COST OF PACKING APPLES IN BUSHEL UNITS AS AFFECTED BY TYPES OF EQUIPMENT AND SCALE OF OPERATION

by

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COST OF PACKING APPLES IN BUSHEL UNITS AS AFFECTED BY TYPES OF EQUIPMENT AND SCALE OF OPERATION

INTRODUCTION

Problem

The apple industry is a 15 to 20 million dollar source of cash income to Virginia farmers, and it is of comparable importance in neighboring states. Virginia is the third ranking state in the production of apples, producing nine per cent of the total national crop.1/ The trend in apple production has been downward in Virginia for the past several years. This downward trend has been accompanied by increased competition from other apple producing areas and from other fruits, by higher capital requirements for equipment, and by higher labor costs.

Much research on cultural and spraying practices has enabled apple growers to increase their efficiency in apple production. However, after apples have been produced they must be prepared for market. Very little research work has been done on problems connected with efficiency in operation of packing houses, yet the cost of packing apples (including packing material) is approximately the same as the cost of producing them.

Apple production is reported in nearly 50 per cent of the counties of Virginia. However, the main commercial producing counties are in

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1/ C. N. Smith, Some Recent Trends in the Appalachian Apple Industry, Virginia Agricultural Experiment Station, Bulletin 462, June 1953, page 7.

the western part of the State extending from Southwest Virginia to Northern Virginia[1]. Figure 1. This area is divided into five districts (Northern, Western, Central, Southwestern, and Southern) by the Virginia Cooperative Crop Reporting Service, as shown in Table 1. The main area of apple production is in the Northern District where roughly 50 to 60 per cent of the State's production is produced.

Many varieties of apples are produced in the State by both large and small orchardists. Most of the apples grown in the State are packed in sheds located on or near the farms on which they are grown and, if stored, they are usually placed in commercial cold storages in nearby towns.

There are approximately 235 packing houses in the State. The facilities for packing apples in these plants vary in capacities from 5,000 bushels to 250,000 bushels of packed fruit annually. Only a small percentage of these plants are equipped to handle a volume of fruit exceeding 50,000 bushels annually. Most of the plants were constructed and equipped many years ago when the cost of labor was low in relation to equipment and building cost. In fact, many of the packing houses were built for other uses and were not properly designed for efficient layout of equipment or use of labor. Several of the commercial apple producers have enlarged their orchards from year to year, which has required expansion of packing plant facilities.

1/ Estimated Apple Production in Commercial Counties, Virginia Cooperative Crop Reporting Service, Richmond, Virginia, July 1955.

Table 1. Estimated Apple Production in Commercial Counties, 1951-1952-1953-1954.

COUNTY	1951	1952	1953	1954
		Thousands of Bushels		
NORTHERN DISTRICT				
Clarke	800	850	710	1,260
Fauquier	150	145	40	210
Frederick	1,550	1,670	1,270	2,830
Loudoun	160	145	130	180
Madison	140	105	80	130
Rappahannock	700	560	380	950
Rockingham	580	670	370	800
Shenandoah	520	620	430	860
Warren	170	152	80	280
District Total	4,770	4,917	3,490	7,500
WESTERN DISTRICT				
Augusta	750	690	430	950
Botetourt	350	430	160	450
Roanoke	340	320	160	350
District Total	1,440	1,440	750	1,750
CENTRAL DISTRICT				
Albemarle	690	655	520	700
Amherst	130	160	110	230
Bedford	170	220	150	240
Nelson	600	655	300	680
District Total	1,590	1,690	1,080	1,850
SOUTHWESTERN DISTRICT				
Carroll	300	250	190	320
Giles	100	60	40	120
Smyth	250	190	195	160
Wise	200	250	190	320
Wythe	190	145	85	80
District Total	1,040	895	700	1,000
SOUTHERN DISTRICT				
Franklin	340	300	157	370
Patrick	380	335	240	430
District Total	720	635	397	800
STATE TOTAL	9,560	9,577	6,417	12,900

Source: Virginia Cooperative Crop Reporting Service, Richmond, Virginia, July 1955.

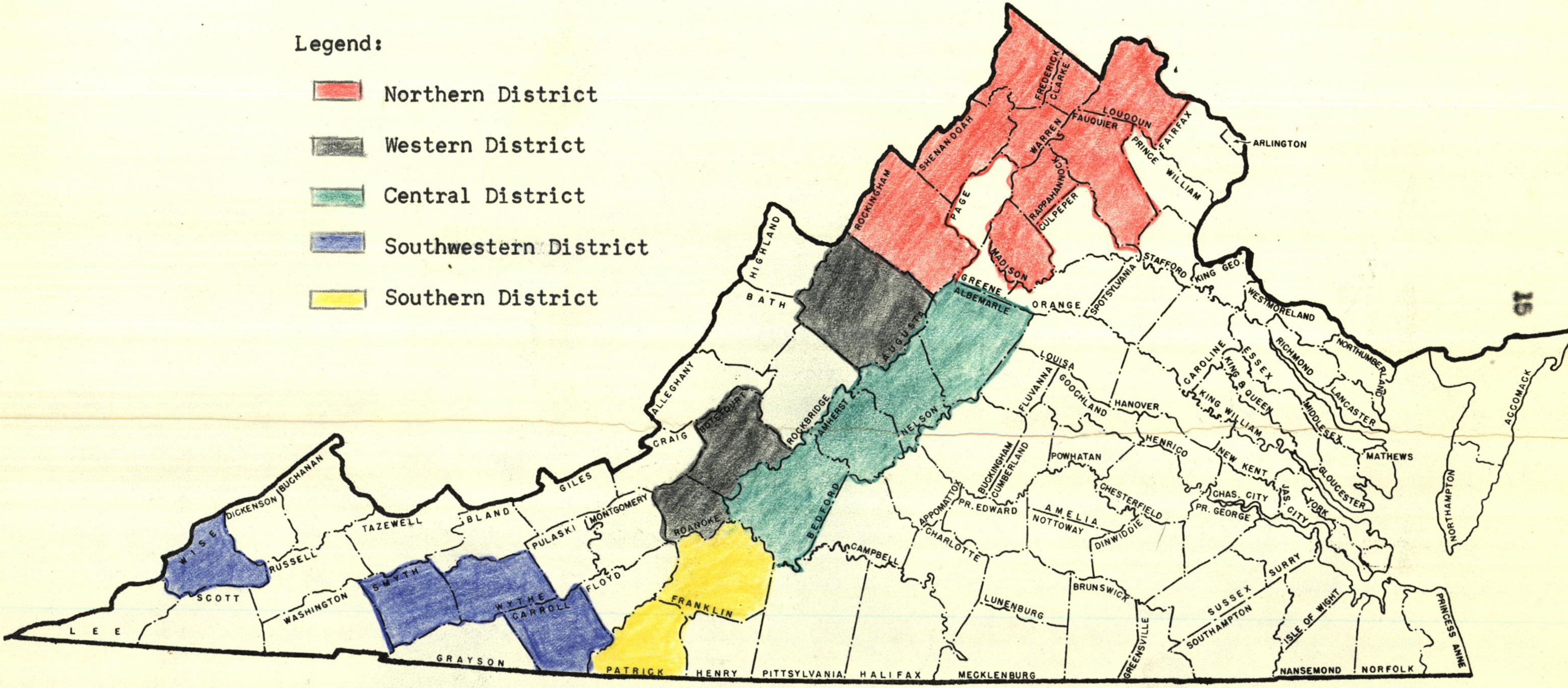

Figure 1. Commercial Apple Producing Districts of Virginia by Counties

However, most of these growers have expanded by adding new pieces of equipment to their old plants, which may or may not have achieved the least cost combination for efficient packing house operations. Since most of the innovations have been in the nature of expediencies, a large percentage of the packing house operations involved in packing apples are performed in ill-designed buildings with obsolete equipment and at a relatively high cost.

A number of orchardists in Virginia and other eastern states do not produce individually a large enough quantity of apples to attract many buyers of fruit. For instance, with the rapid expansion of chain organizations in the retail food trade, buying of fruit for these stores has become concentrated in the hands of a few buyers. In order for these buyers to perform their jobs efficiently, they seek sources of supplies in sufficient volume of specified quality, variety, and type of pack to meet their requirements. Only a few of the larger producers are able to meet these demands; consequently, several of the smaller producers are finding it difficult to market their fruit at a profitable price.

Some apple producers have organized cooperatives to meet these conditions, and other apple producers sell their fruit to commercial packers who pack the fruit and market it in larger volumes than the small independent apple producer is able to do. Other apple growers are planning similar organizations for packing and marketing their fruit. A knowledge of the effect of size of operation and work methods on the cost of packing and handling apples is needed by these growers and plant operators so that they can plan their operations more effectively.

It is recognized that in most industries there are certain economies, or cost savings, available through expansion of scale of operation up to a certain point. These include economies gained from greater labor specialization, greater specialization of capital equipment and increased size of mechanical devices, from large-scale distribution, and so forth. As a firm becomes larger, it can reduce its average cost by taking advantage of these techniques.1/ Since the apple packing industry is not essentially different from any other business, one might hypothesize that there are certain economies to be gained with increase in size of business up to a certain point.

The apple producer is also confronted with handling a semi-perishable commodity which must be harvested with a minimum of delay--usually six to eight weeks; otherwise, the storage life and quality of the apples may be affected adversely. During this period, the apples are subject to all kinds of weather conditions in the orchard and must be harvested at the proper stage of maturity. Hence, it is necessary to have proper equipment and facilities for harvesting the crop with a minimum of delay.

Operating under present economic conditions of rising labor and equipment cost, the apple industry in Virginia is feeling competition more severely than has been the case in the past. In order to meet this competition, apple growers need information on efficient work routines, equipment, and facilities for the packing and handling of apples.

1/ J. A. Bain, Price Theory, Henry Holt and Co., New York, 1948, page 112.

Objectives--Scope and Limitations

The overall objective of this study is twofold: (1) to determine the effect of size of operation, and (2) to determine the effect of different types of equipment and work methods on the cost of packing apples in bushel containers.

In a highly competitive industry such as that of handling apples, a business must be efficiently operated to be successful. The entrepreneur must at all times be ready to take advantage of technological improvements and innovations which will increase his efficiency in the handling and packing of his product. However, before the plant operator can take advantage of new practices, he must have sufficient knowledge of them. It is not the intent of this study to furnish the apple producer with information on all the factors influencing the cost of packing apples. Rather, it will be limited to the phase stated in the title. Other phases of the packing house operation will be studied by other states cooperating in the Northeastern Regional Project on fruit marketing.

The face-and-fill bushel basket and the wrap-and-count Northwestern box were the most common bushel containers used in this area. Therefore, this study makes comparisons of labor requirements and cost of packing apples in various size plants with different types of equipment for these two types of containers. Several plants packed a limited quantity of tray packs (Friday Packs) which were comparable to a bushel unit. However, the labor cost for packing this container was practically the same as that for the wrap-and-count Northwestern box.

It must be emphasized that this study did not attempt to evaluate in economic terms the amount and extent of bruising done to the fruit in the various plants. However, it was recognized that some plants handled the fruit with greater care than did others. Although a comparison of the amount and extent of bruising is desirable, it was impossible to measure these factors in the allotted time and with the personnel available. Therefore, this study was limited to the direct cost of labor, work methods, and equipment for packing apples.

Since this study was conducted in cooperation with other states participating in the Northeastern Regional Project on fruit marketing, it was designed to study plants packing 100,000 bushels of apples or less per season.[1/]

Review of Literature

There is only a limited amount of information on the effect of size of operation and type of equipment on the cost of packing apples. A search of the literature revealed several studies made on various phases of apple production and merchandising of apples, but only one study was found on methods and equipment for handling and packing apples at the packing house. This study was a marketing research project sponsored by the Agricultural Marketing Service of the United States

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1/ One of the plants included in this study packed slightly more than 100,000 bushels during the 1956 packing season; however, this was not usual for this plant.

Department of Agriculture in cooperation with the Washington State Apple Commission. However, the results of the study conducted in Washington State have not been published.

A study by Bere and Cravens[1/] at Ohio State University was the only one found in which an effort was made to determine the effect of size of operation on the cost of packing apples. They concluded from their analysis that labor costs in grading and packing were not related to size of operation. Growers with small volumes had about the same labor costs as the growers with larger volumes. However, the smaller growers tended to have larger machinery investments per harvested bushel, and their operations were not as continuous, with the result that overhead for such items as buildings, managerial expense, etc., were greater than for the larger operations. Their study did not place a monetary value on the cost of packing apples in various size plants, but they concluded that costs per unit of packed fruit were slightly less for the larger operations. More important than size of operation in affecting labor costs were the methods of packing, skill of the packers, and the method of paying the workers (hourly or piece rate).

Gaston and Hurst[2/] in their studies of packing houses found that

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1/ R. L. Bere and M. E. Cravens, "Study Shows Apple Packing Costs Vary," Timely Economic Information for Ohio Farmers, Ohio Agricultural Extension Service, Paper No. 333, Oct. 1955.

2/ H. P. Gaston and W. A. Hurst, Fruit Packing House Plan and Operation, Michigan Agricultural Experiment Station, Spec. Bul. 5362, East Lansing.

the efficiency with which the grading and packing operations were performed depended to a large extent upon the packing house design. Their studies indicated that no two packing houses were exactly the same, but that several fundamental features of design such as floor space, accessibility, number of floors, and storage for empty containers were important. Their studies led to the conclusion that the efficiency of a fruit packing operation depends upon having a packing house of good design, equipment of adequate capacity, and a capable and well-supervised crew.

A study of handling fruit with fork-lift trucks by Levins and Gaston led to the conclusion that, under conditions existing in many Michigan orchards and fruit processing plants, the use of fork-lift trucks materially increases the efficiency with which fruit is handled and such equipment can be operated successfully by the workers commonly employed.1/ It was found that the use of fork-lift trucks saved time, money, and effort, and also maintained quality of the product. Their findings indicated that an investment in such equipment would pay big dividends when handling over 25,000 bushels of fruit per season. However, prices have changed since this study was made.

Definition of Terms

Since different terminology is used between different areas to

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1/ J. H. Levins and H. P. Gaston, Fruit Handling with Fork Lift Truck, Michigan Agricultural Experiment Station, Spec. Bul. 379, East Lansing, Michigan. March 1953 describe the various packing house operations, it is necessary to define certain terms in this thesis for clarity. Some terms such as apple and fruit, plant and packing house, box and container, etc., are used synonymously in this study; however, the terms will be used according to the following definitions.

Bushel unit refers to containers holding 42 to 55 pounds of apples. Weight will vary depending on variety, size, etc., of apples. A standard bushel of apples weighs 48 pounds.

Capacity refers to the potential volume of a machine or worker.

Chute is a slide made of wood or metal and shaped so it guides material from one level to another.

Cider apples are small apples, 2 or 2¼ inches and smaller in size, that are utilized by processing plants for making cider and vinegar.

Cull apples are apples having a limited use for cider and vinegar. This grade is frequently termed "Hog Apples", and they are often fed to livestock.

Table sorts represent apples separated in the grading operation because of lack of sufficient color to meet grade requirements for packed fruit of U. S. No. 1 grades or better. This fruit was usually sold to processors, truckers, or local trade.

Dumping operation includes dumping and removal of apples from the field containers.

