve the standard of grading on roller sorting tables or new sorting tables developed which will lend themselves to both speed and accuracy. Our sizing equipment is on the whole satisfactory. However, greater accuracy could be imparted to most models. They must all of them be adapted to automatic box packing. Individually wrapped apples will soon be superseded entirely by cell packs. Wrapping requires too much skilled hand labour. Semi-automatic cell filling is already being offered by several firms. This trend will obviously continue. It is now time for grader manufacturers to consider designing their machines specifically for fully automatic cell filling. This, of course, will have to be done in conjunction with the box designers. 50% of the labour used on apple and pear grading is employed placing fruit in the boxes. This simple but expensive process cannot be tolerated much longer.

There will, of course, be other mechanical developments in the near future, but the ones I have mentioned are those which, from practical experience are needed most.

Looking Further Ahead

Now let us look further ahead to the more distant future. Because one does not know what cultural advances will be made, I am going to limit my remarks to our three labour peaks, pruning, picking, and packing. It is possible that growth regulating substances may assist us in reducing but not eliminating the pruning peak. I intend to deal with picking and pruning together. I believe that it is possible to create a completely mechanized pruning and harvesting system for apples. The method I am about to promulgate is only meant as a suggestion to show the problem is not insoluble and to start you all talking. In many ways the problem is similar to mechanical blackcurrant picking. The bushes must be grown to suit the machine. Similarly we must grow our fruit trees to suit our picking machine. Before I explain how I would grow my tree, I must digress into the realms of pomology. If a year old apple shoot is left unpruned, in the second year it not only continues to grow but forms fruit buds on the first year's growth. In the third year the fruit buds on the first year's growth blossom and fruit.

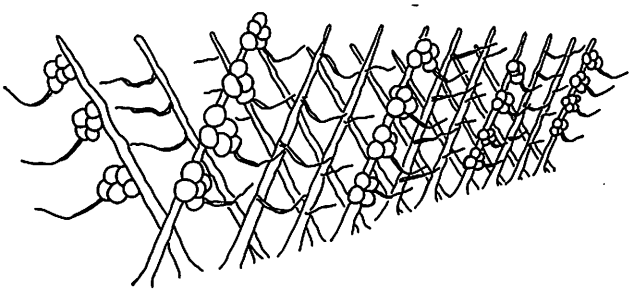

Diagram 1

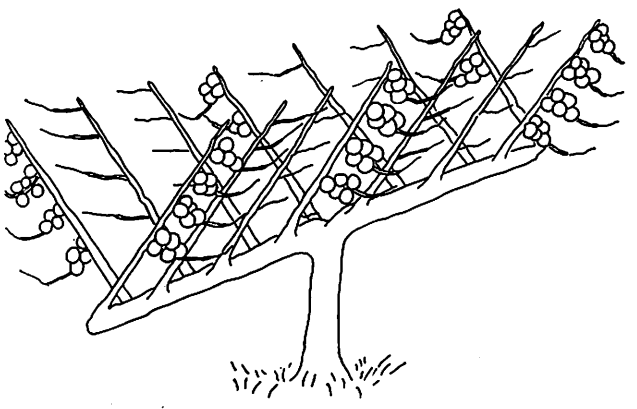

Diagram 2

Diagrams No. 1 and 2 illustrate two alternate systems of growing trees for mechanical picking and pruning. Diagram No. 1 shows trees similar to a cordon plantation, the trees are planted close together as only one in three are cropped each year. Diagram No. 2 shows a larger type of tree, in this case every third branch is cropped annually. In each case the branches are trained at an agle of 75° with the ground. Thus in Diagram 1 the alternate trees form a 'V' and in Diagram 2 the alternate branches form a similar 'V'. In any one year with system 1 a third of the trees will have only 1 year side shoots, a third 2 year and

a third will carry the crop. With system 2 the same principle applies to the individual branches. As we are dealing with the growth of the tree we will deal with pruning first, and come back to picking in a minute.

Pruning will take place twice a year, during the summer a hedge-cutter type of cutting blade will be run down the inside of the 'V' formed by the alternate trees, or branches; this is to stop fruit growing inside the 'V' and to allow light to penetrate the tree. It will also tend to dwarf the trees as this is an effect of summer pruning. In the winter pruning will be confined to branches which have carried fruit. A small circular saw or a reciprocating knife would be run down the three unpruned sides of our angled trees or branches which have carried that year's crop, leaving bare scaffolding poles. It is from these branches that next year's one year growth will grow. The inside of the 'V' will once more be cleared of all growth as in the summer. The remainder of the laterals will be left uncut.

Turning now to mechanical picking, there are two basic principles used today, in what mechanical picking machinery we have. Combing, which is used for hop picking and blackcurrant picking, and high frequency vibrating. The latter is used in the United States for picking nuts, blackberries, raspberries, loganberries and many other fruits destined for processing.

I believe the vibrating principle could be used for fruit destined for fresh consumption, provided the tree is grown to fit the machine. The design of picking machines is a job for the engineer, but I am suggesting a hypothetical machine which, although doubtless open to many criticisms, may start a train of thought.

It would have a vibrator which would make contact with the angled tree or scaffolding branch from which the fruiting laterals are growing (Diagrams 3). The rest of the machine should collect the falling apples without damage. The impact of one apple falling on another must be avoided. For this reason a series of sloping surfaces of a resilient material allowing the apples to roll on to an elevator conveyor is suggested. This would feed to a cull-eliminator to remove all small apples. This sub-standard fruit would be conveyed into a hopper on the top of the machine. After the cull-eliminator the fruit would pass over a roller sorting table, where a few girls would remove any fruit showing any blemish at all, for by the time this machine is built, no blemish will be tolerated on the fresh fruit market. The blemished fruit would be conveyed to the cull fruit hopper. We should now be left with only perfect fruit of marketable size. This fruit would be conveyed to a bin filler and thence to the bulk bin. When the picking machine reaches the end of the row the cull hopper would be emptied into a lorry for direct despatch to the cider or juice factory. No sub-standard fruit would enter the packhouse at all.

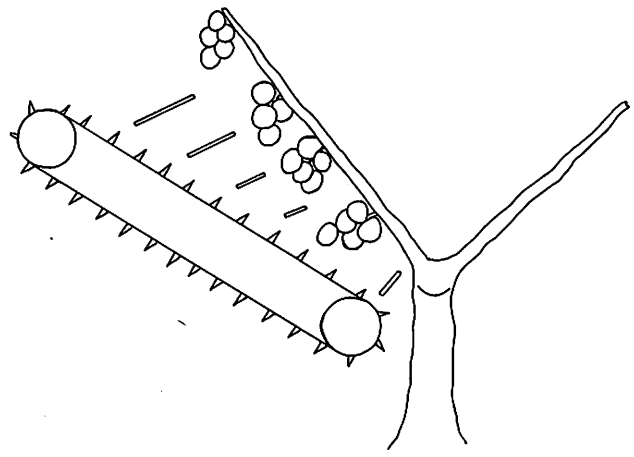

Diagram 3

My main reason for going into such detail concerning the mechanical pruning and picking of the fruit is to show the importance of complete co-operation between the machinery designer and the pomologist. Only when a team of experts in orchard production and machinery design is formed will it be possible to grow the tree and design the machines we require, really to mechanize our orchards.

Finally and very briefly let us have a look at the packhouse of the future. The fruit will arrive with all small and blemished fruit removed. So after bin emptying the only quality grading required will be for colour. It should be possible to do this with the use of colour sensitive cells. Therefore, no girls will be required for sorting. After sizing, the machine will feed the apples into cell packs. After the box is filled the variety of fruit, size and grade will be printed on the box in metallic ink. The grader will be so accurate that no check weighing will be required. An automatic stapler will fasten down the boxes before the boxes are automatically sorted by means of a scanner, and conveyor shunting equipment. Finally, a mechanical stacker will stack the boxes on their respective pallets. Thus, only one man will be required to operate the packhouse. Armed with a forklift truck, he will feed the grader with bins of apples at one end and remove full pallets of packed boxes at the other end. My paper is now finished and I hope you will remember our three labour peaks. The three 'Ps', pruning, picking, and packing

DEVELOPMENTS IN OVERSEAS USE OF MACHINERY IN FRUIT GROWING

by

F. A. ROACH*

Presented at the Spring National Open Meeting of the Institution at Wye College, Kent on 24 March 1966

In discussing recent trends in the development of machinery for use in fruit production, this paper will deal specifically with apple production and handling of the crop in the northern hemisphere in Europe and North America. Many of the recent developments apply also to pear production.

Apple Production

During the last 15-20 years, vast changes have taken place in the production of apples in most countries of Europe, and it is necessary to consider these in relation to their effect on the use of machinery. Prior to the war the bulk of apples for market were grown on large sized, widely spaced trees. Often such orchards formed part of a general farm, and the varieties grown were of indifferent quality. Lack of sufficient attention to pest and disease control and poor preparation for market meant that comparatively little first-class fruit reached the consumer.

At this time apples from the United States, and to a lesser extent from Canada, found a ready sale in the markets of Europe. To ensure that these apples arrived at their destination after a journey of 3,000 to 6,000 miles or more in good condition, considerable attention was paid to the grading and packing of the apples and these were usually shipped in the standard 40 lb wooden apple box. The American apples were exported in large quantities to the United Kingdom and also to Germany and other countries in Europe. They set a standard in presentation which was beginning to have an influence on the production and preparation for market of apples in this country, greater attention being paid to pest and disease control to ensure better quality, while some improvement was made in grading and packing for market. At this time use of mechanization in orchards in most countries of Europe was in general limited to machinery for spraying, cultivating and grass cutting, most other operations being carried out by hand labour.

Little progress was, of course, possible under war-time conditions and little planting was done. Many of the orchards in Europe lacked attention and vast acreages were devastated by military action. The orchards of Holland, Germany and the U.S.S.R. in particular suffered, in the Soviet Union it being estimated that 1¼ million acres were destroyed.

Post War Development

In the early years after the war, supplies of apples, as of other foods, were short, prices were high and since apples sold readily, comparatively little attention was at first given to quality. As a result of the high prices in Europe and the limitation in the supplies sent from America, a considerable extension of apple production took place in Italy, which quickly became the main European exporter of apples and pears, both to the United Kingdom and other countries of Europe, a position she still holds.

As the period of shortages and high prices passed, greater attention was paid to quality and to the planting of new orchards of varieties more acceptable for dessert. Throughout Europe much grubbing of old orchards has been done and in place of the large trees, most new apple orchards consist of small trees worked on dwarfing or semi-dwarfing rootstocks planted in various intensive systems.