Man hour is defined as the amount, or unit, of work performed by a man or woman in one hour--used as a method of measurement of various packing house labor requirements in this study.

Man-minute refers to the amount of work performed by a man or woman in one minute or one sixtieth of a man-hour.

Total labor requirements is the gross labor inputs minus any delays, expressed in man-hours or man-minutes required for the performance of an operation or cycle of operations in the packing house.

Packing house is used in a very general sense to describe the packing shed, house, or building in which the apples are packed. Packing house is uses synonymously with plant and building in this study.

Packed fruit refers to fruit which has been graded, sized and placed firmly in containers for transporting to storage or buyers.

Packing station is used to describe the area and equipment where apples are accumulated and packed in containers (may be packing table, packing bin, rotating tub, or return-flow belt).

Scale of operation refers to the size of the business.

Volume refers to the actual output of the plant, or quantity of fruit handled in bushels.

Methodology and Source of Data

A group of packing houses were selected from the Virginia State Horticultural Society list of packing plants operating in Virginia. These plants were selected on the basis of size and type of equipment. Prior to making any observation in these plants, they were visited to determine their desirability and the willingness of the plant operators to cooperate in this study. From this group, 20 packing sheds were selected for study. However, because of adverse weather conditions during the packing season, usable data were collected in only 15 of the 20 plants selected.

The work-sampling method was used in obtaining data for each of the various operations in each plant. That is, records were obtained on time, equipment and personnel requirements and output for several time periods for each operation or work method. Time requirements for the various operations were taken with stop watches calibrated to one-hundredth of a minute.

Forms were prepared and utilized in recording the information on work sampling. Other pertinent information regarding the packing house was obtained from the plant operator. Scale drawings were made of each packing house operation and packing line so that the flow of fruit could be studied and better analyzed.

As a check on whether the sample time periods were representative of the normal operation of the plants studied, additional data were obtained on the operation of the plants during the entire season. This information was obtained through use of a mail questionnaire. The average total time required to pack a bushel of apples calculated from the work-sample data and from data on the questionnaires was approximately the same for each plant. The average time required as determined by the work-sampling method was slightly lower than that determined from the questionnaire data on all plants. This was expected because the work-sampling data did not include all work stoppages and delays. Therefore, the data collected from work sampling were used in making comparison of the various plant operations because they reflected the potential capacity of the plant.

The costs of equipment and buildings for the various operations were calculated on the basis of replacement cost in order that comparisons of equipment could be made.

Measurement of Size of Business

Size of business is not easily determined or defined. In fact, some writers on the subject maintain that it has never been determined in exact terms. Noyes, in his writing, points out some of the difficulties. The physical plant (building and equipment) is capable of operation at all levels between an absolute minimum (shut down) and some maximum capacity. As the rate of operation is increased from the minimum, it may change in any one or more combinations of at least four dimensions: (1) the number of parallel lines or duplicate machines in use, (2) the number of days per week the plant is operated, (3) the number of hours per day the plant is operated, and (4) the speed (within possible limits) at which each machine is run.[1/]

Apple packing houses are subject to these variations, as is any other business. In arriving at a measure of size for this type of business, perhaps several measures could be used, such as: bushels of apples packed per season or hour, number of employees working in the plant, number of bushels of apples dumped per season, capital investment in building and equipment, square feet of floor space in

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1/ C. R. Noyes, "Certain Problems in Empirical Study of Cost", American Economic Review, Sept. 1948, page 481.

the building, and bushels of apples dumped or processed through the plant per hour. Any one or a combination of these measures could possibly be used in determining the size of a packing house operation.

For the purpose of this study, the number of bushels dumped per hour was used as a measure of size of operation. This measure was used since it reflected the potential rate of output of the plant. It also provided a comparable basis for evaluating like plant operations, work methods, etc.

Classification of Plants According to Size

The 15 plants included in this study were classified as large, medium, and small. Large plants included those dumping 200 bushels or more per hour; medium-size plants included those dumping between 100 and 199 bushels per hour; and small plants included those dumping less than 100 bushels per hour. This study included five large plants, six medium-size plants, and four small plants.

To disguise the identity of these plants, a random number was assigned to each of the plants.

COST AND EFFICIENCY IN PACKING HOUSE OPERATION

Basic Operations Performed in Apple Packing Houses

Many variations in work methods and types of equipment are used in Virginia packing sheds which have significant influences on labor requirements and cost of packing apples. However, before discussing the various factors, it seems desirable to acquaint the reader with the basic operations performed in a typical apple packing house in Virginia.

When the fruit arrives at the packing house from the orchard, it is unloaded and placed in temporary storage or cold storage, or moved directly to the dumping station.1/ From the temporary storage area, the crates are moved to the dumping station. Here the apples are emptied from the containers onto a conveyor belt (usually referred to as a dumping table or receiving table) leading to an eliminator which removes the small apples, commonly termed ciders. The remaining apples pass through a cleaner which consists of a series of revolving roller brushes. These brushes clean the apples, removing spray residues, leaves, and other foreign materials. Since apples have a natural wax on them, the brushes and polishing cloths in the cleaner also polish the apples.

1/ A diagrammatical flow chart of an apple packing house is shown in Figure 2.

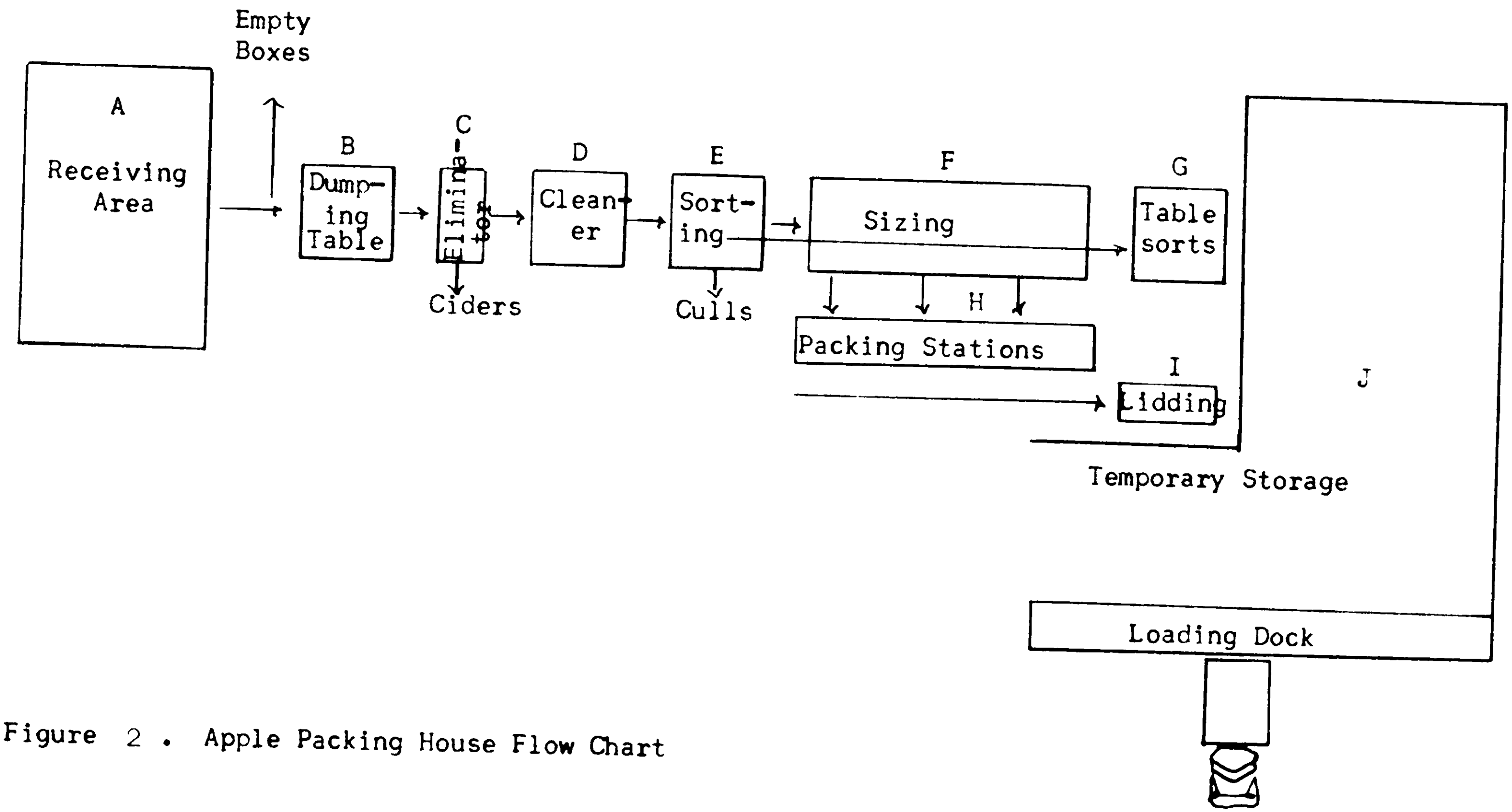


Figure 2 . Apple Packing House Flow Chart

Some plants wash apples by spraying water on them, preceding the brushing operation in the cleaner. However, this practice is not common in Virginia. It is only when the apples are wet that this practice is followed. This method permits cleaning the apples when they are wet, whereas plants which do not have washing facilities have to stop the packing house operations if the apples are wet.

After the apples have been cleaned, they pass over a grading or sorting table. Here the apples are manually inspected and separated into grades for packing, or diversion to processing or other uses.

Following the grading operation, the apples are transported on conveyors to sizing units. The sizing unit mechanically separates the fruit into uniform lots for packaging. From the sizing units, the fruit is diverted to packing stations or onto conveyor belts leading to the packing stations.1/

Packers remove the fruit from the packing stations and place it into containers. The packed containers are then placed on a conveyor which transports them to a lidding machine.

After the containers have been lidded, they are segregated according to size of apple and moved to a temporary storage area for movement to commercial cold storage or to market. In some cases cold storage facilities are available on the farm, in which cases the packed containers may be moved directly to cold storage from the lidding machine.

1/ Packing stations used in a general sense refer to packing table, packing bins, rotating tubs, or return-flow belt where the apples are accumulated for packaging.

To analyze these various operations on a comparable basis, it was necessary to classify the packing house operations into different categories: (1) receiving of apples at the plant; (2) movement of fruit from temporary storage to the dumping station, dumping of the contents from each field crate, and removal of the empty field crates; (3) grading; (4) handling of table sorts, culls, and cider apples; (5) sizing; (6) packaging; (7) lidding of containers; and (8) movement of packed containers to temporary storage, to a loading dock, or to cold storage on the farm.

Receiving Operation

Containers

Three types of containers were used for transporting the fruit from the orchard to the packing house: (1) field crates which hold from 45 to 50 pounds of apples, (2) Northwestern boxes which hold from 40 to 45 pounds of apples, and (3) three-bushel wooden barrels which hold approximately 135 pounds of apples. The field crates were the predominant containers used. Figure 3a. The inside dimensions of this crate are 11 5/16 by 13 7/8 by 19 6/16 inches, and it holds slightly more than a bushel of apples. It was a common practice not completely to fill the field crates so that they could be stacked without bruising the fruit. One of the chief advantages of the field crate is that it can be handled manually or mechanically. In addition, it can be used many times and stacked in a reasonable amount of space (full or empty).

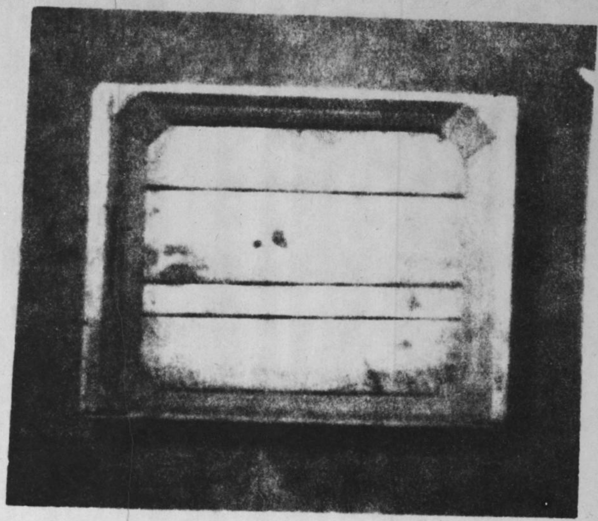


Figure 3a. Field crate - most widely used picking container in Virginia.

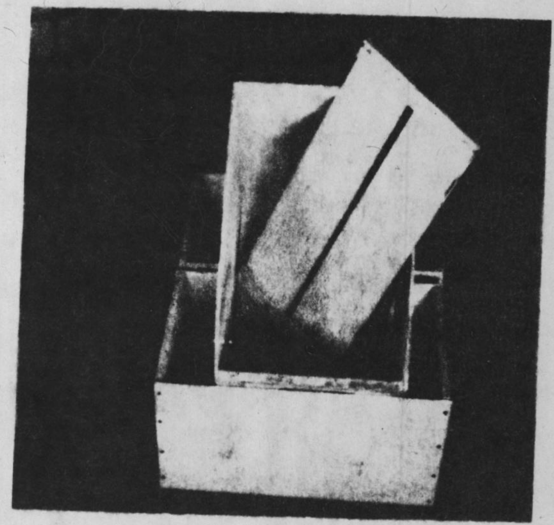


Figure 3b. North-western boxes. Occasionally used as picking containers.

The Northwestern box was used as an orchard container in one plant. It was used once and then packed with fruit for marketing. The use of the Northwestern box as a packing container offers opportunity to reduce the cost by eliminating the requirement for field crates. The handling characteristics of this container are the same as those of the field crate although the capacity is less. Therefore, more boxes must be handled in packing a given volume of fruit. Another disadvantage of the Northwestern box as an orchard container is that if it is used more than once it becomes soiled, weather beaten, and damaged to the extent that it becomes too unattractive to use as a market container.

The use of three-bushel wooden barrels did not appear to be an efficient method for this operation. Two men are required to load and unload these barrels from the truck and the lifting is a strenuous task in relation to handling other types of containers. In addition, barrels can not be handled mechanically, and they require a great deal of space to stack full or empty. The fruit is also subject to more bruising in the barrel because of the increased pressure on the fruit with larger volume per container. Also, the fruit is subject to more bruising in dumping from barrels since they are more difficult to handle.

Load Sizes for Trucks and Trailers

The load size for the trucks and trailers transporting fruit from the orchard to the packing house ranged from 51 to 344 bushels. There was no standard load size except for trucks unloaded with the industrial clamp-lift and the industrial fork-lift truck, which handled unit loads of 60 field crates. Where these machines were used, 192 and 120 bushels respectively were a standard truck load.

Effect of Size of Operation on Labor Efficiency

This study shows that an increase in scale of operation under the variable operating conditions existing, did not have any significant influence on labor efficiency in receiving apples at the plant. The large plants received from 2.18 to 7.24 bushels per man-minute, with an average of 3.72 bushels per man-minute. The medium-size plants received from 2.44 to 12.85 bushels per man-minute, with an average of 4.27 bushels per man-minute. The small plants received from 1.15 to 2.64 bushels per man-minute, with an average of 1.90 bushels per man-minute. Thus, it is easily seen that there was more difference within groups of plants than between groups of plants. This wide variation was due to the fact that some plants within groups use industrial fork-lifts and industrial clamp-lift trucks, while other plants performed the operation manually or with equipment less efficient in the use of labor. The cost associated with owning and operating the various types of equipment handling various volumes of fruit will be discussed in subsequent sections.

Effect of Work Methods and Equipment on Labor Efficiency

Three different practices of receiving apples at the plant are followed in Virginia: (1) movement of fruit directly to the dumping station, (2) movement of fruit to a temporary storage bank, and (3) movement of fruit directly to cold storage from the orchard. The practice of moving fruit directly to the dumping station was followed in some plants that had limited space for temporary storage. However, it was not uncommon for a load of fruit occasionally to be moved directly to the dumping station in any of the plants. Since there was considerable delay in the unloading operation by this method, it was followed by few plant operators.

Movement of fruit directly from the road truck or trailer to a temporary storage bank was the most widely observed method of receiving fruit. By this method, the fruit was first moved to temporary storage and later moved to the dumping station.

The movement of apples directly from the orchard to cold storage is rarely practiced in Virginia because of the inaccessibility of cold storage facilities to most growers. By this method, the apples were removed from storage at some later period and processed through the packing house. The movement of apples directly from the orchard to cold storage has advantages and disadvantages. In any event, the labor requirements and cost of receiving fruit at the storage would be similar to those in receiving fruit at the packing shed and moving to a temporary storage area. The difference in labor requirements and cost would be directly associated with the difference in the distance over which the fruit is moved.

The following types of equipment were used in the receiving operation at the packing house: gravity roller conveyors, two-wheel hand-clamp trucks, industrial fork-lift trucks, industrial clamp-lift trucks, and by hand without mechanical aid. The construction characteristics of some of this equipment varied among individual items of the same type, but the basic construction was the same for each type.

Without Mechanical Aid: Field crates of apples were occasionally received at the packing house without the use of mechanical aid. This method was employed in plants at which the road truck or trailer could be positioned relatively close to the receiving area, and where the field crates did not have to be moved a great distance from the truck. By this method, the field crates were normally moved to the back or to the side of the truck bed by one man, and were stacked in temporary storage by one or two men. Time studies showed that two men could handle an average of 223 field crates per man-hour by this method when the field crates were moved only six feet as compared to 213 field crates per man-hour with gravity conveyors moving the crates 15 feet. Thus, this job can be done as efficiently manually as with gravity conveyors when moving the fruit only a short distance. However, if the boxes are to be moved greater distances, the time requirements for the job by this method increased rapidly. For example, 175 bushels were handled per man-hour when the crates were moved 15 feet, and only 110 bushels were handled per man-hour when the fruit was moved 30 feet. Figure 4.

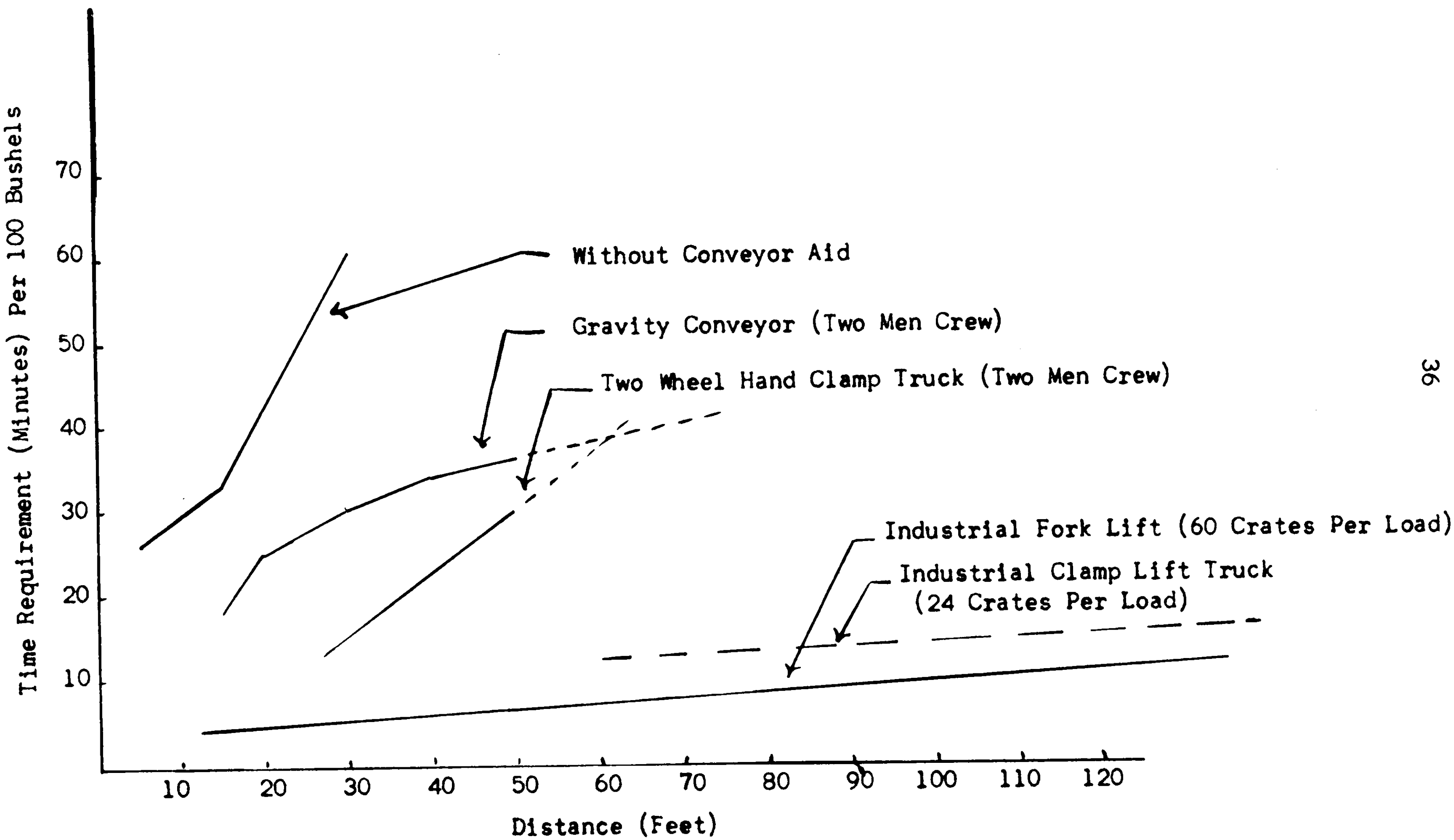


Figure 4. Relation of Distance on Time Requirements for Unloading Field Crates by Various Methods From Road Trucks and Orchard Trailers.

<u>Gravity Conveyors</u>: The most widely observed method of receiving apples at the plant employed gravity conveyors.1/ The cost of gravity conveyors is relatively cheap. They also appeared to be relatively flexible, and were often used for other operations in the plant, such as for movement of items between work areas for relatively long or short distances by gravity.

As an example of the flexibility of this type of equipment in one plant, a section was inverted, a unit load of several boxes was placed on it, and it was then pushed to a storage area. The use of a conveyor section in this manner appeared to be extremely limited because of the difficulty in making turns.

Slight variations were noted in the lengths of the sections for the different types of conveyors, but the costs per section were about the same for all types. The cost of the curved sections (45 and 90 degree curves) was slightly higher than that of the straight sections.

Variations in crew size were observed in the unloading operation, although two or three men were the usual crew. Ordinarily, one man was in the truck or trailer placing the field crates on the conveyor, while one or two men removed the field crates from the conveyor and stacked them in temporary storage or dumped the apples onto a dumping table.

1/ These conveyors had rollers of various types and are made in straight or curved sections. The sections are made in such a way that they may be joined together to extend to any length desired.

Time studies of this operation showed that it could be performed more efficiently with three workers than with any other size crew. When three workers were assigned to the job, an average of 214 bushels were handled per man-hour as compared to an average of 198 bushels per man-hour with two workers, when moving the crates 15 feet. With a crew of three men, two men removed the crates from the conveyor and stacked them in temporary storage at about the same rate that one man could place them on the conveyor from the truck. When only two workers performed the operation, the worker in the truck was frequently waiting on the worker taking the field crates off the conveyor.

Since most of the unloading operations observed were done with two or three workers, only a limited number of observations were obtained with more than this number of workers performing the job. However, it was observed that when four workers were assigned to the operation, only 146 bushels were handled per man-hour when moving the crates 25 feet. The crew organization for these workers was to have two men in the truck placing the crates on the conveyor, and two men removing the crates from the conveyor and stacking in temporary storage. With this size crew, there appeared to be considerable crew interference and waiting time among the workers in the truck placing the crates on the conveyor.

One receiving operation was observed with the conveyors bolted stationary on wooden blocks with a steep incline. In this plant, seven workers handled 174 bushels per man-hour as compared to 131 bushels per man-hour with five workers. This work arrangement consisted of two workers in the truck placing the field crates on the conveyor, and five workers and three workers respectively removing the crates from the conveyor and stacking them in temporary storage. Due to the steep incline of these conveyors, the workers in the truck always had to be sure someone was available to stop the crate when it reached the desired location on the conveyor. Consequently, when only three workers were removing the crates from the conveyor, the workers in the truck had to wait until there was a worker to remove the crate from the conveyor before releasing one to roll down the conveyor. The worker removing the field crates from the conveyor also frequently had to wait on the crate to roll down the conveyor. Thus, there was considerable delay in the operation because the two groups of workers were unable to synchronize their work patterns.

When three workers removed the field crates from the conveyor, they could not remove them as fast as two workers could place them on the conveyor. Therefore, seven workers were more efficient for doing this operation in this particular packing house than were five workers.

Further efficiencies may be gained from labor in the performance of this operation in some plants by use of stops on the conveyors. Workers are often required to wait for each other to send crates down the conveyor. By having stops on ends of the conveyors for the boxes, waiting time could be reduced to a minimum, resulting in greater returns to the plant operator. These stops are manufactured from steel which can be placed on the ends of the conveyor to stop the crates when they reach the end of the conveyor. It is also possible to bolt blocks of wood on the ends of the conveyors to serve the same purpose as metal stops, but they are not as satisfactory because of the additional time required to remove when the conveyor is extended. Metal stops can be purchased from manufacturers of conveyor equipment at reasonable cost or made in almost any machine shop.

It was a common practice for these conveyors to be supported on empty field crates. In most cases, the conveyors had very little incline, if any. Consequently, the crates had to be moved manually when they should have been moved by gravity. This arrangement appeared to be very poor in use of both equipment and labor for this operation. If the conveyors were placed on a sufficient incline so that the boxes would move by gravity, it would not be necessary to move the crates manually.

Conveyors are like a pipe-line in that once they are full, the distance crates are moved on them should not influence the time requirements for the operation. However, improper use of this equipment requires additional labor to move the crates along the conveyor. Figure 4. It was also apparent from this study that these conveyors can be put on too great an incline. If the incline is too great, and the conveyors are very long, it requires extra workers to stop the crates. In addition, the fruit is subject to bruising from jarring if the conveyors have stops on the ends. However, it is believed that a great deal of time and labor could be saved by proper use of gravity conveyors in the packing house operations.

Two-Wheel Hand-Clamp Truck: The two-wheel hand-clamp truck was used in some plants for the receiving operation and for handling fruit in other parts of the plant. Like gravity conveyors, the capital investment in hand trucks is small, and they can be used for many operations in the plants. There are slight differences in construction of these trucks among manufacturers, but the basic construction is the same. They consist of a vertical frame mounted on two wheels with clamps extending out from the bottom of the frame.

These clamps are moved toward each other with an arrangement of levers which are connected to a foot pedal attached to the frame. When the pedal is actuated, the metal edges of these clamps move under the bottom box of a stack to serve as a lifting device. The field crates are released by the operator pressing the foot pedal which causes the arms to move apart.

In the plants surveyed in this study, the field crates were stacked from the road truck and trailer onto the unloading dock into unit loads of five crates each. The field crates were then moved to a temporary storage area or to the dumping station by the hand truck operator. By this method, the field crates were transported various distances. In some cases, they were not transported more than 10 feet. In other cases, they were transported as far as 50 feet. When the field crates were moved 10 feet by this method, it required 11.1 man-minutes per 100 crates as compared to 24.5 man-minutes per 100 bushels when moving the crates 50 feet.

Time studies showed that 260 bushels were handled per man-hour with the hand-clamp truck when moving 30 feet as compared to 212 bushels per man-hour when moving 50 feet. Figure 4. The crew for this method of receiving fruit consisted of one man in the truck stacking five crates on the unloading dock and one man operating the hand-clamp truck. The hand-clamp truck was more efficient than the gravity conveyors when moving fruit relatively short distances. However, gravity conveyors became more efficient when the field crates were moved over 62 feet. Figure 4. This difference was due to the additional time required to move to the storage area from the unloading dock as the distance increased.

It appeared that greater efficiencies could be gained from the use of two-wheel hand-clamp trucks in several of the plants in Virginia by modification of the unloading docks. In the plants surveyed in this study, the field crates were stacked from the road truck or trailer onto the unloading dock into unit loads of five crates each. Then, the field crates were moved to a temporary storage area or the dumping station by the hand truck operator. If these docks were approximately the same height as the truck or trailer bed, it would permit the two-wheel clamp truck to be wheeled directly onto the truck or trailer bed to pick up the stacks of field crates. This method would eliminate the unstacking and restacking of each individual box of apples, resulting in less handling of the fruit. With less handling required, fewer men could perform the same operation. This would result in greater efficiency of labor and greater returns to the plant operator. There would also be less tendency to bruise the fruit with the decrease in the number of handlings.

Industrial Fork-Lift Unpalletized: An industrial fork-lift truck was used in receiving fruit at one plant where the field crates were partially palletized in the orchard, and where the field crates were also palletized at the packing house. By the latter method, the field crates were placed on the floor of the truck bed in the orchard. When the truck arrived at the packing house, a pallet was placed on the ground behind the truck. One worker on the truck handed the full field crates of apples down to another worker who stacked 16 crates on each pallet. This work pattern was followed until there was sufficient work area for the two workers and a pallet to be placed on the back of the truck bed. The fork-lift operator then moved the pallet of field crates to a temporary storage area. This method was inefficient from the standpoint of labor utilization. It required an average of 66 man-minutes per 100 crates received. Stated in different terms, 1.56 bushels were handled per man-minute or 91 bushels per man-hour.

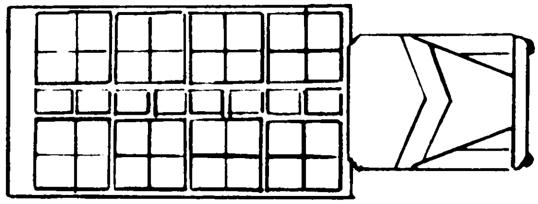
The fork-lift operator observed was inexperienced in the operation of the fork-lift, but this did not affect the efficiency of the operation, as it was necessary for the fork-lift operator to wait for the other workers to load the pallets.

Industrial Fork-Lift Partially Palletized: Fruit was also received at this plant from a road truck which was partially palletized.