The change in the form of orchards has come about as a result of the growing economic pressure to obtain heavy yields of good quality apples early in the life of the trees and also to reduce the cost of picking and other labour costs at a time when prices received for apples show little increase in comparison with rising costs of production.

In France considerable acreages of intensive new orchards, mainly of Golden Delicious apples, have been planted in the newly irrigated areas of the Lower Rhone-Languedoc, and today France is the main supplier of this variety to other countries of Europe.

Of recent years the mounting costs of labour in the U.S.A. and Canada have led to the adoption there also of smaller trees to replace the large types on seedling rootstocks characteristic of orchards in the past. Even in the U.S.S.R. the same orchard pattern is developing in new apple orchards being planted in the Ukraine and Moldavia. Many of these are of enormous size, single orchards covering 1,000 acres.

Since in most countries labour represents the highest cost involved in growing and harvesting an apple crop, much attention has been paid to the greater use of machinery to replace human labour. To ease the burden of labour, attention has also been given to providing mechanical aids for such operations as pruning of trees and movement of fruit within and out of the orchard.

Systems of tree training vary much in different countries, for example, in Italy the palmette, a form of espalier, is popular. The trees are trained to a post and wire fence and usually reach a height of 12 ft—14 ft. In northern Europe, including Holland, Belgium and

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Germany, the spindle bush is the most popular form. Each tree is trained separately to an upright 6 ft stake. In France various forms of palmettes and hedge planting systems are used. In North America and the U.S.S.R. bush trees are most commonly used, though various forms of intensive planting systems are also being tried.

Regardless of the particular type of system being used nearly all have one feature in common, that is the trees are planted more closely in the rows than between. Such a method allows of the passage of machinery between the rows and provides an effective target for spraying.

Developments in the Use of Machinery in Orchards

The grubbing of old apple orchards and their replanting with young trees, as has been done widely in Holland, Belgium and Denmark, has brought into prominence the 'replant' problem. Little is as yet known of the cause of this trouble which results in poor growth of new apple trees planted on sites where apples have been grown previously. Research has shown that injection of soil with chloropicrin (tear gas) some time prior to replanting sterilizes the soil and enables the trees to grow away satisfactorily.

Already injection of soils is being carried out on a commercial scale in Holland and Denmark and active investigations into methods of control of this world-wide problem are being made in many other countries, including Great Britain. It is likely that orchards in the future will be grown for a shorter period than in the past before replanting, and so there will be increasing demand for suitable equipment for doing the injection treatment.

It is probable that there will be a demand for contract injection services since use of chloropicrin calls for special care and experience on the part of the operator. Such services exist in Holland and Denmark and considerable use is made in the U.S.A. of chloropicrin injection before planting other fruits, including strawberries.

To be effective the chloropicrin liquid must be injected direct into the soil to a depth of about 6 in. Within the soil the liquid vapourizes and the vapour spreads throughout the top soil. Satisfactory results depend on the injection being carried out when the soil contains a reasonable amount of moisture and in order to retain the vapour within the soil covering of the surface with polythene sheeting is sometimes done.

When replanting orchards it is not necessary to sterilize the whole orchard area but simply an area a few feet around the individual tree sites. Where a rectangular system of planting is used, injection can be done in strips down the field where the rows are to be planted. Suitable machinery for such work has already been developed for use by contractors in Holland and Denmark.

In Holland one type of machine consists of a tractor mounted 6-tined cultivator, each tine being fitted with a tube down which the chloropicrin trickles into the soil. The rate of delivery of the choloropicrin can be controlled by tractor speed, a normal application being 45 gallons per acre. Where tree row strips are injected the machine covers a width of 4 ft 6 in. Rolls of polythene sheeting of this width can be mounted behind the tractor and unrolled to be spread on the soil surface following the injection, the edges of the sheet being turned in to the soil on either side by small discs.

After an interval of two weeks the polythene sheets can be removed by rewinding, though in the U.S.A. use of a flame thrower to burn the sheets *in situ* is found effective.

Some equipment used for chloropicrin injection in Denmark is somewhat more simple than that employed in Holland or the U.S.A. A 40-gallon barrel of chloropicrin is mounted behind a tractor and plough and the liquid trickles down two tubes spaced about 4 in. apart, on to the soil in the freshly made furrows, to be covered in when the succeeding furrow is made. This means the chloropicrin is placed in double bands about 9 in. apart. The rate of application is controlled by nozzle size and tractor speed and is normally about 20 gallons per acre.

When using chloropicrin especial care is needed to prevent inhalation of the vapour and respirators may be necessary when filling or emptying containers or machinery. On a small scale, injection may be done by injection guns holding 1 gallon of the liquid. Injection is usually done at 9 in. centres at a depth of 6 in.

Equipment for Use in Nurseries and for Tree Planting

With increasing demand for apple trees, as a result of replanting of orchards and the large number of trees planted per acre, there has been an extension of nursery production, especially in France, Italy, the U.S.S.R. and the U.S.A. Mechanization in nurseries includes the planting of rootstocks by machines and lifting of the trees by diggers. High-mounted tractors straddle the rows of trees and are used for spraying during the summer as well as for use in lifting the trees in the dormant season. Modern hydraulic tree diggers in the U.S.A. straddle the rows and cutting blades operating from each side, pass through the soil beneath the trees. The latter are thus left ready to be picked up for transport to the despatch point or to be placed into cold storage and held until required. One such digger can do twice as much work as six teams of horses were able to do years ago.

Both in the U.S.A. and other countries, to facilitate planting in the orchard, large diameter tractor operated post hole borers are often employed for preparing the holes ready to receive the trees. In the U.S.S.R. a prototype tree planter was seen by the author in operation at the Michurinsk Institute of Pomology. This machine had been developed by the Institute's Engineering Department and later, in the normal way, would go on to the Institute of Engineering to be perfected ready for manufacture.

Before planting, the soil, which is of very good depth in vast areas of the U.S.S.R., is ploughed by digger plough to a depth of 16—18 in. The tree planting equipment, pulled by a track laying tractor, has two shares which open up a wide 'V' shaped trench into which the

trees are placed in turn by two workers riding on the machine. The trench is filled in behind the trees by pressure disc wheels.

This machine, with a driver and two planters, can put in 300 trees or approximately 2½ acres per hour and was stated to give better results than a hole-borer. Since apple trees in Russia are often planted with the union between rootstock and scion at, or slightly below, ground level to aid frost protection, depth of planting is not so vital as it is with us where care has to be taken to help the union well above the soil level to avoid scion rooting and collar rot.

Where a post and wire fence is used, to which the trees in an intensive plantation are to be trained, the posts may be inserted with a hydraulic ram such as has been developed in Oregon for inserting posts for the training of raspberries.

Application of Herbicides and Grass Control

During recent years there has been considerable extension in the use of chemical herbicides both to control weed seedlings and also existing grasses and broad-leaved weeds.

In many countries, as in the United Kingdom, a grass sward is grown between the trees in apple orchards but it is necessary to control the herbage around the tree base.

Where the trees are planted in a rectangular system, herbicide treatment can be used down the rows and the sward allowed to develop in the alleys. To apply herbicides either to grass and weed or on the soil surface to control weed seedlings, various types of equipment have been developed overseas as in this country, though nothing different from the type of equipment already in use in the United Kingdom has been seen by the author.

Usually the spraying equipment is tractor mounted and sprays either a band on each side of the rows or only around the tree base. Various systems of trigger action mechanisms which are brought into action when contact is made with the trunks of the trees, are employed either to control the spray or swing the boom away from the trees. Equipment of this kind seen working in the U.S.A. had been made on the farm.

In the U.S.S.R. such trigger activated mechanisms have been developed for use with offset grass cutters, discs and other cultivation equipment employed in orchards.

In England normal practice in modern apple orchards is to cut swards by cylinder or rotary blade machinery keeping the grass fairly short so as to avoid undue competition with the trees. In the more arid apple growing areas of the U.S.A. such as Washington State and in British Columbia where constant irrigation is essential, there is not the same need for frequent cutting and the grass may be cut only 2-3 times during the summer. Rotary blade mowers have been used and now the flail has gained favour.

Irrigation

Although the use of irrigation channels running down between the rows of trees in most countries has been increasingly replaced by sprinkler systems, irrigation channels are still used in areas where the land is either naturally suited to such a method or, as in California, is artificially graded.

The development and use of irrigation has often followed the damming of rivers and hyrdo-electric schemes. Such has been the case with the extensive irrigation canal systems in the Lower Rhone-Languedoc region of France and also in the irrigated areas of the Ukraine and Moldavia in the U.S.S.R. where extensive new orchards have been planted on state and collective farms.

In Southern France large pumping stations have been built to deliver water into the smaller canals and thence from a network of water towers to permanent underground mains laid throughout the newly developed area. From these 4 in. mains the water is commonly distributed by overland plastic pipes supplying overhead or low-level sprinklers.

In Moldavia in the U.S.S.R. a large collective farm covering 20,000 acres visited by the author, has its own automatic pumping station at river level and from a reservoir the water is distributed by some 20 miles of open concrete aqueducts. From these aqueducts the water is supplied to the orchards by irrigation channels or plastic pipes. A recent development in these orchards has been the use of large diameter plastic pipes which can be laid flat and rolled up on a tractor mounted reel.

The most commonly used systems of irrigation in the U.S.A., Canada and many countries of Europe are portable pipes and low level sprinklers which are moved as required. In intensively planted orchards in Washington, a system of permanent plastic irrigation pipes fitted with trickle nozzles is gaining favour. These pipes can be easily pulled along between rows of trees. In Italy permanent irrigation systems are often installed in orchards of apple trees trained as palmettes on a post and wire fence. The irrigation system can be used for water sprinkling for frost protection in spring and also for the application of fungicides and insecticides and foliar feeding by liquid nutrients.

Orchard Spraying

In general spraying for pest and disease control in most apple producing countries is now done with tractor drawn automatic machines. Modern rectangular and hedge planting systems are particularly suited to double side spraying and the limited height of the trees results in good cover. Medium to low volumes and air carrier systems are usual but high volume spraying is still used by many apple growers in the U.S.A. Here the large air sprayer type of machine with a 400-500 gallon tank and applying 600 or more gallons per acre is used by the majority of growers in Washington where there has been reluctance to adopt lower volume sprayers. There is, in fact, relatively little comparative experience of the two types of spraying in most orchard areas and some growers seem to cling to large machines and very high volumes as a result of the American love of large things!