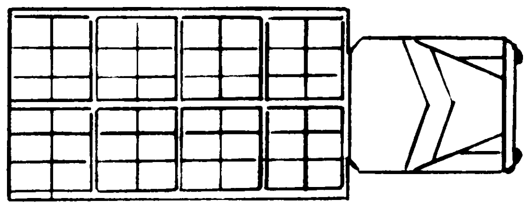
Pallets were placed on each side of the truck bed, and the center of the truck bed was filled with one row of stacked field crates. Figure 5, Method A. The pallets were stacked with field crates three high, two wide and two long, or twelve per pallet, and the row of field crates on the floor of the truck bed were stacked four high in the orchard. When the truck arrived at the plant, the tie ropes were removed from the truck and four more boxes were placed on each pallet from the stack of unpalletized crates in the center of the truck bed.

This operation was performed by the truck driver and his helper. The helper removed the tie ropes and stacked the extra boxes on each pallet, while the truck driver started the fork lift and moved each pallet of boxes to temporary storage. By this method, it was possible to handle 229 field crates per man-hour, which was a great improvement over the unpalletized method. This method was relatively efficient as compared to some of the other methods observed. Figure 5, Method B.

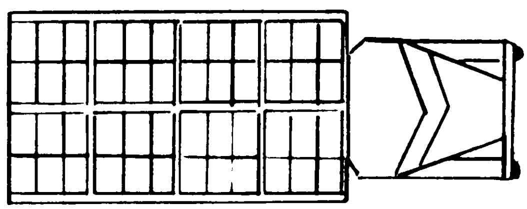
The operator of this fork-lift was inexperienced in the operation of the machine, which likely resulted in heavier time requirements for the operation than would have been required with an experienced operator. It is believed that greater efficiencies and better utilization of labor could be achieved in performing this operation by having larger pallets so that the road trucks could be completely palletized in the orchard. If the pallets were large enough to stack the boxes in a 3 by 2 arrangement on the pallets, it would eliminate having to stack four additional boxes on the pallets at the plant. By having pallets 36 by 40 inches instead of 34 by 34 inches, this objective could be achieved.



Method A



Method B



Method C

Figure 5. Position of Loaded Pallets on Road Truck.

The larger-size pallet would permit stacking the field crates lengthwise or crosswise on the pallets. Figure 5, Methods B and C. By this arrangement, the field crates would be stacked three wide and two long, or a total of 18 boxes per pallet, while by the present method 16 boxes are handled per pallet. Figure 5, Method A. The suggested method would give two more field crates per pallet load, which would not exceed the capacity of the fork-lift. It would also increase the truck load size from 128 field crates to 144 field crates. Thus, it would be more conducive to effective utilization of the road truck as well as of the work crew, assuming that orchard and road conditions would permit it.

Industrial Fork-Lift Completely Palletized: One plant was observed where the unloading operation was done with a 6,000 pound capacity fork-lift truck moving 60 field crates per pallet. The field crates of apples were received at the plant on pallets 71 inches by 73 inches. The crates were stacked three high, sixty per pallet, on the road truck which hauled 120 field crates per load. When the truck arrived at the plant, the truck driver removed the tie ropes and side board from one side of the road truck. Then the fork-lift operator unloaded the apples by removing 60 field crates per trip. The pallet of field crates was deposited along the side of a long dumping table built on one side of the packing shed.1/ After both

1/ The field crates were occasionally stored temporarily at a nearby barn or garage, and moved to the dumping station later.

pallets had been removed from the truck, the fork-lift operator placed two more pallets with 120 empty field crates back on the truck. This method of receiving apples required very little time once the unloading operation was begun, and was done very efficiently. When moving the fruit an average distance of 91 feet, 728 bushels were handled per man-hour. Less time was required by this method, and more bushels were handled per man-hour than by any other method of receiving apples observed. Figure 6.

However, the road truck appeared to be very poorly used in this operation. When it arrived at the plant, it often had to wait considerable periods of time on the fork-lift, since it was performing other material handling operations on the farm. The efficiency of the road truck was further reduced by the small load.

It appeared that the same operation could have been done with a smaller machine, but this machine was purchased at a war surplus sale at a relatively low cost. It was also used in connection with another enterprise on the farm which decreased the fixed cost of its use in the packing of apples. Under these circumstances, this machine was used economically on this farm, whereas it would have been prohibitive to use a machine[1/] of this size in the typical packing house in Virginia, because of the high fixed cost.

Industrial Clamp-Lift Truck: The industrial clamp-lift truck[2/] was used

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1/ Fork-lift 6,000 pounds and gasoline operated.

2/ Industrial clamp-lift truck had rated capacity of 2,000 pounds--gasoline operated.

in one of the plants studied for receiving field crates of apples from the road truck. It was very similar to the industrial fork-lift truck except that the fork had been replaced with a pair of hydraulic arms which extended out on each side of the load and squeezed the unit of boxes together so that they could be lifted and moved as a unit to storage.

The field crates were loaded at the orchard four high and forty-eight to a section on a heavy piece of plywood placed on the truck floor. The four pieces of plywood were connected together on each side with short lengths of chain which permitted each unit of 48 boxes to be moved apart, allowing space for the clamp lift arms.

When the road truck of 192 field crates arrived at the plant, the truck driver removed the cables which secured the load by releasing two small winches built on the truck bed next to the cab. Then another hand-operated winch was positioned against the back of the truck to pull each unit of 48 field crates apart. The section on the back of the truck was separated first for the clamp truck arms. As two unit loads of 24 field crates each were removed from the truck (one from each side of the truck bed), successive units were separated and unloaded in a similar manner. When the load was removed, the plywood sections were pushed back together, and the road truck returned to the orchard for another load.

Time studies showed that it was possible with the industrial clamp-lift truck to receive 536 and 483 bushels per man-hour when moving fruit 60 feet and 93 feet respectively. This method was considered a very efficient one for receiving fruit at the plant. It was comparable to the industrial fork-lift, and more efficient than the other methods for receiving fruit at the plant. Direct comparison of the efficiency of this method with others will be made in subsequent sections.

With the existing arrangement of this plant, the industrial clamp-lift truck could not be used to move fruit directly to the dumping station. A hand-clamp truck was used to move the fruit from the temporary storage area to a floor chain conveyor leading to a destacker and automatic dumper. However, if it was necessary to move the fruit more than 10 feet[1/] to the floor chain conveyor, the crates were moved from the storage area to a position adjacent to the floor chain conveyor with the industrial clamp-lift truck.

Some people maintain that clamping boxes together in units by this method is hard on the field crates. From general observations of various methods of receiving apples at the plant, this one did not appear to damage the crates any more than the other methods observed. Furthermore, this method did not require a large capital investment in pallets.

The distance field crates were moved had less effect on the efficiency of the industrial fork-lift and industrial clamp-lift truck than on that

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1/ Distance crates moved with the two-wheel clamp truck varied, but 10 feet was considered the average distance.

of any of the other methods. This was due to the relatively large number of crates handled per load and the speed at which the machines moved. However, as shown in Figure 4, distance did affect the time requirements up to 125 feet. These trucks were not observed moving fruit greater distances than 125 feet, but the time requirements for the operation would continue to increase as distance increased. However, 125 feet is about the maximum distance fruit would normally be moved with these machines in typical packing house operations. The distance moved did not appear to be as important as having a relatively smooth surface and sufficient space for maneuvering these machines. Otherwise, the efficiency with which these machines could be used in receiving fruit was seriously hampered.

Comparison of Different Methods and Equipment

Time studies revealed that there were significant differences in the time requirements for receiving apples at the plant by various methods. Figure 6. Receiving apples without mechanical aid was comparable to that with gravity conveyors and with two-wheel hand-clamp trucks when moving only short distances. For instance, 213 bushels were handled per man-hour when moving the fruit six feet without mechanical aid as compared with 212 bushels when moving crates 15 feet with gravity conveyors and with 260 bushels per man-hour with the hand-clamp truck when moving the crates 30 feet. However, as the distance increased, doing the job without mechanical aid became an inefficient method.

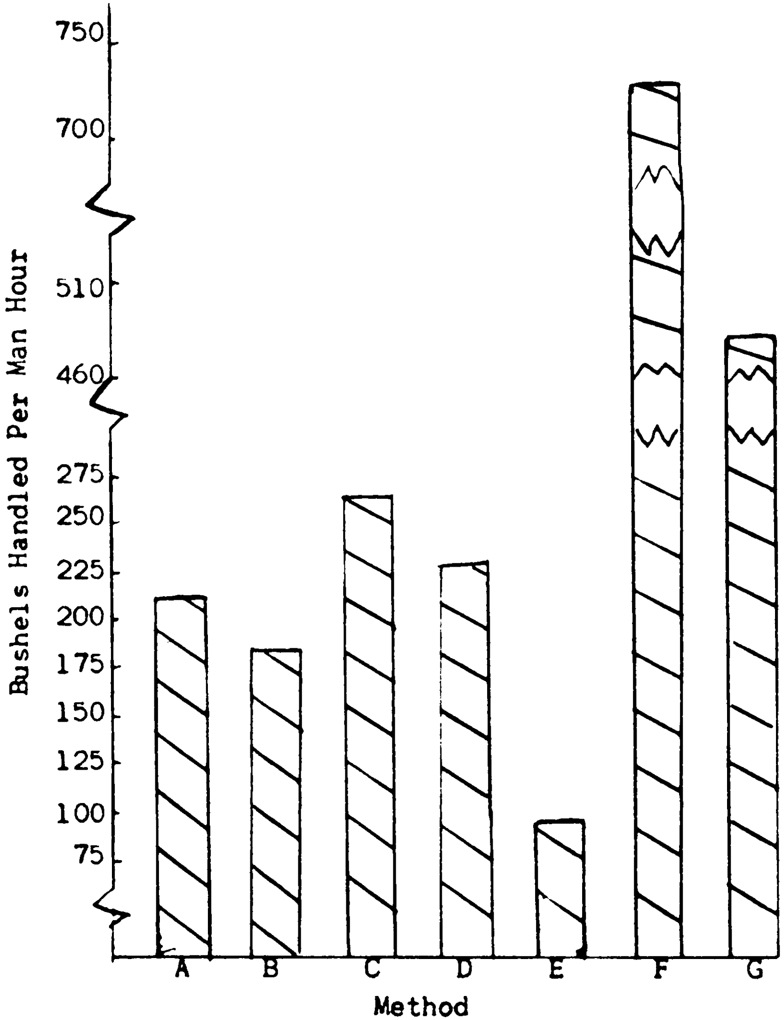

Figure 6. Comparison of Bushels Handled Per Man-Hour by Different Methods.

Method:

A Gravity Conveyors - Moving Field Crates an Average Distance of 30 Feet

B Without Mechanical Aid Moving Field Crates an Average Distance of 15 Feet

C Two Wheel Hand Clamp Truck - Moving Field Crates an Average distance of 30 Feet

D Industrial Fork Lift Partially Palletized in Orchard Moving 16 Field Crates Per Load an Average Distance of 36 Feet

E Industrial Fork Lift Moving 16 Field Crates Per Load an Average Distance of 36 Feet. Field Crates Palletized Manually at Plant from Road Truck

F Industrial Fork Lift Completely Palletized Moving 60 Field Crates Per Load an Average Distance of 91 Feet

G Industrial Clamp Lift Truck Moving 24 Field Crates Per Load an Average Distance of 93 Feet

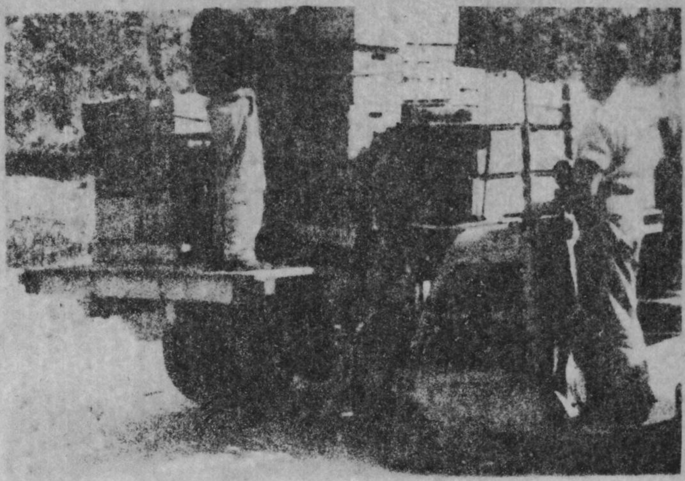

Figure 7a. Industrial fork lift truck (1000 lbs) unloading pallet of 16 field crates from road truck.

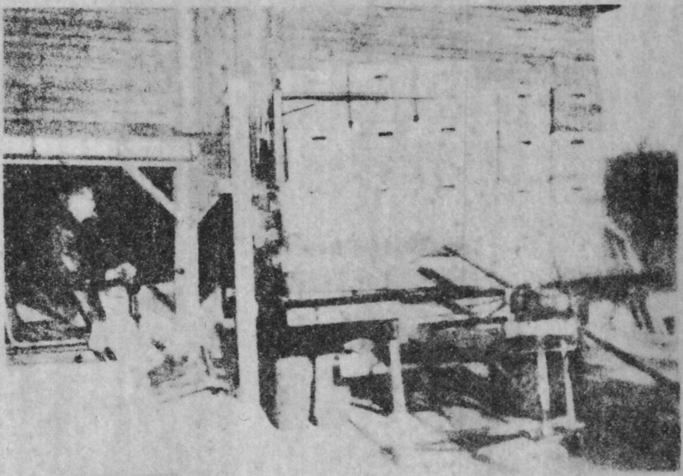

Figure 7b. Industrial clamp-lift truck unloading unit load of 24 field crates from road truck. (Note: winch positioned against back of truck to pull unit loads of field crates apart for clamp-lift arms.)

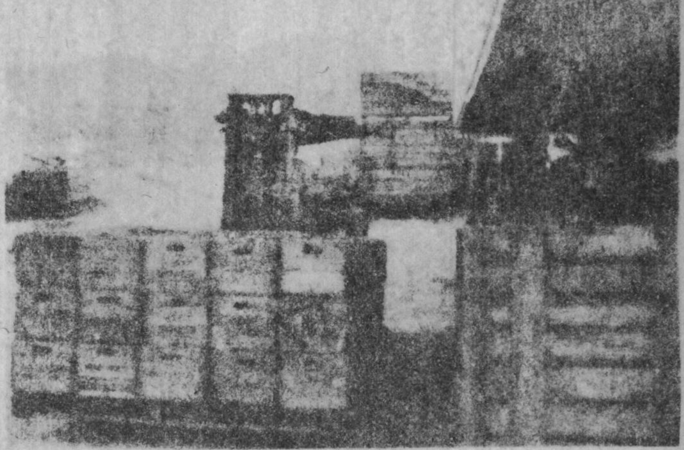

Figure 7c. Industrial clamp lift truck (6,000 lbs) moving pallet of 60 field crates.

An average of 228 bushels was handled per man-hour with an industrial fork-lift when the field crates were partially palletized at the plant and moved 36 feet to temporary storage. When the field crates were completely palletized at the plant and the industrial fork-lift was used, only 97 bushels were handled per man-hour moving the field crates 36 feet to temporary storage.1/

More bushels were handled per man-hour with a 6,000 pound industrial fork-lift than by any other method observed. Using this equipment, 728 bushels were handled per man-hour when moving the fruit 91 feet as compared to 483 bushels with the industrial clamp-lift truck when moving 93 feet. The bushels handled per man-hour with these two machines were calculated for two workers for each of the two operations--the operator of the machine and the road truck driver.2/ Therefore, the labor productivity seems low for this equipment. If only one worker had been counted for each of the receiving operations, the number of bushels handled per man-hour would have been twice as much.

Alternative Uses of Receiving Equipment

The equipment used in the unloading operation was often used for other operations in the plants. For instance, the two-wheel hand-clamp

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1/ Both of operations in this paragraph performed with a 1,000 pound fork lift.

2/ Road truck driver prepared the load for unloading.

truck was used for transporting the fruit from a storage bank to the dumping station as well as for the removal of the empty crates from the dumping station. The 6,000 pound industrial fork-lift was observed moving packed containers from a temporary storage area and loading them on a road truck. The 1,000 pound fork-lift was observed moving tree-run fruit out of cold storage to the dumping station and moving packed containers into cold storage. This equipment has possibilities for many uses in the plant, but the above operations are some of the more common uses for this equipment in addition to its use in the receiving operation.

Comparison of Cost of Handling Apples with Different Equipment at Various Levels of Use

The total cost of handling apples with the various types of equipment at different levels of annual uses at three different wage rates is shown in Figures 8, 9, and 10. By referring to these figures, one can see that the cost of the industrial fork-lift trucks and industrial clamp-lift trucks would be prohibitive for handling relatively small volumes of fruit. For example, for handling 10,000 bushels annually with an industrial clamp-lift truck, the cost per 100 bushels was $3.63, whereas the cost per 100 bushels with gravity conveyors was 78 cents. Figure 8. However, when handling 200,000 bushels annually, the cost per 100 bushels was 36 cents with the clamp-lift truck as compared to 42 cents with the gravity conveyor. This wide change in the relative unit cost of handling apples with industrial clamp-lift trucks and gravity conveyors at different

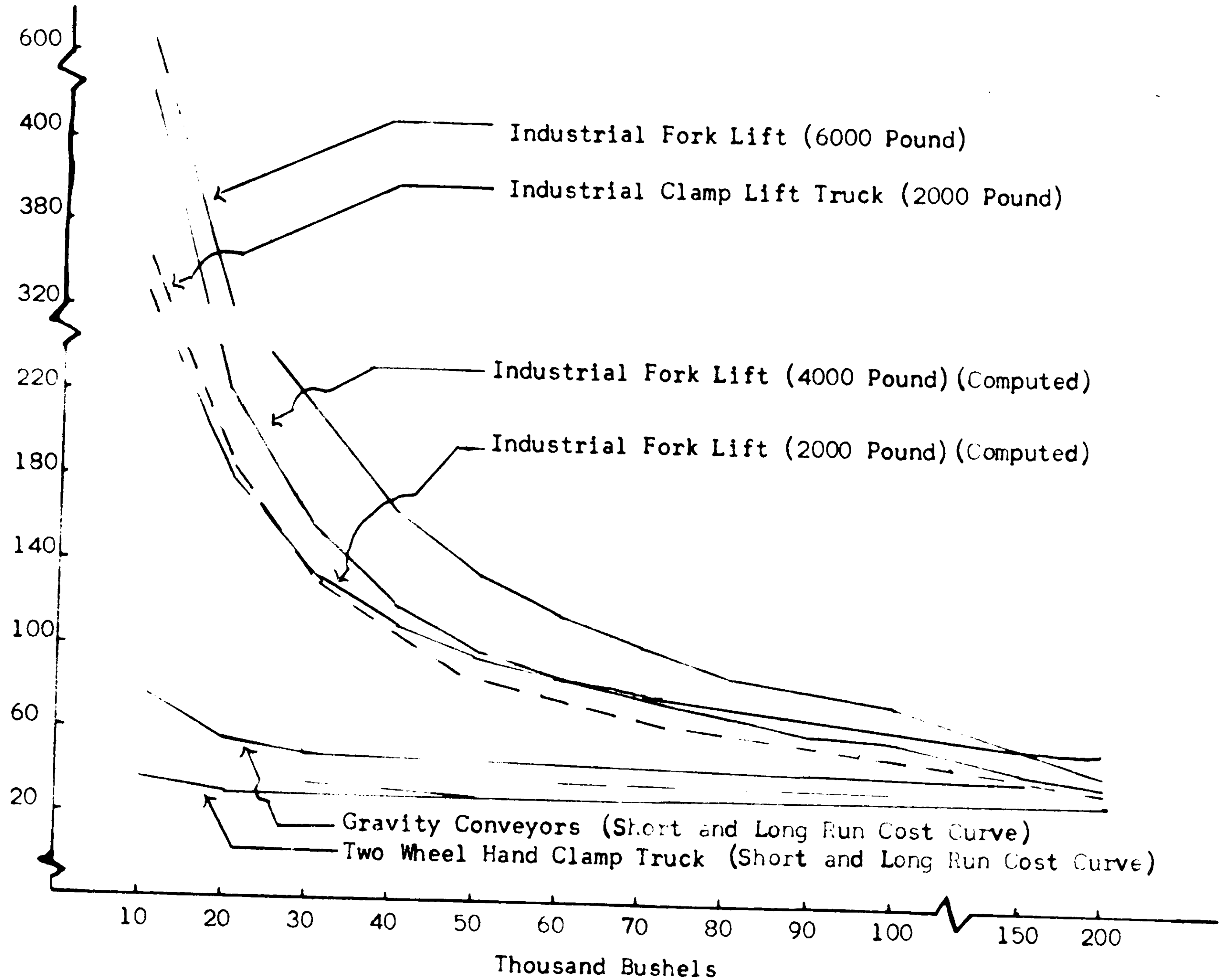

Figure 8 . Cost of Receiving Apples at the Plant With Various Types of Equipment and at Various Levels of Annual Use. **Wage Rate for Fork Lift Operator $1.00 Per Hour and Road Truck Driver $.60 Per Hour.**

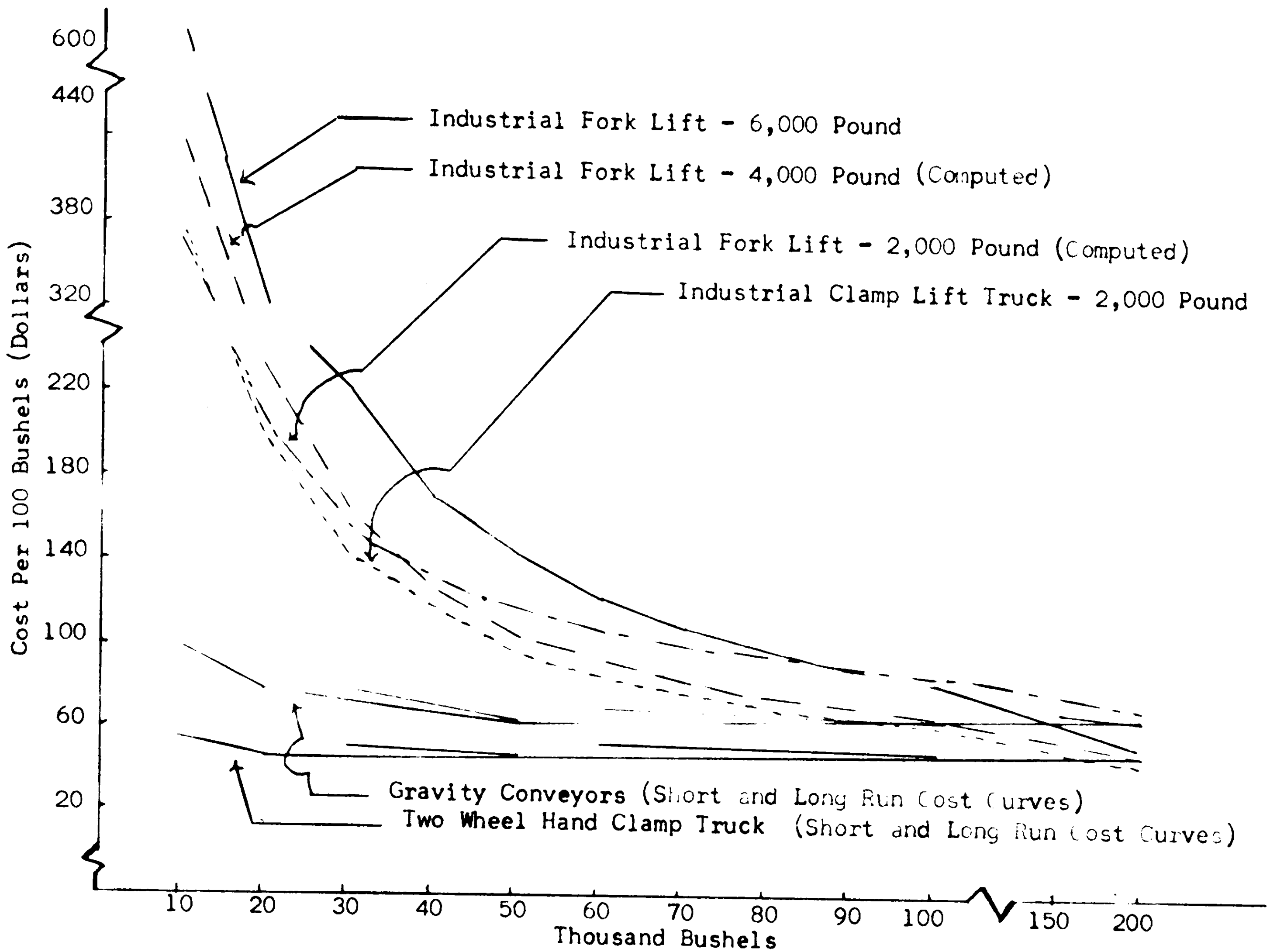

Figure 9. Cost of Receiving Apples at the Plant with Various Types of Equipment and at Various Levels of Annual Use. Wage Rate for Fork Lift Operator $1.50 Per Hour and Road Truck Driver $1.00 Per Hour.

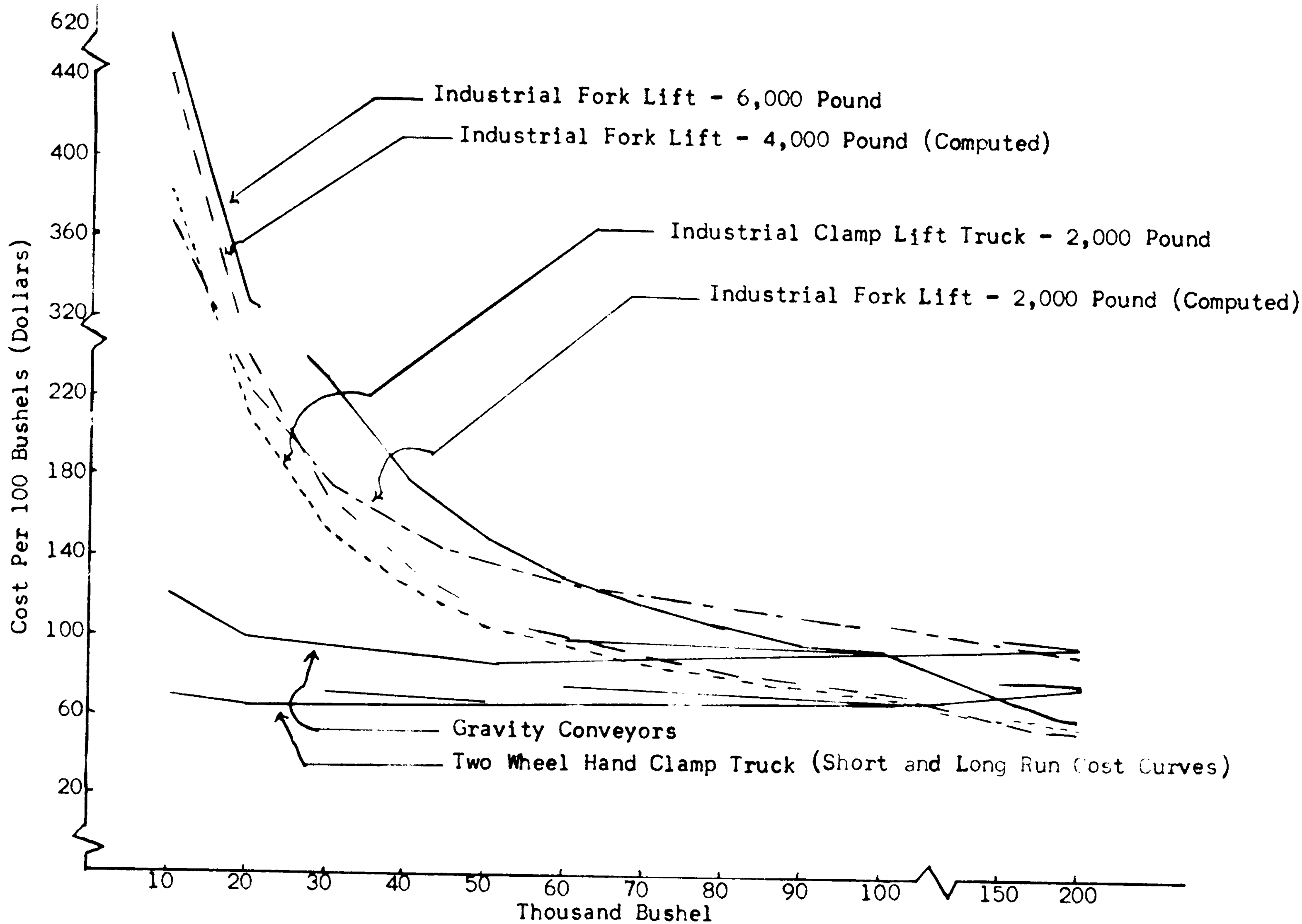

Figure 10. Cost of Receiving Apples at the Plant with Various Types of Equipment and at Various Levels of Annual Use. Wage Rate for Fork Lift Operator $2.00 Per Hour and Road Truck Driver $1.00 Per Hour.

levels of use is due to the fact that the total cost of the clamp-lift truck is largely made up of fixed cost, while most of the cost associated with the gravity conveyor is variable or direct cost.

As the wage rates increased, the lift trucks became more advantageous to use. Therefore, if the plant operator can foresee increased labor cost in future years, it would be economical to purchase these machines at some smaller volume than feasible at present wage rates. In addition, a plant operator anticipating an increased volume of fruit would likely find it profitable to shift to lift trucks at some point before the curves for the lift trucks intersected with the curves for the two-wheel clamp truck or gravity conveyor.

Assuming a wage rate of $1.00 per hour for the road truck operator, and $1.50 for the clamp-lift operator, it would require handling approximately 90,000 bushels of apples to justify the substitution of an industrial clamp-lift truck for gravity conveyors[1/]. Figure 9. Substitution of the industrial clamp-lift truck for two-wheel hand-clamp trucks would appear to require handling approximately 150,000 bushels.

The initial cost of the industrial clamp-lift truck was slightly higher than that of an industrial fork-lift of similar size. However,

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1/ Table showing cost of owning and operating the industrial fork-lift and industrial clamp-lift truck is shown in Tables 2 and 3 of the Appendix. B.

the cost of the pallets for the industrial fork-lift would more than offset the added cost of the clamps for the industrial clamp-lift truck. The cost curves in Figures 8, 9, and 10 are based on cost of fork-lifts and the estimated number of pallets required to handle the various volumes of fruit.