One argument put forward by growers in favour of these high volumes is that with modern insecticides they are able to control their principal pests, codling moth and red spider mites, with about two applications compared with possibly 7-8 in the past, but in cutting these down they consider it is imperative to obtain a really effective cover. The dry climatic conditions in the Okanagan Valley in Washington and British Columbia do not favour apple scab and so frequent spraying to control this disease is not necessary.

Encouragement to growers to use lower volumes and even concentrate spraying has been given in British Columbia by the entomologists at the Summerland Research College, though even in this State some growers still use very high volumes.

There has also recently been some interest in the U.S.A. in more versatile machines able to apply both high and low volumes and it seems likely that such machines with their ability to cover larger acreages at lower volumes without refilling, will gradually come into favour.

In Europe there is generally greater use of smaller types of spraying machines than in the U.S.A. and, as mentioned earlier, some limited development in the use of permanent irrigation spray lines for application of fungicides and insecticides.

In the U.S.S.R. hand lances have been given up in favour of tractor drawn equipment but until recently, owing to shortage of tractors in Poland, much orchard spraying was done by bullock or horse drawn carts carrying simple spray pumps and tanks equipped with hand lances. In general, there has however been an improvement in the type of machines used in Europe for orchard spraying and the Danes set a standard which has had its influence in other countries.

Pruning

Hand pruning of large trees is a very time consuming operation and one of the benefits of growing apples on dwarfing or semi-dwarfing rootstocks is that most of the pruning can be done from the ground.

The use of pneumatic pruners has been adopted by many growers in the U.S.A. and in Europe, but the majority of growers still use hand secateurs and, as an aid in reaching the upper and less accessible parts of large trees, various forms of special equipment have been developed. In Italy and the U.S.A. tractor drawn elevated platforms are often used. Such platforms are frequently constructed on the farm and simply consist of a raised stage fitted above a trailer and on which two or more workers can be carried. Such platforms may also be used for picking the upper parts of high trees such as the tall hedge-like palmettes in Italy or the large standard trees of America.

In Canada and the U.S.A. there has been some development and use of self-propelled three-wheeled hydraulically operated machines. These are under the complete control of the worker who is carried on a small platform or basket and can move himself about to reach any part of the tree. These machines can be used for many operations in the orchard, including pruning, thinning and picking the crop.

The opinion of some growers in the U.S.A. is that the machines are relatively expensive items of equipment and may be of most value on the smaller farm managed by the owner with perhaps one additional worker. On larger farms, if a few workers have these aids, all want them, and this can involve considerable and unjustified capital outlay.

As a step towards mechanization of pruning, interesting developments are now taking place in America. Most of these started with the pruning of citrus and peach trees. In order to keep down the height of the trees to a reasonable level, several trials were made with hydraulically operated mower blades with a 9 ft cutter bar mounted on the front-end fork lift of a tractor. The cutter bar, working horizontally, simply mowed off the top-most branches leaving the rest of the pruning lower down and the cleaning up of rough cuts left by the mower, to be done by hand.

As this method showed promise, especially for peaches, a further step was the mounting of the mower bar in a vertical position so as to cut up the sides of the trees down the length of the rows in order to maintain a clear alley.

A more recent development has been the introduction of tree topping machines by firms of contractors in California. These again have been principally used for peaches and citrus and one was seen by the author in early summer operating in a peach orchard in Washington State. The machine consists of a battery of 7 large circular saws mounted on a horizontal swinging arm and under the control of the operator who is carried on a framework above the driving cab of the tractor. The driver below is well shielded to protect him from flying branches!

Claims made for this type of machine topping in summer are that it eliminates most of the expensive hand pruning at the top of the trees, aids picking and thinning the crop and, when done in summer, stimulates lower wood to produce fruit buds for the following year.

So far little use has been made of this mechanical pruning by apple growers in America, but a trial comparing the cutting of the tops and sides of the trees by mower bar and pruning by hand with pneumatic pruners, is being carried out in an apple orchard in the Hudson Valley, New York State. To date the mechanical cutting plus some hand pruning has shown a saving of about one-third of the time taken for hand pruning alone. It is hoped that by regular cutting back of the branches protruding into the alleys and keeping down the height of the trees, their size will be controlled and there will be less need for grubbing of alternate trees as would normally be needed.

One disadvantage of mechanical pruning of this kind is that it is apt to leave ragged cuts which need cleaning up by hand or they may die-back and become infected by various fungi including apple cankers.

Whether complete mechanization of pruning will ever become feasible remains to be seen, but it would seem more suited to the modern type of semi or complete hedge row planting than to the more widely spaced trees.

Machinery for Harvesting Tree Fruits

The cost of labour for picking any fruit crop represents the highest annual cost involved on the farm in production of the fruit. The ever increasing cost of labour and the difficulty in obtaining sufficient at a particular time, has therefore centred much attention on the possibility of mechanization of this operation.

Major progress in mechanical harvesting has been made in the U.S.A. where labour costs and shortages are more acute than in any other country. The majority of machines so far developed are based on the effect of vibration applied to some part of the crop plant, so causing the fruit to fall off.

One of the first uses of this principle of vibration was application to the harvesting of blueberries and at the present time various forms of vibrators or shakers are successfully employed for the harvesting of sour cherries, prunes, apricots, peaches and nuts. So far, owing to the damage caused to the fruits as they fall from the tree, only limited use has been made of this method for harvesting apples. As the apples fall they are likely to hit the branches of the trees or collide with other fruits on their way to the ground. Investigations are being made in several countries, including the U.S.A. and the U.S.S.R. into the possibility of arranging the branch framework of the trees, so that no two branches overhang each other, and thus damage from the apples hitting the branches should be reduced. However, at present the vibration method seems unlikely to be successful for dessert apples but it may be developed for handling apples intended for processing.

For the harvesting of apples for processing, experimental use has been made of tractor mounted vibration arms and elevated catching frames which can be held beneath the upper branches of tall trees and so reduce the distance of fall.

One of the most important uses of tree shakers in the U.S.A. is for the harvesting of sour cherries and commercially available equipment has shown considerable improvement during the last few years. This method of harvesting is now used quite extensively for the picking of sour cherries in New York State, Michigan and other cherry producing areas.

Shaking of the trees is done by vibration arms which are attached to the tree trunks or main branches by clamps. Hydraulic motors provide high velocity shaking action which reduces movement of the branches to a minimum but separates the cherries from the stems quickly and without injury.

Where tree fruits are harvested by shakers, they are usually caught in catching frames placed beneath and around the trees. The most modern form of catching frames for sour cherries consists of two halves, self-propelled and each equipped with a shaker. From the catching frames the cherries pass up elevators into tanks of water carried on lorries which transport the fruit to the processing plant.

In the harvesting of prunes by tree shakers it has been found possible to mechanize the picking up of the fallen fruit from the ground, provided the latter is rolled flat before shaking is done.

Aids to Harvesting

Since considerable time can be wasted in picking apples from tall trees entailing the use of ladders, both in America and countries of Europe, various aids to harvesting are used. The use of platforms and mechanically operated self-propelled baskets has already been described in the section on pruning and various forms of these are used for picking.

As the use of bulk bins for harvesting of apples has become general practice in North America and their use is extending in countries of Europe, attention is now being given to aids to picking which can be coupled with the use of bins. A prototype of this kind was tested in 1965 by the U.S. Department of Agriculture engineers in Washington. The machine was designed to carry two workers who picked apples from a hedge type plant as the outfit was drawn at a slow speed between the rows of trees. The apples were picked by hand and conveyed, cushioned between two foam rubber bands, to the bin carried on the rear of the machine. Further developments in aids of this kind are likely to be made during the next few years.

A recent introduction to help in picking citrus from ladders is a plastic chute attached to the ladder. The fruits are placed in the chute and pass down into picking bags at the foot of the ladder. Bruising is reduced by plastic baffles placed along the length of the chute. Modifications of this type of chute have been used for harvesting apples and chutes of this kind have also been used to transfer apples from a picker working in an hydraulically operated basket down to a bulk bin carried on the machine at ground level.

Movement of Apples from Orchard to Packhouse

The expanding use of bulk bins in many apple producing areas of the world, has led to the development of special transport for moving the bins from the orchards to stores or packhouses.

Various forms of low loaders are employed for movement on the farm but in the U.S.A. where greater distances are to be covered, elaborate straddle trucks have been developed. A type used in Washington State can pick up a line of twenty-eight 25-bushel bins stacked three deep. The straddle truck reverses over the stack of bins and hydraulic lifting shoes clamp the load which is then raised to the carrying position. The load is slung within the outer framework of the straddle truck and a special sway restricting bar keeps the load safely in check even if the truck is stopped abruptly. In this way the bins can be carried at speeds up to 50 mile/h without causing undue bruising to the apples.

Straddle trucks operating between co-operative headquarters and members farms may be fitted with two-way radio so that the drivers can be directed to particular loading points.

Recent Developments in Packhouse Equipment

Much of the development of specialized equipment for use in packhouses is done in the U.S.A. where such equipment has reached an advanced state.

The emptying of bulk bins is most commonly done by the water flotation method but dry dumpers which completely invert the bins are also used.

To control storage scald in apples in the U.S.A. approval has been given to treatment with the chemical D.P.A. diphenylamine. Application of the chemical is most easily made by dipping the bins in a solution of the material. Dipping is done either before or within a few weeks of storage. Various types of equipment have been developed for dipping the bins. This usually consists of a tank containing the chemical into which the bins are either dipped when they pass on to an elevator or they may pass down an inclined track into the solution and up the other side to be rinsed in water and allowed to drain before going into store.

Coupled with the use of bins in the States has been the production of various kinds of automatic bin fillers. These are designed so as to reduce to a minimum risk of bruising by limiting the distance the apples fall. One form makes use of a spiral filler which is raised as the bin fills while another type carries the apples to the bin in cups on a continuous belt. The height of the head of the filler, relative to the level of fruit in the bin, is controlled by a sensitive arm.

Waxing of certain root vegetables during preparation for market to reduce water loss has been commercial practice in the U.S.A. for some years, but this treatment is only used to a limited extent for apples. The bins of apples received from the orchard are emptied by the flotation method and are first washed in a warm detergent solution before passing through a wax spray, mai ıtained at a temperature of 135°F. and then on to a drier and polisher. An edible 10% vegetable wax is used and, if required, D.P.A. can be added to it for the control of apple scald.

A recent introduction in the U.S.A. has been the use of an electronic colour sorter for apples. Such equipment has already been successfully employed for colour grading of tomatoes and the first installation in an apple packhouse in Washington, at the Cowiche Growers Co-operative, was seen by the author in 1965.