The total cost of handling apples with the different types of equipment was based on the data on the receiving operation. In actual practice, these machines would likely be used for other handling operations in the plant, such as movement of the tree-run fruit from temporary storage or cold storage to the dumping station, handling of packed containers, handling of empty containers, etc. The extent of the uses of this equipment would not likely be the same in any two plants. It was impossible to determine the exact amount of use for this equipment in each of the plants, but the per unit cost for equipment requiring a high capital investment would decrease progressively faster than equipment requiring a smaller capital investment. Thus, the cost of owning and operating the industrial fork-lift trucks and industrial clamp-lift trucks would likely be less under normal conditions than that shown by the cost curves.

Advantages and Disadvantages of Industrial Fork-Lifts and Industrial Clamp-Lift Trucks

Since plant operators are often faced with a decision of whether to purchase industrial fork-lifts or industrial clamp-lift trucks for handling fruit, it seems desirable to list some of the advantages and disadvantages of these machines. Perhaps the main advantages from use of these machines are the following:

1. They save labor by reducing the number of workers and the time requirements for the receiving operation. At times it may be difficult to hire sufficient, good, or even poor help. However, it would probably be easier to hire one good worker or keep one worker on the farm as a year-around employee to operate these machines during the packing season, than it would be to secure several workers.

2. They increase efficiency of road truck crew by reducing the time required for the road trucks to remain at the plant, thereby resulting in greater efficiency in use of the road truck and driver. Since the road trucks are required to spend less time at the plant, they make more trips per day. Thus, the number of road trucks may be reduced.

3. They aid in maintaining quality of fruit. The fruit is subject to less handling, and thus there is less bruising from jolts and drops of field crates when handled in unit loads than when each field crate is handled individually.

4. They offer flexibility. Fruit can be received at the plant and moved to temporary storage or to cold storage and high piled. They can also be used for movement of fruit out of storage. In addition, these machines can be used for handling such things as packaging material, fertilizer, spray materials, etc.

5. They reduce congestions. Lifts aid in keeping working area clear by unloading and movement of fruit to desired location more rapidly.

6. They reduce the labor requirements for dumping of tree-run fruit at the dumping station. These machines can be used for movement of fruit from temporary storage or cold storage. Consequently, fewer workers are needed for the dumping operation.

The disadvantages of these machines include:

1. There are high fixed cost in these machines. Their cost ranges from $2,500 to $5,000.

   a. Unit cost of these machines is determined by amount of use.

   b. Fluctuations in production cause an apple producer to be faced with uncertainty. He may have a large, medium, or small volume of apples to handle, or perhaps none in certain years. Thus, he may be faced with a high fixed cost in a machine for the volume of apples handled.

2. These machines require more room to maneuver than do two-wheel hand-clamp trucks or gravity conveyors. If the lifts are to be used successfully, there must be sufficient space to maneuver in unloading and placing fruit in temporary storage. The turning radius of these machines is relatively short, but, for efficient operation, sufficient space is required for turning and backing.

3. Lifts and unit loads are relatively heavy and so require stronger floors. The tires on the machines are usually small and provide a minimum clearance. Thus, it requires a hard, smooth surface for operation of these machines. Most growers have surfaces of concrete, black-top, or hard-pack gravel for the operation of these machines.

Transfer of Fruit from Temporary Storage, Dumping and Removal of Empty Containers

Work Methods and Equipment

Three methods were observed in moving field crates to the dumping station, dumping and removal of the empty crate: (1) without mechanical aid, (2) with mechanical aid, and (3) by automatic machines. Figure 11. Most of the smaller plants only use one man for this operation, whereas the larger plants use from two to four workers for this operation. In some cases, the operation was done by workers used also in receiving apples at the unloading dock. For instance, in some of the plants the man who moved fruit to the dumping station and removed the empty field crates also helped in the receiving operation.

For clarity of presentation, it is necessary to distinguish between "with mechanical aid" and "without mechanical aid" for this operation. If the fruit was moved from temporary storage to the dumping station and the empty field crates returned manually, the operation was classed as without mechanical aid. If gravity conveyors, two-wheel clamp truck, etc., were used in any part of this operation, it was classed as with mechanical aid.

It seems appropriate to inject into this discussion one of the main factors affecting the rate of dumping and the efficiency with which the labor was used for the performance of this operation. The dumping rate did not appear to be the limiting factor in the packing house operation in any of the plants studied. In most instances, the dumping rate had to be regulated to meet the requirements of the

Figure 11a. Manual dumping of apples from field crate onto dumping table.

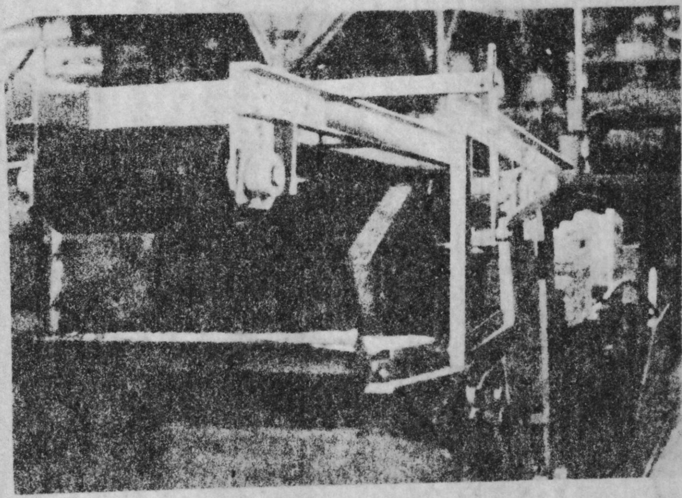

Figure 11b. Dumping apples with automatic machine.

Figure 11c. Automatic box destacker in foreground unstacking boxes for automatic dumper.

other plant operations, such as grading, sizing, and packing. However, in some plants the rate of dumping could not be materially increased without modification of crew size and/or equipment. It appeared that about 150 to 160 bushels per hour was the maximum one man, working alone, could handle in performing the entire operation. One man could dump 275 to 300 bushels per hour if his job was limited to standing in one place, picking up a full box, emptying it, and releasing the empty box. Therefore, manually dumping more than 300 bushels per hour would require modification of the dumping table to permit two men to work simultaneously. The overall efficiency of this operation depends not only on the rate dumped per hour but also on the total size of crew. Thus, it was apparent that the efficiency of this operation could be increased by revising the size of crew and work routines in some of the plants observed.

Without Mechanical Aid

When the dumping operation was done without mechanical aid, very little variation in method of performing the operation was observed. It consisted essentially of obtaining a full field crate from a temporary storage area, emptying the crate, and restacking the empty field crates in a temporary storage area. The empty field crates were restacked at the dumping station in three-crate units by placing one crate inside of two crates so they occupied only the space of two. Whenever three crates were accumulated at the dumping station, the dumper would carry them to a temporary storage area for empty field crates.[1/]

The rate of dumping varied between plants, but 150 to 160 crates per hour seemed to be about the maximum rate for one man performing the operation without mechanical aid. Table 2. Plants having a capacity greater than this volume per hour normally used mechanical aid of some kind.

More bushels were handled per man-hour in performing this operation by one man than by any other size crew. However, this size crew was used only in the smaller plants where the fruit was stacked in temporary storages relatively close to the dumping station.

The exact influence of the distance on this operation was not determined in this study. It was shown, however, in two of the larger plants (Plant Numbers 2 and 3) that the distance the fruit was moved influenced the time requirements as well as the size of crew required for this job. Plant Number 2 had a long dumping table through the center of the temporary storage area with an average distance of approximately five feet to the dumping table. Plant Number 3 had a short dumping table, and a gravity conveyor was used to move the fruit an average distance of 25 feet. The latter plant used three workers for this operation, and Plant Number 2 used only two workers regularly. Three workers were used part-time in Plant Number 2 when it was necessary

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1/ Normally the field crates were carried 15 to 20 feet to temporary storage.

to move the fruit over 5 to 10 feet to the dumping station. Plant Number 2 dumped 275 bushels per hour or 110 bushels per man-hour, as compared to 250 bushels per hour or 83 bushels per man-hour in Plant Number 3.

Mechanical Aid

Five different types of mechanical aids were used in this operation: gravity conveyors, power chain conveyors, power belt conveyors, two-wheel hand-clamp trucks, and wooden chutes. Gravity conveyors, power chain conveyors, power belt conveyors, and two-wheel hand-clamp trucks were used for moving the full crates to the dumping station and removal of empty field crates. Wooden chutes were used only for removal of empty field crates from the dumping table.

Gravity conveyors and two-wheel hand-clamp trucks were used for transporting the full field crates to the dumping station in different plants. Plants Numbers 5 and 6 had similar size crews for this operation, but the rate of dumping varied a great deal. Plant Number 5 used a gravity conveyor and two workers. Plant Number 6 used a two-wheel hand-clamp truck for movement of the full field crates to the dumping station and removal of the empty field crates. Two different workers were actually performing this operation, but the operator of the two-wheel hand-clamp truck devoted one-half or more of his time to the receiving operation. This plant (Number 6) dumped 175 bushels per hour, or 113 bushels per man-hour, as compared to 130 bushels per hour, or 65 bushels per man-hour, in Plant Number 5.

The workers in the latter plant could have handled more fruit, but they were limited by congestions at the packing stations--i.e., too much fruit of one size moved into one packing table and the workers could not remove it fast enough to prevent slowing down the entire packing house operation. Thus, the two workers at the dumping station were idle a considerable portion of the time. It would have been possible for one worker to do the entire operation with proper type of equipment. For instance, one worker with a two-wheel hand-clamp truck could have done the entire operation. On the other hand, if two workers were performing the operation with a two-wheel hand-clamp truck, the worker operating the hand-clamp truck could have assisted in the receiving operation, as was done in Plant Number 6.

Table 2. Comparison of Bushels Dumped Per Hour and Per Man-Hour With Various Types of Mechanical Aid.

Method	No. Workers	Bushels Dumped Per Hour	Bushels Dumped Per Man-Hour
Without Mechanical Aid	1	160	160
" " "	1	148	148
Gravity Conveyor	2.5	275	110
" "	3	250	83
Two-Wheel H.-C. Truck	1.5	175	117
Power Chain Conveyor	3.5	222	64
Power Chain Conveyor	3.5	256	73
Automatic Box Dumper	3	220	73
Automatic Box Destacker and Box Dumper	2	360	180

Two plants included in this study used power chain conveyors with automatic stops for conveying the fruit from temporary storage to the dumping station. These conveyors extended through the temporary storage area. A short section of gravity conveyor was placed perpendicular to the power conveyor for conveying the fruit over to the power conveyor.

Four workers were normally assigned to the job of moving the fruit from temporary storage to the dumping station, dumping, and removal of the empty field crates in each of these plants. One worker placed the boxes on the gravity conveyor leading to the power conveyor, and one worker removed the crates from the gravity conveyor and placed them on the power conveyor. One worker dumped the crates, and one worker stacked the empty field crates in a temporary storage area. This method was relatively inefficient because it required a large number of workers in relation to the number of bushels dumped. Table 2. It is believed that the same operation could have been done by two workers with a long dumping table extending through the temporary storage area to replace the power chain conveyor.

Automatic Dumper Without Destacker: One plant was observed dumping the field crates with an automatic dumper. The field crates were placed on a gravity conveyor leading to the dumper by a set-on man, one worker fed the crates into the machine from the conveyor, and one worker stacked the empty crates in temporary storage. By this method, 220 bushels were dumped per hour, or 83 bushels per man-hour. Plants of similar size using gravity conveyor, and the same size crew for transporting the crates to the dumping table, and dumping the crates manually dumped 275 bushels per hour, or 110 bushels per man-hour.

Automatic Dumper Used with an Automatic Destacker: An automatic box destacker and an automatic dumper were used in one plant for the dumping operation. By this method, a stack of four full field crates was moved with a two-wheel hand-clamp truck from a nearby storage bank and placed on a floor chain conveyor. These stacks were moved automatically to the automatic destacker where they were unstacked and moved into the dumper one at a time. This machine dumped at a rate of 360 bushels per hour, or 180 bushels per man-hour, as compared to 220 bushels per hour, or 73 bushels per man-hour, for the automatic dumper described in the preceding section.

The work crew for the machine dumping 360 bushels per hour consisted of one worker moving the crate onto the floor chain conveyor with a two-wheel hand-clamp truck, one worker stacking the empty field crates, and the clamp-lift operator part-time moving the crates from temporary storage to an area adjacent to the floor chain conveyor. Since the clamp-lift operator's primary duty was to unload the road trucks, his time was charged to the receiving operation.

The machine dumping the least number of crates per hour seemed to be continuously giving trouble, whereas the machine dumping the most crates gave very little trouble. The machine dumping at the faster rate was larger, but it appeared that the smaller machine was out of adjustment, as both machines had variable speeds from four to twelve boxes per minute.

Effect of Size of Operation on Labor Efficiency

The study showed labor is used more efficiently in large plants than in small plants. The average labor requirements for the large plants was .57 man-minutes per bushel, ranging from .25 to .81 man-minutes per bushel. The labor requirements for medium-size plants for this operation ranged from .34 to 1.16 man-minutes per bushel, averaging .67 man-minutes per bushel. The requirements for the small plants ranged from .80 to 1.84 man-minutes per bushel dumped. The average for the small plants was 1.32 man-minutes per bushel dumped.

It is readily seen that the variation in labor requirements between the most efficient and the least efficient plants in each size group is greater than the variation between the three sizes of plants. This wide variation within each group indicates that efficiency in the use of labor may be affected more by the work methods and equipment used than by the size of plant. Some of the difference found between the large size plants and the small size plants may be due to the ability of the large plants to use more equipment. This will be discussed further in another section in which comparisons will be made of the cost of different work methods and equipment.

Cost by Methods, Equipment, and Scale of Operation

The total cost of transporting fruit to the dumping station, dumping the field crates, and removal of empty field crates, varied a great deal between different plants. Since this operation was done universally by men, the labor cost varied in direct ratio with labor requirements where the operation was done without mechanical aid. In other plants, there was wide variation between labor requirements and labor cost because mechanical aid was employed. The average labor cost for performing this job without the automatic dumper, automatic destacker, and automatic dumper was 1.20 cents per bushel.[1/] The labor cost of dumping fruit with the automatic dumper at the rate of 220 bushels per hour was 1.36 cents per bushel, whereas the labor cost of dumping fruit with automatic destacker and automatic dumper dumping at a rate of 360 bushels per hour was 0.59 cent per bushel.

The above cost figures were based on the rate at which these machines were used. Labor cost was charged at $1.00 per hour, which made the dumping by hand slightly higher than the actual cost for most plant operators. This provided a basis for comparing hand dumping with mechanical dumping.

<u>Gravity Conveyors, Two-Wheel Hand-Clamp Truck, and Power Conveyors</u>: The average cost of moving fruit to the dumping station, emptying the container, and removing the empty container was 0.83 cent per bushel in plants using gravity conveyors. The plants using two-wheel hand-clamp trucks had an average cost of 0.56 cent per bushel. Plants using power conveyors had an average cost of 1.05 cents per bushel.

1/ For cost comparisons, no charge was allocated to this operation for use of gravity conveyors or two-wheel hand-clamp trucks because the cost of this equipment would be infinitesimal on a per-bushel basis.