The colour sorter makes use of light sensitive 'eyes' which scan the apples as the latter pass before them in the cups of the grading belts. The average colour reading is worked out electronically and the appropriate trip mechanism operated to sort the apples into up to four colour grades. This colour sorter has proved very successful with Golden Delicious and apples of a uniform red colour, but is not satisfactory with striped apples.

This colour sorter has resulted in a considerable saving in labour in the packhouse. When dealing with 800 bushels of Red Delicious an hour, whereas normally 35 women would be grading and about 30 packing, with the colour sorter the number grading was reduced to 9, with 20-30 packing. Such results can only be obtained where the apples are relatively blemish-free so needing little hand sorting.

The Future

In every form of industry today, the trend is to further mechanization and ultimately to automation. In fruit production, as in other horticultural industries where we are dependent on the growing plant to produce the final product for market, complete mechanization and possible automation of production of and, in particular, harvesting the crop, is a much more difficult matter.

However, if the burden of physical labour is made lighter for the industrial worker, it is evident that in horticulture also everything will have to be done, both to ease the work done by the individual and to meet the growing cost and shortage of labour.

We can learn much of the likely developments in the future from a study of trends in the U.S.A. where these problems of labour are already becoming acute. There much attention is given to mechanization of harvesting fruit crops and recently, in Washington, a new investigation into the harvesting of apples which might cost the industry 100,000 dollars has been under consideration.

While engineers in Washington consider that aids to hand picking in the form of machines carrying the pickers, and which might also carry sorters to grade the fruit, will be the first step, ultimately 'a completely automated unit capable of sensing and locating the fruit may be the only real solution to assure a reasonable return on capital and continuing profitability of apple production'.

Developments in packhouse equipment already include the electronic colour sorter and at present investigations are being undertaken into the use of light rays to judge internal quality of apples.

A final stage might, of course, be the production, in a laboratory-like factory, of apples grown from tissue cultures on a nutrient medium, so cutting out the need for the tree and orchard altogether. But such dreams seem a long way off and how dull life would be with no apple blossom in spring or orchards of ripe fruits in autumn!

A DESIGNER'S APPROACH TO FRUIT HUSBANDRY

by

J. B. HOLT, M SC (AGR ENG), MIMH, AMI MECH E, AMI AGR E*

Presented at the Spring National Open Meeting of the Institution at Wye College, Kent on 24 March 1966

First and foremost in orchard mechanization the designer must determine for himself what the problem really is before setting about finding a solution in engineering terms. If he accepts the requirement as posed by the fruit grower he may well produce a practical answer to the wrong question. Of course the engineer whose first responsibility is to design something which has an immediate and profitable market is not always free to take a broad look at the true requirements.

The man who is prepared to devise or design for a complete system and not just a small component part of a fruit mechanization scheme, evolved perhaps with little forethought, has to become concerned with the trees in the orchard and the fruit itself.

The great difficulty in designing, for example, a fruit handling and transport system for use in orchards is in knowing what the tree size, shape and spacing will be in the future. The variety of planting distances being adopted currently is an indication that fruit growers are not all in agreement on this subject. While rootstocks and spacing should be selected to suit the soil and growing conditions, some flexibility may be possible without any loss of yield. There are of course some traditional ideas which might well be changed to simplify the designer's problem. Tree rows are traditionally straight and they often, although not always if the trees have been thinned run at right angles to the headland. Curving the row ends may be one way of easing the manoeuvring of larger fruit transport units without the need for wider headlands. Many existing orchard layouts involve cross-roadways, at distances sometimes as close as 50 yards, to which the unfortunate pickers carried the bushel boxes of fruit. Mechanization should be designed to make possible longer row lengths with less wasted land.

The current trend is towards smaller trees, partly to reduce the amount of ladder work at picking time. However, trees of the height which fruit specialists in general favour still produce fruit which cannot be picked by a person standing on the ground, and so steps are used. The interesting possibility here is that if the engineer produces a suitable mobile platform from which the workers can pick all the fruit as readily as they can that within reach of the ground, there may be no real need to restrict the trees to a low height. To obtain a given fruit-bearing area of tree, the 'hedgerows' could be higher and further apart which may in turn provide more inter-row space for the movement of machinery. If the best solution to a problem would involve radical changes to the trees

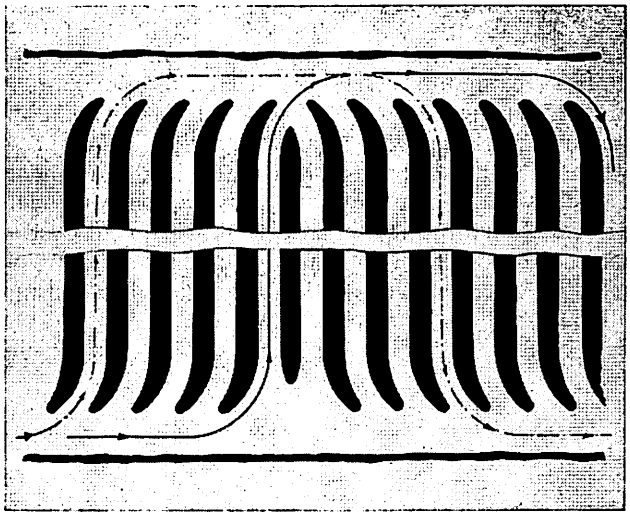

Fig. 1

Diagram of proposed orchard layout with curved row ends to facilitate mechanization.

the designer may have to be content with a compromise for the immediate future. However, if possible it should take a form which would demonstrate to the fruit grower the advantages to be gained by following the longer term policy of adapting the trees to suit a fuller degree of mechanization.

Fruit Harvesting

Although the cost of picking the fruit is only a small part of the total expenditure on it before it reaches the wholesaler, a reduction in the labour content of harvesting is considered important throughout most of the fruit growing countries of the world. There is a general shortage of the right sort of labour in this country and there is an increasing desire to shorten the harvest period so that fruit is picked at the correct stage of maturity for long term storage.

There seem to be only two approaches to this problem, these being mechanical means for shaking fruit off trees into a catching frame, and presenting the human picker to his work by using a powered platform or other device. Unfortunately it seems that the tree shapes required for these two methods are radically different. For the shaking method an umbrella shape, perhaps multi-layer, is required so that the fruit may have an unobstructed fall

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into the catching device, and for assisted hand picking a hedge shape is desirable. In this instance perhaps the grower must decide, on the basis of the level of fruit damage associated with each method and the intended outlet for the fruit, which system is to be adopted.

Work which was started during 1965 at the N.I.A.E. on assisted hand picking was linked with the handling of the fruit in bulk bins. With conventional hand picking methods it had been found that in some circumstances it was desirable to move the bin from time to time during filling to keep it close to the picker. The picking bucket itself was also suspect from the damage point of view. Both these problems were overcome in an experimental mobile picking unit which was devised to operate in an orchard having trees 4 ft apart in 8 ft rows. Unlike the powered platforms which have been tried in the U.S.A. where only one worker is carried and his ladder is eliminated, the N.I.A.E. unit carries between four and eight pickers so that the capital cost would be spread over an improved performance of a number of pickers. Conveyors take the fruit from close to the pickers and deliver it into a bin carried on the machine.

The aim was to produce a continuously moving machine

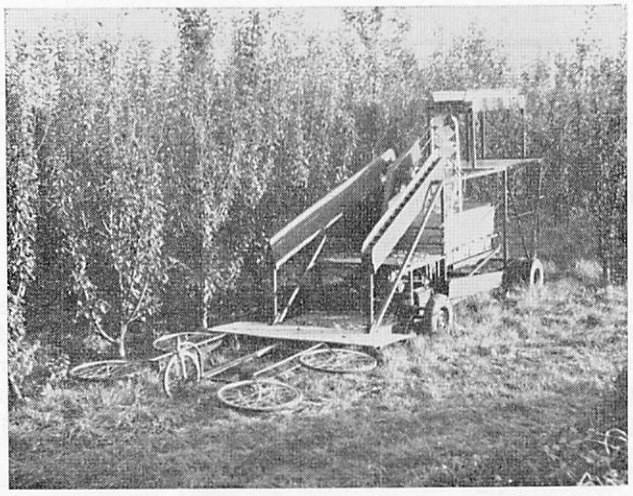

Figure 2

N.I.A.E. Self-Propelled Picking Unit ("Orchard Mobile")

which guided itself between the rows of trees so that a driver was not necessary. The pickers have to regulate the forward speed and periodically move a full bin to the carrying position at the rear and an empty bin into the filling position. At cross roadways or on headlands full bins can be released from the rear of the unit. Upon examination, after four and a half months in store, fruit in bins filled on the machine was found to have a lower level of damage than that in some control bins filled in the normal way.

From the engineering point of view the problems encountered were mostly connected with variations in the height of the trees, the extent to which they protruded, yield per tree and the disposition of the fruit in the vertical plane. Unless the workers could move in some way in and out from the centre line of the machine the trees would require pruning and tying-in more accurately than is normally considered necessary. Perhaps a prescribed gap between rows of trees could be obtained by a form of double cutter hedge trimming machine used before the normal pruning operation. To cope with the variations in yield and disposition of the fruit, it is essential that the pickers should be able to change their areas of work relative to the machine and to each other fairly easily.A self-propelled picking unit of this sort would also be suitable for pruning operations, its engine providing power for pneumatic or electric pruning tools if required.

One of the reasons for designing this first experimental picking unit for a highly intensive orchard was the belief that if the problems of carrying and handling the bulk bin could be solved in a restricted space it would be relatively easy to produce wider units. A completely unrestricted clear space about five feet wide between the rows of tree would probably be most suitable for a machine carrying 40 in. $\times$ 48 in. bins. A greater clear width up to a height of about 20 in. above the ground would be required for the wheels. It would seem to be preferable for all the pickers working in conjunction with the unit to be carried on it, including those picking fruit close to the ground. Although the lowest platform can be within a few inches of the ground it may not be economical to pick fruit lower than 18 in. or 2 ft from the ground.

If existing trees planted at a spacing of 20 ft $\times$ 20 ft were reshaped into 'hedgerows' say 12 ft thick, leaving 8 ft clear space between, it is possible that the bulk of the crop could be picked from a large mobile unit. The remainder would be picked by conventional methods presumably by workers following close behind and placing the fruit into some of the same bulk bins. The eight foot clear space would provide adequate room for bin handling and transport equipment. Obviously tree rows narrower than this would be preferable.

The Design of Fruit Containers

From a materials handling point of view, bins offer many advantages over smaller orchard containers and there is considerable scope for the designer in this apparently simple field.

Generally the bin is filled in the orchard and then put into a gas or cold store for a period before being emptied. The bin should therefore be designed to suit the filling operation, the orchard handling equipment, the transport from orchard to store and the store itself. The method to be adopted for emptying may determine whether the bin has to have a hinged panel or not. Apart from the tedious method of emptying bins by picking the fruit out, they may be emptied by the flotation method, by tilting the bin which has a hinged opening in the side, or by inverting the bin and controlling the flow of fruit through a door in a padded lid. In practice the design of the bin may decide some of the features of the handling equipment,

while the tree spacing or variety of fruit may help to establish some of the bin's dimensions. The first reason for the departure from the normal pallet based container and the evolution of the various forms of the N.I.A.E. well-based bin was the desire to make the best possible use of the available volume of a cold store. It is of course accepted that the refrigeration equipment of existing stores may limit the weight of fruit which can be accommodated. The proportions of the space under the shoulders of the bins were dictated by the requirements of the handling equipment envisaged.

However, the present harvesting, storage and grading cycle may not necessarily be the sequence in the future. There would be advantages in using separate orchard and storage containers, the transfer operation being combined with any necessary treatment to reduce deterioration during storage, and including some size grading, perhaps the removal of low quality fruit and pre-cooling. It would be important that these operations were as fully mechanized as possible since little spare labour is available at harvest time. It is likely that most of this sequence could take place in water. With this system the two types of container could be designed for their specific functions. The orchard container, which with reasonable organization could be used at least twice a day, could be relatively more expensive while the storage container could be designed for handling accurately on flat level surfaces by fork trucks. It could therefore be relatively cheaper than a normal bin. Its capacity might be a multiple of that of the orchard container.

Fruit growers who have reasonable quantities of both apples and pears present something of a challenge for mechanization since, despite the different characteristics of the two fruits, it is desirable that there should be some interchange and flexibility of the handling equipment and possibly containers. Pears are more prone to compression damage than most apples and do not float in water, thus intensifying the problems of bin design and bin emptying.

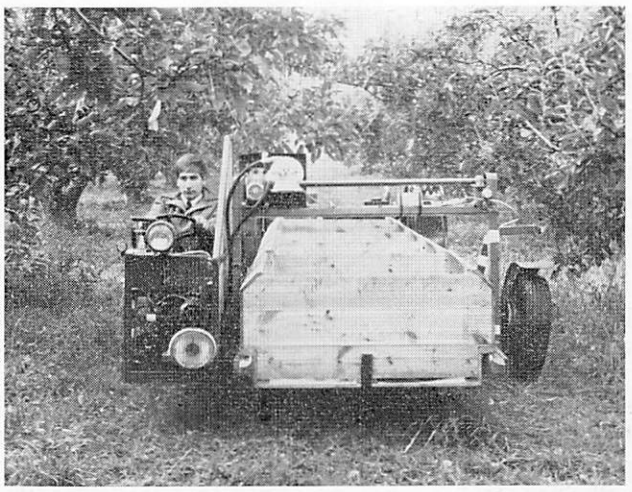

Figure 3

N.I.A.E. Experimental Orchard Self-loading vehicle

Handling Within the Orchard and Transport

The ubiquitous tractor is generally used for carrying the containers of fruit from among the trees or for loading them on to trailers which it pulls. The tractor is not the ideal machine for carrying fruit and work with the N.I.A.E. experimental orchard self-loading vehicle has shown the potential for a greater rate of work with reduced damage to the fruit. The basic concept is of a transport vehicle in which the loading, transport and unloading is a one man, one machine operation. While various forms and sizes of such machines are possible, the present vehicle has illustrated that it can work among the trees and also be suitable for road hauls of perhaps three miles. Self-loading vehicles more suitable for longer journeys would probably require other equipment to move bins to the headland or subsidiary roadways. The variations of tree size, shape and spacing and the uncertainty about future trends make the designer's problems very difficult. A low but fairly wide vehicle can work amongst trees of the umbrella shape but a narrower vehicle would be required for hedgerow arrangements.

The designer of a fruit transport system must consider the importance of the timeliness of the handling operation, the variable ground conditions and the operations which occur in the orchard throughout the year. To be a commercial success on many fruit farms, the transport vehicle probably has also to form the basis of the equipment required for spraying, grass cutting and fertilizer distribution. It perhaps has to play its part also in pruning operations and the removal or disintegration of prunings. A self-loading vehicle which could pass between the rows of trees at harvest time could be used to carry and power spraying or grass cutting machinery.

Automation is a subject which is very real in manufacturing industries and to some extent the principles could be applied to orchard mechanization. While at the present time it might not be economical to eliminate the driver of a spraying outfit, it could be attractive in the future on the grounds of labour costs and health. An orchard is an ideal environment for the use of a buried leader cable system of vehicle guidance. Such a system could be used for spraying and grass cutting operations and for the guidance of harvesting units. It might prove difficult to use it for guiding fruit transport vehicles if there are casual pickers and their young children in the orchard. However, it would be more practicable where the vehicle has to travel a considerable distance on farm roads.

In attempting to evolve sound systems of mechanization and in particular methods of materials handling in orchards, the engineer and designer cannot ignore the many factors concerning the trees, the land, the storage and even the grading and packing of the fruit.

Discussion of Paper by J. B. Holt

Mr T. J. M. Bot (Wye Fruit) said that it was important not only to eliminate small fruit and bad quality fruit but also to prevent bruising in the orchard. Apples were liable to damage from the moment of leaving the branch until reaching a static position in the bin and he welcomed the developments described by Mr Holt. The machine he had discussed was particularly suitable for large scale farmers; for smaller scale farming simple conveyor belting into bins would enable a much closer supervision of picking than at present.

In reply Mr Holt said that the picking bucket was somewhat suspect from the damage point of view and had been eliminated from the design of the unit. Another problem was the supervision of pickers when working with bins. In his experience every fruit farmer in this country who had adopted bins had found an extra degree of supervision necessary during their introduction. This extra supervision might of course be necessary for more than one season because fresh pickers were taken on annually. By grouping the workers together, however, into a team of six or eight working on the machine, it was possible to have a forewoman who could to some extent supervise and control by regulating the forward speed of the unit. This in turn would regulate the work of the team and hence, he believed, the amount of damage. Once the fruit had been picked from the tree and put on to the conveyor there should not be any occasion for any damage inflicted by the pickers themselves. There was of course the problem of making sure that the bin filling mechanism and the descenders were satisfactory in this respect but by eliminating the human agency it was probable that the likelihood of damage had been much reduced.

Mr L. C. Pearch (Kent) referred to Mr Holt's statement that the self-loading vehicle could be used for spraying machinery and asked how such machinery could be driven.

Mr Holt said that if the vehicle could pass between the trees at harvest time then it could certainly pass through at any other time of the year. It could load on to itself, by means of its built-in mechanism, various types of machinery unit—even a complete body equivalent to the ordinary trailer body if required. There was no mechanical or engineering problem involved in loading a spraying mechanism on to it. While there was adequate space for a power pack, the mechanism could be driven by means of a p.t.o. shaft from the basic power unit of the vehicle. He should stress, however, that the machine he had discussed was not intended to be a production prototype. This unit had been built primarily to find out about the techniques involved in handling bins in orchards.

Mr Pearch commented that a spraying machine mounted on or drawn by a tractor was a very compact unit capable of turning easily on headlands. He felt it would be dangerous to have to try to turn on the headlands when spraying with the long vehicle described by Mr Holt.

Mr Holt said that his work had been based on existing orchards which did not have curved row ends; he believed these to be desirable. Whilst he would admit that it was sometimes necessary to do a simple reverse turn in order to enter a row end in the case of narrow headlands, reversing and manoeuvring did not normally present a problem with a four wheeled machine. In reply to Mr A. M. Davidson (Ivy House Farm, Kent), he said that the mobile picker had not been utilized on steep banks.

Mr J. R. Galt (Kent Farm Institute) questioned Mr Holt on the percentage increase in picking ability which could be expected from pickers working on the platform of the self-propelled unit.

Mr Holt said that certain problems had been encountered in the experimental use of the unit, the main one being the difficulty of the pickers in changing their level of position of work on the machine. It so happened that in the particular orchard selected for the experiment there was not as much fruit on the top branches of the trees as is normally expected, with a result that the pickers on the top of the platform were not fully occupied when the rate of work was set for the whole group of six or more pickers. Work study investigations, however, had shown that worthwhile improvements in the rate of working should be obtained. A colleague had in fact demonstrated that if an improvement in picking was achieved to the extent of twice the output of work from the normal system the machine would pay for itself in a normal picking season, working with a crop of one variety.

Colonel W. N. Bates (Kent) invited Mr Holt to quote a production price for the equipment and asked whether he envisaged it would be suitable for export.

In reply Mr Holt said that the machine would be of value for any sort of plantation crop. He did not feel it possible to quote an eventual price for the machine at this stage of its development. The machine had to be self-propelled and thus as a prime mover must have an internal combustion engine or a battery-electrical system. Whether or not one could use a battery system depended on the length of the season, in view of the capital cost of the battery. The very low forward speed of the machine involved big reductions, either by means of gears or some form of hydraulic drive. There were numerous ways of approaching these problems and their principal concern to date had been in finding out the potential improvement in removing fruit without damage from the point of picking from the tree to its placement in the handling container.

THE HANDLING, GRADING AND PACKAGING OF FRUIT

by

S. H. BROWN*

Presented at the Spring National Open Meeting of the Institution at Wye College, Kent on 24 March 1966

It is always reassuring when the picked crop arrives under cover from the orchard, for then we feel the results of a season's efforts are safely gathered in. This is too often regarded as the end of the growers' principal worries but we must not lose sight of the jobs that still remain to be done after the crop has been picked and before it is finally marketed. It does not need me to remind you of the extent of the work still remaining to be done or of the cost of this but I will do so if only in order that its significance is fully realized. If we take the dessert apple crop the fact is that up to that point of time namely at which the fruit has been picked and transported from the orchard, only 50% of the total costs of growing and selling the crop will have been incurred. That is to say that from the time the gathered fruit arrives at the packhouse door the cost of its further handling up to and including marketing is equal to the sum already spent on its production and harvesting over the previous twelve months. The growers' worries, matters for serious consideration in regard to capitalization, equipment, and management thus do not end at the stage where the crop has been picked—they are in one sense only just beginning.