Most of this variation was due to the number of workers assigned to the operation and the distance the fruit was moved from temporary storage to the dumping station. However, some of the variation was due to the cost of owning and operating the equipment. The average cost of owning and operating two-wheel hand-clamp trucks was 0.05 cent per bushel as compared to 0.10 cent per bushel for the gravity conveyor and 0.20 cent per bushel for power conveyors.

Since power conveyors required a higher capital investment, increase in scale of operation had a greater influence on unit cost with these machines than with gravity conveyors or with two-wheel hand-clamp trucks. For instance, as the scale of operation increased from 10,000 to 100,000 bushels, the cost of owning and operating the power conveyor varied from $1.10 per 100 bushels to 11 cents per 100 bushels. Increase in scale of operation did not appear to have any significant influence on the cost of owning and operating gravity conveyors and two-wheel hand-clamp trucks because of the relatively low capital investment in this equipment.

Automatic Dumper Without Automatic Destacker: The total cost of moving the fruit to the dumping station, dumping without an automatic destacker, and removing empty containers is shown in Table 1 of the Appendix C. The same cost figures are also plotted in Figure 12 to show the relationship of dumping by this method to other methods. It is difficult to state the average cost of dumping for a machine of this type because of the variation in volume of fruit dumped annually. However, as this machine was used, it cost 1.52 cents

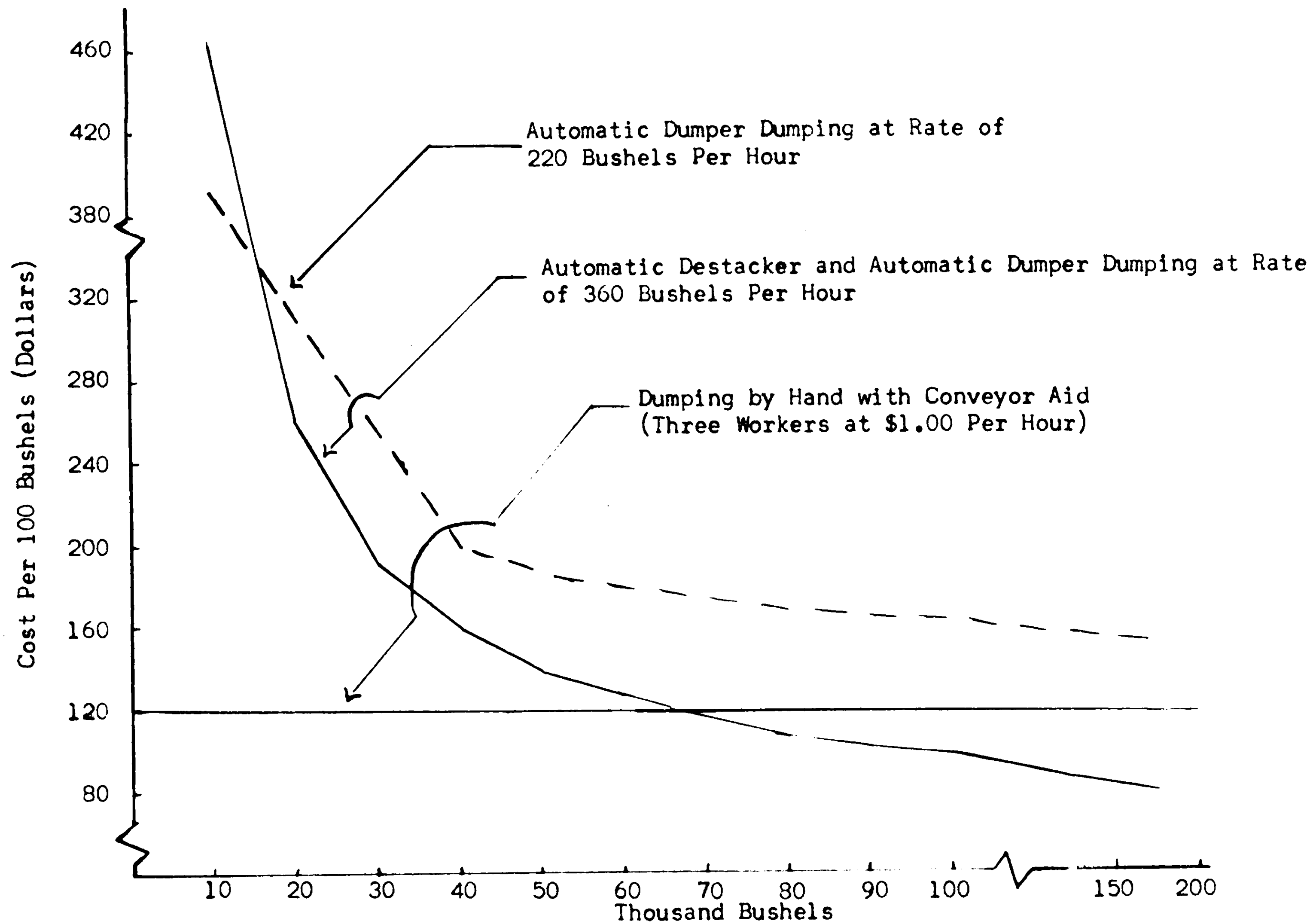

Figure 12. Cost of Owning and Operating Automatic Destacker and Automatic Box Dumper at Various Levels of Annual Use. (Labor Cost Figured at $1.00 Per Hour)

per bushel (assuming labor cost at $1.00 an hour and dumping at the rate of 220 bushels per hour).

The total cost of dumping with this machine would range from 3.37 cents per bushel when dumping 10,000 bushels annually to 1.00 cent per bushel when dumping 150,000 bushels annually if used with the same efficiency as was observed in this study. It is easily seen that an increase in scale of operation had a significant influence on the cost of owning and operating this machine.

Automatic Dumper with Automatic Destacker: The total cost of owning and operating the automatic dumper and automatic destacker is shown in Table 2 of the Appendix C as used in the plant which was observed. The cost of dumping with this equipment as being used was 0.98 cent per bushel (assuming labor cost at $1.00 an hour and dumping at the rate of 360 bushels per hour).

An increase in scale of operation had a significant influence on the cost of dumping fruit with the automatic destacker and automatic dumper. The cost per bushel was 4.64 cents when only dumping 10,000 bushels annually. When dumping 150,000 bushels annually, the cost was 0.79 cent per bushel. Thus, it is readily seen, an increase in the volume of fruit dumped had a significant influence on the cost of this operation. An increase in volume dumped annually affected the per unit cost of dumping by this full automatic method more than was the case with the automatic dumper discussed in the preceding section. This was due to the higher initial cost and higher dumping rate of the automatic destacker and automatic dumper. When dumping below

15,000 bushels annually, the cost per bushel was less with the automatic dumper than with the automatic destacker and the automatic dumper. However, when more than 15,000 bushels were dumped annually, the automatic dumper and automatic destacker became more economical to use for this operation.

Based on the findings of this study, it would be economical for a packer to own an automatic destacker and automatic dumper for an annual volume of 65,000 bushels or more if organized to dump at a rate of 360 bushels per hour.

This study revealed that the automatic dumper, without automatic destacker, dumping at a rate of 220 bushels per hour, costs more per bushel of fruit handled than any of the other methods. Figure 12. Perhaps this machine would have been economical to use if the other equipment had sufficient capacity to handle a greater volume of fruit.

Effect of Method of Dumping on Bruising

From a general observation of the dumping methods, dumping by machine appeared to handle the apples somewhat easier and with less bruising. The machine seemed to roll the crate over more steadily than did the average worker. Consequently, the apples were removed from the crate more gently. However, the amount of bruising depends upon the rate of dumping, care used in dumping, and how well the fruit was cushioned as poured from the crate. As indicated previously, hand dumping at less than 150 field crates per hour appeared to handle the apples with the same degree of care as any machine dumping operations observed in this study.

Grading Operation

Grading involves separating the apples into lots so that they will be uniform in size, shape, color, and quality. Grades serve as a means whereby a grower can differentiate his product and maximize his returns in marketing his apples by the elimination of cull fruit and making the fruit more uniform in each package. This job requires considerable experience and knowledge of apples and grade specifications on the part of the sorters. They must be able to recognize the different grades of apples at a glance so that they can remove the objectionable fruit from the sorting table. The grading operation is also important from the standpoint of packing house labor requirements. In the plants surveyed, labor for grading accounted for roughly 27 per cent of the total labor force and 14 per cent of the total labor cost.

The volume of fruit to be removed by the sorters depends largely upon the quality of the tree-run fruit which, in turn, is influenced by how well the spraying operations were done and the effect of biological and climatic factors on the apples. The percentage of the total volume of fruit received from the orchard which was packed ranged from 42 per cent to 85 per cent for the plants studied. Theoretically, the residual of these figures leaves from 15 per cent to 58 per cent of the fruit unpacked. However, the volume of unpacked fruit was somewhat smaller because some of the field crates were not completely filled, and there was a loss from shrinkage of fruit while in temporary storage.1/

The number of times apples are handled also depends upon the number of grades packed. Apples in Virginia are sorted into several grades, but it is not a common practice to pack more than three grades at one time. Some orchardists grade on the basis of U. S. grades, while others grade on the basis of Virginia grades. These grades range from extra fancy to cider apples. The larger plants tended to separate apples into more grades and to pack higher grades than the smaller plants. For example, several of the large plants packed three grades: (1) Extra Fancy, (2) Fancy, and (3) a combination grade, and the smaller plants packed only two grades: U. S. No. 1, and a combination grade. This difference was primarily a result of the smaller plants not having adequate facilities for the separation and packaging of apples into as many grades as had the larger growers.

Effect of Size of Operation on Labor Efficiency

Increase in scale of operation was not directly associated with the labor requirements for this operation. For instance, the large plants had an average labor requirement for this operation of 2.94 man-minutes per bushel, medium-size plants used 2.60 man-minutes per

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1/ Most plant operators figure 10 to 15 per cent shrinkage in the volume of apples between the dumping station and packing station.

bushel, and small plants used 3.07 man-minutes per bushel. The plants classified as small had a higher labor requirement per bushel than the medium and large size plants, but the medium size plants had lower labor requirements for this operation than the large plants. On the other hand, the large plants generally separated the fruit into more grades, which probably accounted for the greater time requirements.

The labor requirements for this operation in the large plants ranged from 2.16 man-minutes per bushel in Plant Number 7 to 3.75 man-minutes per bushel in Plant Number 8. Plant Number 7 was packing Virginia Extra Fancy, Virginia Fancy in Northwestern boxes, and U. S. No. 1 Grade in consumer bags. Plant Number 8 was packing U. S. Fancy and U. S. Utility Grades. A general observation of the grading job done in these two plants indicates that Plant Number 7 was doing a better job. However, Plant Number 7 was grading a better quality fruit. The difference in labor requirements between these two plants resulted primarily from an even flow of fruit across the table at all times and better supervision of employees in Plant Number 7.

The medium-size plants had a variation in labor requirements from 1.72 man-minutes per bushel in Plant Number 1 to 4.95 man-minutes per bushel in Plant Number 10. Plant Number 1 had the largest percentage of cull fruit of all plants observed, but still had a low labor requirement per bushel of fruit dumped. However, most of the grading in this plant was done under an excellent woman supervisor who had a direct influence on the accomplishments of the laborers and, therefore, on the cost for the various operations in the plant.

The small plants had a variation in labor requirements for the grading operation from 2.40 man-minutes per bushel in Plant Number 15 to 4.60 man-minutes per bushel in Plant Number 14. Plant Number 14 had a reverse-roll sorting table and Plant Number 15 had a spiral-roll sorting table. The main difference in the grading efficiency in these two plants appeared to be in management. The management in Plant Number 15 was done by a woman supervisor who adjusted the sorting crew according to the quality and volume of fruit dumped, whereas the sorting crew tended to remain constant in Plant Number 14 regardless of the quality of the fruit or the rate of dumping.

Effect of Work Methods and Equipment Used on Labor Efficiency

Apples are delivered from the cleaner to the sorting table or to a short conveyor which leads to the table. Graders are stationed on each side of the sorting table to inspect the fruit.[1/] As the fruit moves along the table, each grader picks out any fruit that does not meet the requirements for the grade being packed and places it in a different lane, on an overhead conveyor, or in a chute attached to the side of the grading table. The efficiency of this operation depends on the type of sorting table arrangement. If the sorting table is equipped with belt conveyors above the table and chutes on the side, the second-grade fruit is normally lifted from

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1/ The grading is done by women normally because no heavy lifting is required, and they can be hired at a lower rate per hour than men for this type of work.

the table and placed on the belt conveyor above the table. Cull apples are placed in the chute on the side of the table and conveyed to a bin on the side of the shed. The fruit which can make grade is left on the table and passes on to the sizing unit and packing stations.

Some sorting tables are manufactured with partitions, or lanes, for separation of the fruit. Figure 13. As the fruit is moved from the cleaner, it is diverted to two lanes on each side of the table. The second-grade fruit is lifted from the outside lanes and placed in the center lane where it moves through a series of sizing units to the packing stations. The first-grade fruit remains in the outside lane and moves through another series of sizing units on one end of the sizing line. Cull fruit may be placed on a conveyor belt above the tables or in chutes on the side of the table leading to a conveyor belt under the table. In either case, the conveyor belt transports the cull fruit to a temporary storage bin or packing station for cull fruit.

The reverse-roll table is the principal type of sorting table used in the apple packing houses in Virginia. Figure 16a. This table consists of a series of closely-spaced rollers that rotate clockwise as they move forward. Apples move across the top of these rollers and rotate counter-clockwise as they move forward so that the entire surface of the apple is visible to the grader without touching the apple. These tables are of various lengths and widths, but tables 12 feet long and 28 inches wide appeared to be the most common size used.

Other types of tables used in this area are the spiral-roll table and the belt conveyor table. The spiral-roll table consists of three

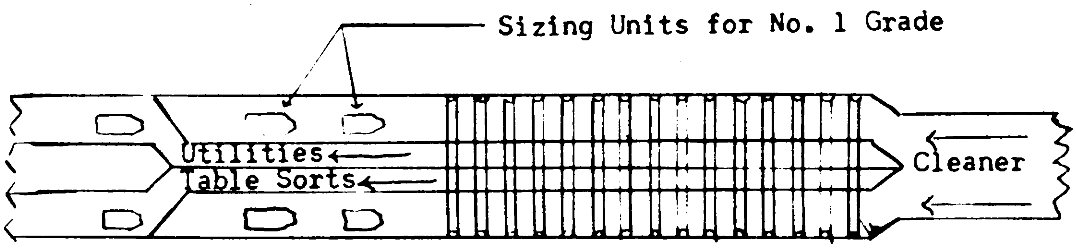

Figure 13. Sorting Table with Lanes for Different Grades of Fruit

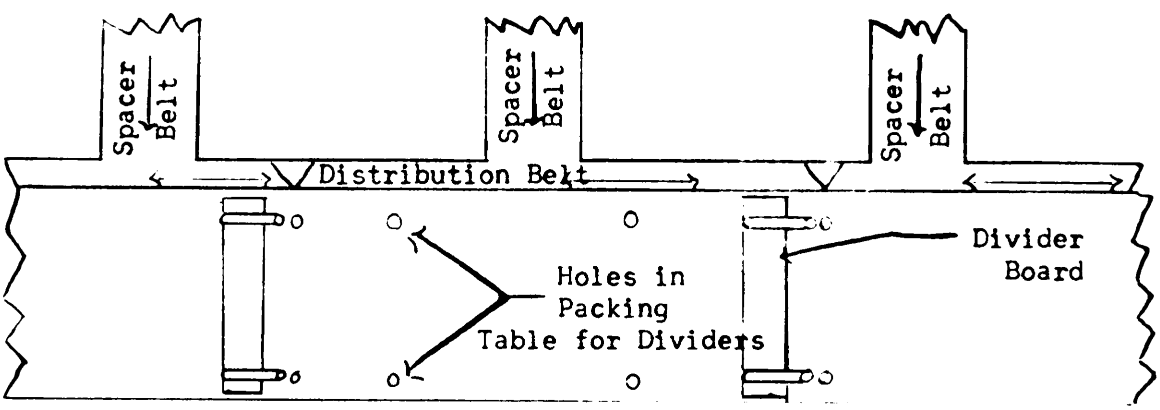

Figure 14. Packing Table with Moveable Dividers

Figure 15. Apples being exposed to weather.