Let us look at the facts. Dessert Apple Costings compiled and issued by Hunt and Porter in January 1966 show that at a yield of 400 bushels per acre the cost up to and including picking, i.e. the cost in the orchard, is around 9s 0d per bushel and thereafter, storage, grading, packing and marketing, cost a further 9s 6d per bushel. Thus cost in the orchard is about 47% of the total cost and the remaining cost amounts to about 53%.

How does this fit in with the overall economic position of dessert apple growing in this country? To answer this it is necessary to review the likely position of the industry in the next decade. There can be no doubt that dessert apple production in this country will become subject to an increase in competition from overseas and particularly from European countries where extensive plantings are being undertaken. This competition will arise in two particular respects—quality and price. I do not propose, at this moment, to go into the quality aspect though I shall return to it later, but instead to concentrate on the price factor. Whilst we can anticipate an increased demand by the affluent societies of Europe and this may help to maintain price structure we cannot lose sight of the fact that in a competitive world the price at which one's competitors can sell is the dominating factor. For us to remain competitive therefore our primary need, in addition to quality will be to decrease the cost per unit to a level no greater than that of our competitors.

Assuming that by improved production and harvesting methods the orchard cost per unit of produce is reduced there remains that other 50 per cent of the total costs, i.e. after-picking costs to contend with. Unless this also can be reduced it is unlikely that reduced orchards costs alone will suffice to bring the price of the product to a competitive level. This means that it is essential that we pay a great deal of attention to store and packhouse costs and calls for much thought and action by both management and engineer.

As neither orchard nor packhouse can be considered in isolation this is an appropriate moment for me to return to the orchard and also to the matter of quality. Efficient and economic operation of the store and packhouse is greatly dependent on the quality and condition of the article received from the orchard. All stages in the chain of operations in store and packhouse are influenced by the quality of the article being handled. Low quality, for whatever reason, will hinder and reduce throughput and so increase cost. It is not inappropriate therefore for me to discuss this in broad terms. Obviously there are many factors which affect the type and quality of fruit produced. I refer to such things as site, soil, rootstock, variety, and so on, and also management matters such as manuring, soil management, pruning, thinning, and not least pest and disease control. Suffice to say that all these have a bearing on the type of fruit arriving at the packhouse. Assuming a suitable type of fruit is produced there still remain its picking and handling which call for good organization and supervision. The stage at which to pick needs to be determined with the greatest care and judgement. Fruits increase in size and weight considerably in the few weeks prior to picking and so ideally should be left until the optimum condition is reached. If picked too early they may shrivel in store and be more susceptible to 'scald'. If picked too late they may become over mature, greasy, and subject to breakdown. Over-ripe fruit is also subject to excessive bruising in bins. In practice some compromise is necessary and allowance made for completing picking in the limited time available prior to the break in weather conditions including the onset of Autumn gales. Whilst mechanical aids and every other effort to speed picking are fully justified it must be emphasized that care in picking has a profound effect on its suitability for storage and the amount of work during grading. Marks left by picker's finger nails and even

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slight bruising show up in the store and may be the forerunners of secondary infections whilst in store, and add to the work on the grading lines. Great care in the transfer of fruit from picking container to tray box or bin, to avoid bruising, is most important.

I think we might now have a look at stores and packhouses in greater detail.

1. Storage

For obvious reasons stores should be located as near as possible to the packhouse. They should have a concrete apron forecourt of at least 40 ft × 40 ft if large loads on trailers or lorries are to be loaded and unloaded mechanically using industrial or tractor-mounted fork-lift equipment. The stores themselves can be either within an existing building provided there is room for mechanical handling or can be prefabricated and free standing. They should:

(*a*) be as near a cube in dimensions as possible to secure good air distribution and circulation;

(*b*) have a floor area designed to take bulk-bins or palletized fruit. When calculating floor areas required for bins or pallets an additional inch should be allowed on the length and breadth of each bin or pallet for ease of stacking and removal.

(*c*) if an orthodox cooler is to be installed this should be placed centrally on the back wall and be of the same base dimensions as the bulk bin or pallet to be used.

Alternatively this cooler could be located in the roof thus providing a completely free floor area.

(*d*) have doors at least 9 ft wide to allow for mechanical handling and these should extend to the full height of the store i.e. approximately 15 ft.

They should be positioned in a corner to obviate 'dead spots' in mechanical handling and preferably be of sliding type which does not obstruct the movement of mechanical handling equipment.

The cost of stores at present varies from about 35s 0d to 20s 0d per bushel held. But there is increasing evidence to support the view that recent developments in prefabricated methods could reduce such costs.

2. The Packhouse

Basically the packhouse should be sub-divided into three sections namely, reception, grading and packing, and despatch.

(*a*) *Reception* should be large enough to accommodate at least one day's through-put and this is particularly important when the fruit to be handled is ex-store. It should also accommodate tipping or dumping equipment and the emptied orchard containers, and also cull elimination.

Additionally areas are needed for storage and assembly of market containers and other ancillary needs.

(*b*) *Grading and packaging* section should be large enough to accommodate quality grading and sizing equipment and packaging space *only*. This is important because this area which requires heating for the operators should, for heat economy reasons, be kept to a minimum. The heating system should be capable of maintaining a temperature of 60°F in this grading and packing area and if a ducted system is used the heat can be directed to operator positions without overheating the fruit.

(*c*) *Despatch* area should, like the reception area be large enough to accommodate the daily through-put in palletized or similar form, including access to various consignments and/or grade stacks.

When planning the packhouse the first consideration must be the type of orchard container to be used and the type of market pack to be produced. These two items considerably affect its size and layout.

The next stage to consider is the flow pattern of the handling, quality grading, and sizing equipment. In this connection it should be borne in mind that in future packhouses it may be necessary to grade and pack to higher grade standards and provision may therefore need to be made for the smaller fruit to pass to processing plant e.g. peelers and corers, etc. in an adjacent area.

Finally, having determined the reception and despatch area needs and designed the flow pattern through the packhouse, the type and size of building required can then be considered. By considering things in this sequence the difficulties resulting from erecting the building first and then trying to fit in the equipment will be eliminated. This point cannot be over-stressed and the rule should be to plan flow pattern and lay-out first and then the building to cover it. Care should also be exercised to construct only the simplest type of building which is necessary to meet the needs. Elaborate buildings are unnecessary and unwise capital investment. As a guide to floor area requirements in a packhouse Devine of the N.I.A.E.[1] has shown these for throughputs ranging from 250 bushels per day to 2,000 bushels per day sub-divided into machinery area, pre-despatch holding area and total area per bushel of fruit.

We can now pass on to consider the handling of fruit from orchard or store containers, the quality grading and sizing flow line and equipment, the packaging of the graded product including packages, and the despatch to market.

3. Handling from containers

There are four methods of transferring fruit from the containers to the grading and sizing line:

(*a*) placing direct on the line;

(*b*) tipping, either manually or by box tipper;

(*c*) dry dumping either by tilting or complete inversion of container;

(*d*) by water flotation.

None of these methods is perfect by any means and each has its own drawbacks. Thus:

(*a*) *placing* means all fruits have to be handled individu-

ally though for soft varieties this method will reduce bruising;

(*b*) *tipping* involves physical effort and possibility of too much bruising;

(*c*) *dry dumping* by tilting can cause bruising, particularly of the first fruits. A negative tilt of 5° may overcome this problem. With complete inversion the equipment is expensive—in the region of £1,000—since hydraulic systems are involved if bruising is to be avoided;

(*d*) *water flotation* will cost about £1,000; there is a risk of freezing up during severe weather; for pears a brine solution is necessary; and lastly the fruit has to be dried following the use of this method.

Since, unless the elimination of culls is done before the fruit reaches the grading and sizing stages much time is wasted and throughput reduced, it is appropriate here to say that this, if not eliminated at the orchard, should be done *before* the fruit reaches the main flow line. The cull-eliminator and the polisher or drier/polisher should therefore be located between the reception area and the grading room.

4. Quality grading and sizing

With the introduction of compulsory grading more attention will have to be paid to quality inspection and grading before the fruit passes to the sizing mechanism. This will result in a higher standard of fruit being packed and should increase the rate of packaging since workers carrying it out will be relieved of secondary inspection at this point.

When considering methods of feeding the sizing line this is a factor again to take into account alongside the present known quality-inspection output performance of the various feeding methods.

To increase efficiency in quality inspection it is often better if the conveyor of a float-roll table is divided into lanes, each operator being responsible for one lane only.

We now come to the sizer and the decision must be made as to whether a single or double sided sizer should be installed. With a double sided sizer fruit can flow to bins on either side of the machine whereas in the single sided machine it is supplied in one side only. The type of sizer to install will depend on the number of grades required, the volume of throughput required daily, and the rate at which packers can receive and deal with sized fruit. The latter in turn is related to the rate at which empty packages are conveyed to the packer and full ones are removed and to the method of packing used.

5. Packages and Packing

At the present time there are many—too many—sizes and types of package in use of both wood and cardboard construction. With the growing tendency of individual packhouses to merge for the purpose of marketing, standardization of type, which is long overdue, may be encouraged.

There are four principal methods of container filling in use at the present time and these range in potential output from 8-38 bushels per hour where skilled operators are employed. Studies by Devine of the N.I.A.E.[1] have shown that output per operator hour for the various methods is as follows:

(*a*) hand wrapping and cell packing — 8 bu/h
(*b*) hand layering —15 bu/h
(*c*) jumble pack —18 bu/h
(*d*) semi-automatic filling —38 bu/h

There will undoubtedly be further developments of many kinds including mechanical filling. The Italians already have this for filling trays direct off the sizer. Removal and transfer of filled packages from the packer can be done by gravity or powered conveyor or on pallets to the point needed. If to be weighed this will be to the weighing position which should be alongside the stacking and despatch area.

6. Despatch

I need add little to what I have already said concerning this. The area allocated must be sufficient to accommodate the daily throughput in palletized or other form.

FUTURE NEEDS

1. Can I, at the risk of repetition, reiterate the basic need? This is to recognize that to remain competitive the fruit industry must reduce its costs per unit and positively and energetically do the things necessary to achieve this. Apart from doing so in the orchard we must also achieve this in the packhouse where 50 per cent of our total costs still occur.
2. The first of our needs is a still better article from the orchard both in size and quality and also condition after handling. Without this the chances of reducing costs of store and packhouses are limited. I, like many others, think that most progress towards this need is likely to be obtained by a change in the type of tree and plantation lay-out and the consequential changes and improvements in such operations as pruning, spraying, picking and handling that this could provide. I believe that a change from 'extensive' to 'intensive' type of plantation, with its smaller tree, suitably trained, should provide higher yields and fruit more uniform in size, colour, and 'finish'. It should also make for easier and more efficient pest and disease control, easier pruning, and most important of all simplifying the picking. Handling and transportation within and from this type of plantation will need particular consideration by our engineers. In all there is reason to feel confident that the product from this type of plantation should be a far more suitable one to receive and handle in the store and packhouse and will go some way towards reducing the packhouse costs.

MATERIAL HANDLING

3. There are, I think, two basic factors which govern the handling of the fruit from the tree onwards. The

first is that the handling into and out of stores and thence through the packhouse will depend upon the long term policy in regard to the type of plantation and market package envisaged. These two things will materially influence the degree of mechanization employed and lay-out. The second is the capitalization aspect. Full mechanization of handling methods is justifiable only on holdings where the tonnage exceeds 200 tons per annum, though partial mechanization such as pallets is worthwhile at less than this output. Determination of the level of mechanization justified is not the simplest of exercises but is very important. On the one hand it is essential to recognize and determine with accuracy all that is involved in material handling in the chain of operations concerned, and on the other hand to decide upon the worthwhileness and economic justification of the capitalization envisaged. Take the first of these. A recent survey of material handling on a fruit farm producing 600 tons of apples per annum without mechanical equipment showed that haulage to and distribution of empties in the orchard, collection after picking (which was excluded from the figure I shall mention in a moment because it was a piecework job), loading into stores, extraction from stores, and moving to head of grader involved a total handling of 7,500 tons of boxes and fruit. This figure I suggest gives some idea of the man-hours, effort, and cost involved unless mechanization is used. Similar surveys have also shown the net output inclusive of all personnel working in the packhouse amounts to only 2½-3 bushels per operator hour. Additionally it is fair to say the handling by such laborious manual methods much increases the damage risk to the product. Secondly, it must be realized that capital investment must be studied and determined with equal care. Not only must it be shown that the proposal has an economic justification in the widest sense but also that it has so over a shorter investment period than has tended to be allocated in the past. I say this because in these days of rapid technical and mechanical progress change falls due more rapidly and at more frequent intervals than hitherto and unless the industry makes change when it is due it will very quickly lose ground. When budgeting equipment should be written off over no longer a period than 5 years and buildings over 10 years, the whole investment should be considered rather than individual items as rarely will new requirements fit with old when changes are made.

ORCHARD AND STORE CONTAINERS

4. Whilst progress has been made with the bulk bin further development of this is needed. In particular a better ventilated bin appears necessary. It is doubtful if we can accept present emptying methods as ideal. Tipping methods subject the fruit to rather too much bruising and in the case of water flotation adds the further operation of drying.

LABOUR IN THE PACKHOUSE

5. On what in particular is the major cost incurred? The answer is labour.
   Labour spent on:
   (*a*) removal of cull and sub-standard fruit which should never come into the packhouse;
   (*b*) quality grading and
   (*c*) container filling by hand.

   These are the present labour consumers on which attention and action should be focused. And what is the answer to these problems? Further mechanization without doubt though one must warn against mechanization at any price otherwise cost reduction will not be achieved. Engineers please note this.

   (*i*) *Removal of culls and sub-standard fruit.* Whether or not the crop is ultimately harvested mechanically, this must be done in the orchard. We cannot afford to continue transporting culls through store and packhouse to then spend still more labour hours separating them out to throw away. As I have said this should be done in the orchard and ultimately we hope in conjunction with mechanical harvesting. Much better equipment for processing small fruits is required.

   (*ii*) *Quality grading.* If fruit being fed into the grading line has had culls and sub-standard fruit removed the job of quality grading will have been reduced considerably and many unproductive hours avoided. But is this enough? We still need the remainder of quality grading (and this is colour grading) done mechanically. The photo-cell to distinguish and differentiate between degrees of fruit colouring as being explored in the U.S.A. is a possibility in this respect. Compulsory grading may necessitate an increased number of grading lines compared with the present, and this could mean that the size of the grading room may also need to be increased by as much as 33%.

   (*iii*) *Container filling.* I note Mr Hiller[2] says that at present this takes 50 per cent of all labour hours used on grading and packing and he is about right. We must get away from hand filling. Mechanical filling direct off the sizer such as we understand the Italians already have in operation is a *must*. I hope our engineers will get down to this urgent need.

6. I would like to come back to sizing for a moment. Though present methods are moderately satisfactory for dessert apples this is not true for such things as Conference pears. Secondly when we come to mechanical filling for the containers sizing will need to be much more accurate than at the present time. In general therefore sizing equipment needs further development and improvement.

PACKAGING AND CONTAINERS

7. The problem we are faced with is that on the one

hand the need is for as light and cheap a package as possible whilst on the other hand it needs to be of sufficient strength and substance to withstand the rigours of bulk handling and transportation. To an extent these two requirements are incompatible. Having in mind that when despatched to market the container must afford the maximum protection and be capable of bulk handling, but thereafter each unit need only comply with the need to hold the product and afford reasonable protection, I believe a fresh approach to the problem is needed. I suggest that we need to turn our consideration to what might be termed a *master market container* i.e. a collapsible bin type pallet into which individual packages of minimal strength and cost are packed and transported to the point of sale. This collapsible pallet would be returnable and would be 40 ft × 48 ft which size is acceptable for both rail and road transport.

It is likely that the present trend from wooden containers to 20 or 30 lb cardboard containers will continue. One of the disadvantages of the cardboard at the moment is that if made up too long before use it can absorb moisture and become soft. Development of containers for smaller units, i.e. 3, 5 or 7 lb packs may also be needed.

What we do not know with certainty is whether or not pre-packing will need to be extended. I personally believe that the desire to reduce or eliminate handling and weighing out at the point of retail will increase the demand for more pre-packed fruit. If this does prove to be the case it is a matter which cannot be ignored by the producer. Whether the need will be 20 or 30 lb containers or smaller pre-packs or both there is considerable scope for research and development into containers, their mechanical filling, and also master market containers.

I suggest there is also a need for research and development into suitable transporting vehicles from packhouse to market.

8. This leads me on to Time and Method Studies. Whilst valuable work has been done in this field particularly by Devine of N.I.A.E.[1] much more is needed and greater use made of such tools of management.

SUMMARY

1. I have pointed to the need to realize that the fruit industry will face increased competition and to meet this quality must be improved and cost per unit reduced.
2. I have emphasized that approximately 50 per cent of the total costs are incurred after harvesting i.e. in store and packhouse, and unless this is reduced the overall required reduction in cost per unit is unlikely to be achieved.
3. I have made the further point that a pre-requisite to economic operation in the packhouse is a much higher standard of fruit from the orchard. I have also briefly explained how I feel various changes in the orchard could help to achieve this.
4. I have drawn attention to present weaknesses associated with grading, packing, and containers and have suggested changes.
5. All these and other issues I have raised point to the need for increased mechanization. I hope our engineering friends will have noted the developments we need and which call for their immediate attention. But equally I hope that they have also noted that the economics of the fruit industry are critical, that whatever we do must *reduce* costs, not increase them, and therefore further mechanization must achieve this.
6. I feel I must mention that as an industry horticulture including fruit growing too often suffers from the engineer's doubt of the worthwhileness to him as a manufacturer. That is to say the engineer too often concludes that the sale potential of a piece of machinery in an industry like horticulture is too small to justify its development and marketing. I would suggest that apart from the likely home sales the engineer should additionally consider the possibility of export. As a nation we exist through the export of industrial goods and having in mind the extent fruit production is developing in Europe and indeed elsewhere I cannot believe that machinery for its production, grading, packing etc. cannot be exported and so increase the worthwhileness to the manufacturer.
7. Finally, I must point out that we cannot escape further mechanization in both orchard and packhouse and this therefore takes us into the field of further capital investment. This must be considered with very great care and judgement based on *fact*. How adequate and accurate are our facts? Is the data on yields inputs, including individual costs, outputs, returns, etc. adequate, from which a fully reliable assessment and budgeting can be made to determine what would be sound capital investment? I will leave the subject with this last parting observation—the fruit industry from now onwards will be operating in a highly competitive market demanding the highest level of business management, capital investment and efficiency.

REFERENCES

1. DEVINE, E. S. 'An investigation into productivity of Apple Packhouses'. *Journal of Agricultural Engineering Research.* Vol. 6 No. 4 1961.
2. HILLER, R. 'The Development of Specialized Machinery for Apple and Pear Production and Packing in U.K.' *Jnl. I. Agr. E.*, Vol. 22, No. 2.

General Discussion following all four papers presented at the Spring National Open Meeting on 24 March 1966

MR J. N. HUNT (Sussex Grower) said that the master market container was in very extensive use in the United States, particularly in the grocery trade; at central warehouses a variety of packages of different shapes were assembled in a collapsible pallet, which was loaded and unloaded by fork lift. He had believed that this system could be applied to the fruit growing business in this country and he had, in fact, obtained a sample of a pallet three years ago size 40 × 48 in. Unfortunately he could not get any container to fit it. A further problem lay in transport organization for the smaller grower. It was by no means certain that the containers would be returned to the grower intact.

MR HILLER agreed that this was a problem which would probably be solved only when markets were equipped with fork lift trucks.

MR ROACH commented that a promising development in the United States was that the unit of selling to the customer was frequently a 10 lb carton into which the picker in the orchard picked the fruit without further grading: this carton was then put into the master container. He believed that this system had many advantages from the point of view of hygiene but could only be practicable in the foreseeable future where there was a closed cycle of handling and transport. This would be possible in the case of marketing to a group of chain stores, a system which would enable the produce to go direct to a distribution centre operated by the customers.

MR BROWN said that it was inevitable that a large amount of money would be spent on containers the only function of which was to transport the produce from point to point. For this system to be fully effective it was necessary for fork-lifts to be installed in the markets which handled the containers. Admittedly this was not the case at present but it would be wrong to assume that fork-lifts would not be installed in the markets, rather that the markets would modernize themselves. He agreed with Mr Roach that an increasing proportion of sales was likely to be through chain stores.

MR A. T. GILLING (Massey-Ferguson Ltd) referred to a recent television programme on farming and horticulture in which it was reported that the Government would contribute £25 million to modifying the markets. Sheffield and Cardiff already possessed modern markets with access for bulk handling and he believed that growers should promote the use of bulk containers. In this way the growers could benefit from the governmental development of the market.

MR PEARCH asked whether there was any likelihood of reverting to the National Mark and the use of non-returnable wooden cases and boxes by the growers; he believed that this was the most prosperous period that fruit growers in this country had ever enjoyed.

Mr Roach said that in the period 1934/39 he had been concerned personally with instructing packers on packing to the standard of the National Mark. In those days there had been a limited number of first class growers who had the monopoly of the market for their high quality fruit. He did not believe it was possible for the National Mark system to be restored as a universal standard grading could not offer a premium to growers producing particularly outstanding fruit.

MR MORRIS (Kent Farm Institute) said that most of the speakers had suggested that a close planted hedge would be the most useful type of plantation for the future. Bearing in mind the question of maximum crop, optimum size and quality, and ease of picking—possibly with the picking machine designed by Mr Holt—what were suitable dimensions for this type of hedge? He would like information on the appropriate width between rows, height of the hedge or (assuming the plantation was not of complete hedges) the height and width of the trees. A standard layout of orchards in the United Kingdom would enable growers to perfect growing techniques and machinery manufacturers to standardize machinery.

Mr Hiller considered that he had found the following dimensions for a plantation most suitable under his local conditions: a plantation of M 26 stock with 24 ft between the rows and 12 ft between the trees. This resulted in a hedge-row that was not too high and gave a useful planting distance. He found it difficult to make a definite recommendation, however, owing to the number of variables involved.

Mr Roach said that no fruit growing nation in the world had discovered the best solution. The Russians and Americans had experimented with various dimensions but no satisfactory answer had been discovered. Some growers now favoured very intensive planting but he felt that this would eventually lead to serious difficulties. He would agree with Mr Hiller that under U.K. conditions, particularly with regard to light, the hedge-row should not be too high. He preferred the bush type of plant, a rectangular type of tree—M 29 or M 26—or possibly a spindle bush on the Dutch pattern with a stake. A major essential was that light could penetrate, and therefore a bush type of plant was more suitable for the United Kingdom than the solid hedge which had been adopted in countries with higher light intensity and better illumination. Mr Holt, invited to comment from the point of view of picking and transporting fruit, recommended that the reach from the edge of the hedge to the centre of the tree must be approximately 2 ft 6 in. for pickers standing on platforms. This gave a hedge thickness of about 5 ft. From the point of view of the handling equipment and mobility of the platform, a clear gap down the centre of approximately 6 ft and 7 ft, as he had said in his Paper, would be ideal; this gave a row spacing of 11 ft or 12 ft. From the engineering point of view the height of the tree was not significant in the case of picking from platforms, and a 12 ft high tree was as easy to pick from as an 8 ft, and the consideration of light penetration should be the arbiter in that respect.

Mr Brown said that while it was important to consider the density relative to maximum production it was certainly necessary to have regard to our climatic conditions. The necessary quality, particularly in view of

the competitive market could not be obtained if trees were too densely planted.

MR I. J. BALLS (Kent Engineering & Foundry Ltd) made a plea for increased research and comparative investigation into the equipment currently manufactured in the United Kingdom. The majority of fruit equipment manufacturers were represented at the Meeting, and he felt they would agree that it would be uneconomical for an individual company to spend a large amount of money on research, which was inevitably expensive. Neither were there sufficient experimental farmers to handle research and investigation. He feared that the present situation might result in a necessity to import into the United Kingdom fruit handling equipment.

Mr Roach said that this problem existed also in the United States in spite of the apparently large financial resources available for research. It was said that many of the American manufacturers were not sufficiently interested in the market to invest in research and development. For this reason the agricultural engineering research division of the United States Department of Agriculture had undertaken a great deal of experimental work in conjunction with state colleges. He understood that recently some of the state apple commissions, which collected a levy for publicity purposes in the sale of fruit, had been approached with a view to their providing a grant towards machinery investigation and development. A number of developments were at the moment the work of individual growers but the bulk of the work had in fact been done by the United States Department of Agriculture

MR J. H. W. WILDER (President I Agr E) drew the meeting's attention to the research undertaken by the National Institute of Agricultural Engineering as exemplified by Mr Holt's contribution. He expected that many of the audience would be aware of the developments in this sprayer field achieved by the NIAE over a period of years.

Another questioner said he would welcome the views of the speakers and growers in the audience on the basic power unit currently available. He was speaking as an arable farmer who had been involved with a considerable acreage of top fruit. He had a good supply of what he would call 'toy tractors' for light hauls, but a large tall tractor had to be used in cases where a powerful unit was necessary for spraying, grass cutting, chopping, pruning and sub-soiling. In this case safety became a problem. What was the likelihood of a squat powerful unit for the future? A further speaker suggested that the answer to the problem was the 30 hp tractor recently imported to this country which had an overall width of 37 in. and which was only 44 in. high; it was powerful enough to deal with all spraying equipment likely to be used in modern plantations.

Mr Holt said that he had questioned in his Paper whether the basic tool for the fruit grower should be the tractor. He felt that the questioner was in rather a special position as an arable farmer with other uses for tractors. He believed that farmers who were purely fruit growers needed a tool rather different from the current tractor. Sub-soiling, which was an exception to his statement, could be done on contract but apart from that sort of work the operations which took place in the orchard did not in fact require traction.

Mr Hiller expressed keen interest in Mr Holt's power unit. He had in fact been reasonably content with the use of tractors in fruit growing until about 12 months ago when American developers began to have their influence on what had been good workable units from the fruit growers' point of view. He now believed that the power unit favoured by Mr Holt had certain advantages which should be investigated very closely. Mr Roach agreed with this viewpoint and expressed satisfaction with the adaptability of the unit.

Mr L. Pearch said that it was important not to overlook the necessity to produce Bramleys in this country: no Bramleys were imported. He believed that an item of equipment which stood in need of improvement was the mower. He felt it should now be possible to produce a mower which was more satisfactory both mechanically and economically, possibly resembling the flail type of machine.

MR HOWARD JONES (Fruit grower) stated that he had been drying apples for several years and three years ago had started to use an installation designed by the National Institute of Agricultural Engineering. The installation had proved very satisfactory in use and cost approximately half the figure quoted by Mr Brown. Drying was achieved on a cellulose covered belt and while the principle was very sound he believed there was scope for improvement. There was no hydraulic equipment except for a small rotary pump. There was provision for removing wastage from the apples and soaking with water very thoroughly. The installation had many advantages one of which was that it permitted a very accurate control over the flow of the apples to the grader. The installation was excellent and worthy of wider adoption although drying was still a problem.

Mr Roach said that he had discussed the problem of drying recently with Professor Dewey of Michigan who was currently working on driers and flotation methods. Professor Dewey had told him the growers in the States who were not using the flotation method were sprinkling their apples with water because the wet appearance improved their marketability.

In reply to a questioner, Mr Brown said that compulsory grading would not in fact increase grading cost by 33⅓% as the questioner supposed but would increase the packhouse grading area by this percentage.

MR J. L. CARPENTER (Essex Institute of Agriculture) invited the comments of the speakers on circular packaging. He himself believed spherical packaging to have many advantages: this type of packaging was very strong, it rolled easily and therefore would almost stack itself, and was easily controllable. In a conical store, for example, it would almost store itself properly. A member of the audience commented that a round pack was virtually impossible to manufacture on standard equipment and that a comparatively large amount of space was required between round packages when they were stacked. He considered the square pack to be by far the cheapest and the most satisfactory method.

Mr Holt said that he would like to draw the meeting's attention to the very interesting shaped containers which were tried out experimentally at the Cornell University. The containers were multi-sided with flat sides (perhaps five or six) and were stacked in groups with other containers which again were multi-sided and were made of plastic.

Another questioner invited the speakers' comments on possible future developments in storage buildings, mechanization of gas readings and automatic temperature recordings.

Mr Roach said that this was a complete subject in itself but in a necessarily brief comment he would forecast big advances in controlled atmosphere storage, possibly along the American lines of artificially introducing the required atmosphere so that the storage could be treated just like an ordinary cold store and normal ingress and egress were possible. Mr Hiller believed that an artificially-controlled atmosphere was probably most useful where an existing storage building was not readily adaptable to complete gas proofing. The system was not particularly efficient however in the case of buildings that were normally built for storage purposes today.

Correction

On page 24 of the Spring 1966 issue of the *Journal* (Volume 22 No. 1), a reference to a Paper by P. H. Southwell should have read 'An Investigation of Traction and Traction Aids' *A.S.A.E.* Trans. Vol. 7. No. 2. 1964.

ELECTIONS AND TRANSFERS

Approved by Council at its meeting on 5 April 1966

ELECTIONS

Member	Coales, J. F.	.. ..	Cambs
	Keer, M. C.	.. ..	Warwicks
	Moss C. J.	.. ..	Beds
Associate Member	Adams, J.	.. ..	Herts
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Abbreviations and Symbols used in the Journal

a	year
A or amp	ampere
ac	acre
a.c.	alternating current
atm	atmosphere
b.h.p.	brake horse-power
bu	bushel
Btu	British Thermal Unit
cal	calorie
c.g.	centre of gravity
C.G.S.	centimetre gramme second
cm	centimetre
c/s	cycles per second
cwt	hundredweight
d	day
dB	decibel
D.B.	drawbar
d.c.	direct current
°C, °F, °R	degree Celsius, Fahrenheit, Rankine
deg	degree (temperature interval)
dia	diameter
doz	dozen
e.m.f.	electromotive force
ft	foot
ft^2	square foot (similarly for centimetre etc.)
ft lb	foot-pound
G.	gauge
g	gramme
gal	gallon
gr	grain
h	hour
ha	hectare
Hg	mercury (pressure)
hp	horse-power
h	hour
in.	inch
in^2	square inch
i.d.	inside diameter
kWh	kilowatt hour
l	litre
lb	pound
lm	lumen
m	metre
max.	maximum (adjective)
m.c.	moisture content
m.e.p.	mean effective pressure
mile/h	miles per hour
mill.	million
min	minute
min.	minimum (adjective)
o.d.	outside diameter
o.h.v.	overhead valve
oz	ounce
Ω	ohm
pt	pint
p.t.o.	power take-off
qt	quart
r	röntgen
r.h.	relative humidity
rev	revolutions
s	second
s.v.	side valve
S.W.G.	standard wire gauge
t	ton
V	volt
v.m.d.	volume mean diameter
W	watt
W.G.	water gauge
wt	weight
yd	yard
>	greater than
≯	not greater than
<	less than
≮	not less than
∝	proportional to
~	of the order of
° ′ ″	degree, minute, second (of angles)

The above abbreviations and symbols are based mainly on B.S. 1991 (Part 1), 1954

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