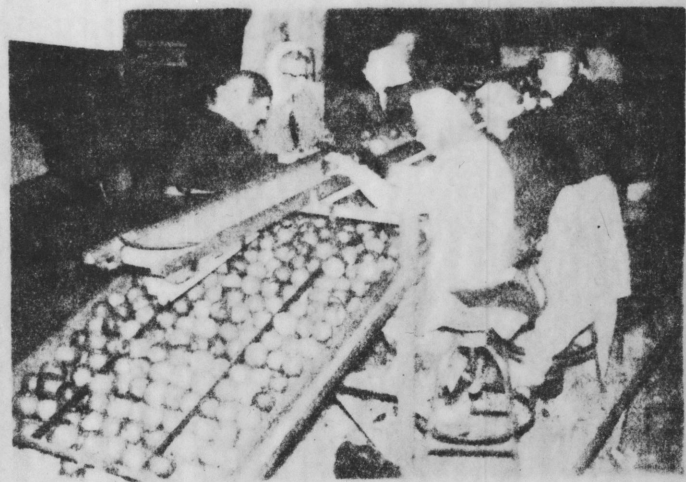

Figure 16a. Reverse roll sorting table divided into lanes.

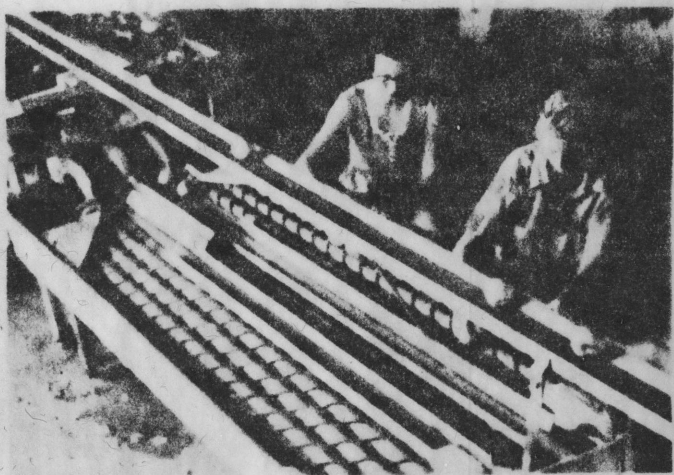

Figure 16b. Spiral roll sorting table

to four rollers on each side of the table positioned perpendicular to the sorters. A rope is wound around each roller forming a spiral. These rollers are power driven and turn the apples as they move past the graders. All fruit going to the packers is left on the rollers, and objectionable fruit is lifted by hand from the rollers and placed on a conveyor in the center of the table. The table sorts are placed on an overhead conveyor which carries the fruit to sizing units or directly to packing bins.

The conveyor belt sorting table is a flat belt on which the apples move past the graders. On these tables the apples are not mechanically turned, so only part of the surface of the apple is visible to the grader unless each apple is picked up or rolled over by hand.

Reverse-Roll Tables: The average number of bushels graded per man-hour in plants equipped with reverse-roll tables was 22.31 bushels per man-hour. The bushels graded per man-hour ranged from 13 bushels in Plant Number 14 to 30 bushels in Plant Number 7. Plant Number 7 was a large plant, and supervision appeared to be more effective, and these facts had a direct influence on the labor requirements for this job. Plant Number 14 had five sorters, which appeared to be too many for the volume of fruit graded. The sorting operation in this plant was retarded by an insufficient capacity of the sizing unit and by bottlenecks in the packing operation.

The sorters in Plant Number 7 graded approximately 360 bushels per hour as compared to 65 bushels in Plant Number 14. The fruit passed over two sorting tables in Plant Number 7 to insure an effective job of grading the fruit. Three sorters were assigned to the first table and six sorters to the second table. The sorting tables in Plant Number 7 were 30 inches wide and about ten feet long (9 feet, 7 inches). The table in Plant Number 14 was 30 inches wide and 14 feet long. In essence, the tables were of similar type and size in both plants, but the chutes and conveyors for removal of table sorts and ciders were at different heights. Plant Number 7 had a conveyor 12 inches above the sorting table for table sorts, and chutes on the side of the table for removal of cull apples. Plant Number 14 had a conveyor 15 inches above the sorting table for table sorts, and a conveyor 20 inches above the table for removal of cull apples. Perhaps the increased height of these conveyors had a significant influence on labor efficiency in these plants, but most of the difference appeared to be due to better management, adjusting of crew size according to volume of fruit graded, and a more uniform flow of fruit over the table in Plant Number 7.

Plant Numbers 8 and 11 had sorting tables divided into lanes which limited the responsibility of any sorters to part of the table. Figures 13 and 16a. Analysis of the data showed that these plants did not use labor more efficiently than some of the plant without lane dividers, but it appeared that the sorters did a more effective job of grading the fruit. Without lanes in the sorting tables, there was a tendency for the sorters to overlook the apples on the sides of the table--i.e., they were looking at apples 12 to 18 inches from the side of the table most of the time. Consequently, some fruit was left that should have been removed. There was also a tendency for the last sorters on the table to inspect fruit previously inspected.

It is believed that other plants using this type table would do a more effective job of grading by dividing the table into lanes and assigning one sorter to each lane. This arrangement would reduce the number of workers required for the grading operation and, thereby reduce labor cost. Perhaps further efficiencies could be gained if the width of the tables were increased sufficiently so that lanes could be used for second-grade fruit, and if chutes were placed on the side for removal of cull apples. This arrangement would eliminate lifting the objectionable fruit 12 to 15 inches from the conveyor to an overhead conveyor.

From general observations of sorting tables, it appeared that the reverse-roll was the most desirable type of table. These tables had a greater capacity than the other tables. However, some plant operators objected to them because the sorters were continuously trying to focus their eyes on a moving object spread over a relatively wide area. They maintained that the sorters tended to become "cross-eyed" and had trouble in focusing their eyes when grading fruit over relatively long periods of time.

Spiral-Roll Tables: Only a few plants were observed using the spiral-roll table. This study showed an average of 19 bushels was graded per man-hour on these tables, which was slightly less than that on the reverse-roll tables. Three to four workers were assigned normally to each side of these tables.

Conveyor-Belt Sorting Tables: Most plant operators did not like the conveyor-belt sorting table because they think it is not an efficient method of inspecting apples. They maintained that it requires the use of the hands when the graders should be using their eyes. On the other hand, some plant operators liked this method for conveying the apples past the graders. They maintained that there is less eye strain on the sorters than when the apples revolved. However, it appears that the labor requirements would be significantly higher for these tables since the sorters have to pick up or roll over each individual apple to do an effective job of grading.1/

Cost by Method and Scale of Operation

The average cost of grading was 2.84 cents per bushel. The large plants had an average cost of 2.94 cents per bushel. The medium-size plants had an average cost of 2.60 cents per bushel. The small plants had an average cost of 3.07 cents per bushel. Based on the findings of this study, an increase in scale of operation did not appear to have any significant influence on the cost of this operation. Labor cost varied more within each size group of plants than between different size groups of plants--i.e., some small plants had essentially the same cost as some of the large plants.

1/ This type table was not used in any of the plants included in this analysis, but it was observed in another plant.

Handling Table Sorts, Culls, and Cider Apples

The handling of table sorts, culls, and cider apples has been classified as a separate operation. It consists of collecting these grades at packing stations, placing them in containers, moving to temporary storage and stacking.[1/] In most plants the table sorts and cull apples were lifted from the sorting tables and placed on a belt conveyor above the sorting tables leading to the packing stations. From the packing stations, the apples were transferred to a container by a packer.

In some plants, the lower-grade fruit passed over a second sorting table where it was regraded. From this sorting table, it passed over one or more sizing units, going to packing stations. The better apples were packed in face-and-fill bushel baskets, and the lower grades were transferred to jumble containers.

Most cider apples were removed by an eliminator. From the eliminator, the apples dropped into a chute leading to a container or belt conveyor. These conveyors were frequently constructed under the main floor of the plant and conveyed the apples to a temporary storage bin on the outside of the plant. In some plants, these temporary storage bins held only a small volume of apples. In other plants, such bins held several bushels and were so constructed that the apples could be dumped into a truck by gravity.

1/ The field crate was the most widely used container to catch table sorts, culls and cider apples, but other types of containers such as universal crates and bushel baskets were used in some plants.

Variations from the above methods in handling table sorts, culls, and cider apples were observed in some plants, but the basic elements of this operation were the same in most plants.

After the apples had been collected in the container, the fruit was moved to storage areas by either a power chain conveyor, gravity conveyor, two-wheel hand-clamp truck or manually without mechanical aid. In some cases, a combination of two pieces of equipment was used. For example, in some plants a power conveyor transported the fruit part of the distance from the packing station with a gravity conveyor completing the job. The power chain conveyor and two-wheel hand-clamp truck were the most widely observed methods for transporting this grade of fruit to temporary storage.

With the two-wheel hand-clamp truck. it was possible for one man to handle 3.55 bushels per man-minute when moving the fruit 30 feet, and 2.96 bushels per man-minute when moving the fruit 40 feet to temporary storage. However, this operation required the workers to spend a great deal of their time waiting for sufficient volume of apples to fill the containers and raking the apples into the containers. Consequently, considerably less fruit was handled per man-minute than the workers were capable of handling. For instance, one plant observed using the two-wheel hand-clamp truck for this operation required 3.48 man-minutes per bushel to move the fruit. These workers were idle a considerable portion of the time, but they were required to keep a close watch of this grade on the packing tables to prevent apples from running over the side or piling up on the conveyor belt. Perhaps, these workers could have performed additional jobs in the plant, but this grade of fruit was frequently collected on one side of the plant or at one end of the packing line a considerable distance from the other operations of the plant.

With the use of the two-wheel hand-clamp truck, 3.56 man-minutes were required per bushel to handle this fruit as compared to 2.22 man-minutes per bushel with the power conveyor.

Since this operation depended largely on the number of workers assigned to it, the quality of fruit, and the time the workers spent waiting on the containers to fill, it is difficult to draw any absolute inferences from the above figures. However, it appeared that labor would be more efficiently utilized by using the hand-clamp truck if the fruit was moved a distance of 50 feet or less.

Effect of Size of Operation on Labor Efficiency

This study showed size of operation to have very little influence on the efficiency with which labor was used in handling table sorts, culls, and cider apples. The man-minutes required per bushel for this task averaged 3.93 for large plants, 3.28 for medium-size plants, and 3.32 for small plants. In fact, the small and medium plants had slightly lower labor requirements for the operation than did the large plants. This difference was due primarily to the larger percentage of the apples falling in this grade in the medium and small-size plants. This permitted a better utilization of the workers on this operation in the smaller plants.

The small plants generally handled these grades of fruit manually as usually it was moved only a few feet to temporary storage. It was a common practice for the medium and large-size plants to use mechanical aid of some type because of the greater distance involved in getting it to temporary storage.

Equipment for Sizing Apples

Two basic methods of sizing apples were observed in Virginia. One method is based on the outside dimensions[1/] of the apples and the other on weight. Sizing on the basis of dimension was the most widely observed method. By this method, the apples move on a belt conveyor from the sorting table to a series of sizing chains or to a series of beveled wheels which separate the apples into various sizes. Figures 17a and 19. Using such equipment, apples are sized within a range of 1/8 to 1/4 inch. It is possible, however, to size apples within other ranges by using different sizing chains or adjusting the machines with beveled wheels.

When apples are sized on the basis of weight, they are diverted from the sorting table into canvas cups which are pulled along a track on the sizing line. Figure 17b. Sections of the track of this equipment are movable and connected to a balance-type scale. These scales are adjusted so that the movable sections of track trip when a cup containing an apple of the correct weight passes over it. When the track trips, the cups are released, which, it turn, dumps the apples into a canvas chute leading to the packing station.

Two variations in arrangements were observed in sizing apples with chain units. By one system, the larger fruit is removed first

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1/ Outside dimensions for sizing based on the diameter of apples perpendicular to the longitudinal axis from the stem to blossom end of the apple.

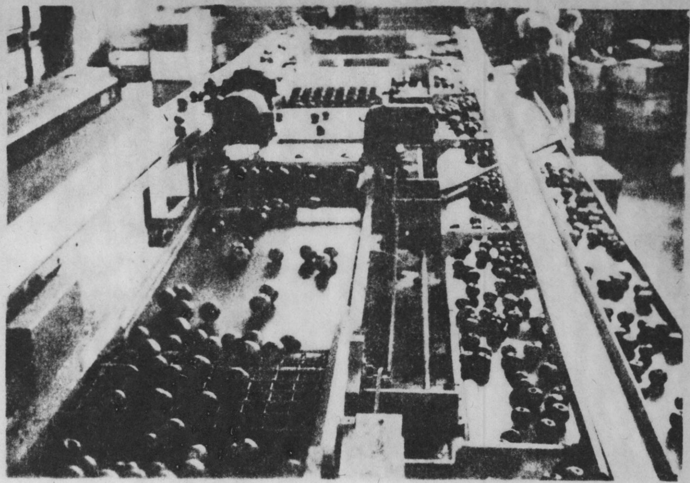


Figure 17a. Chain sizer and return flow belt.

Figure 17b. Packing Northwestern boxes from rotating tubs. Weight sizing unit in center.

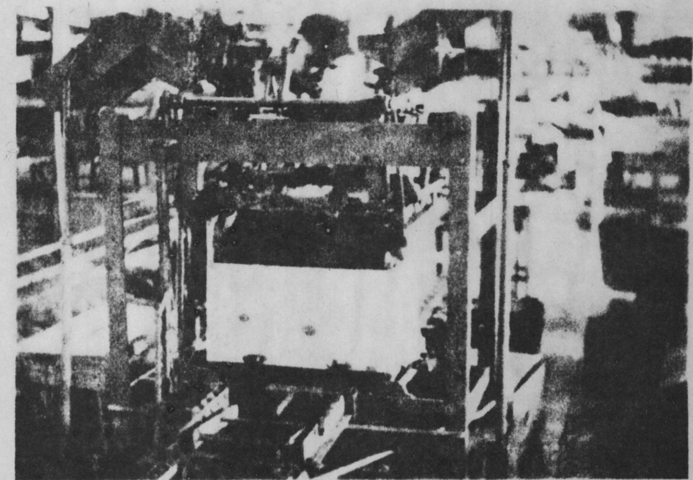


Figure 18. Lidding Northwestern box with automatic machine.

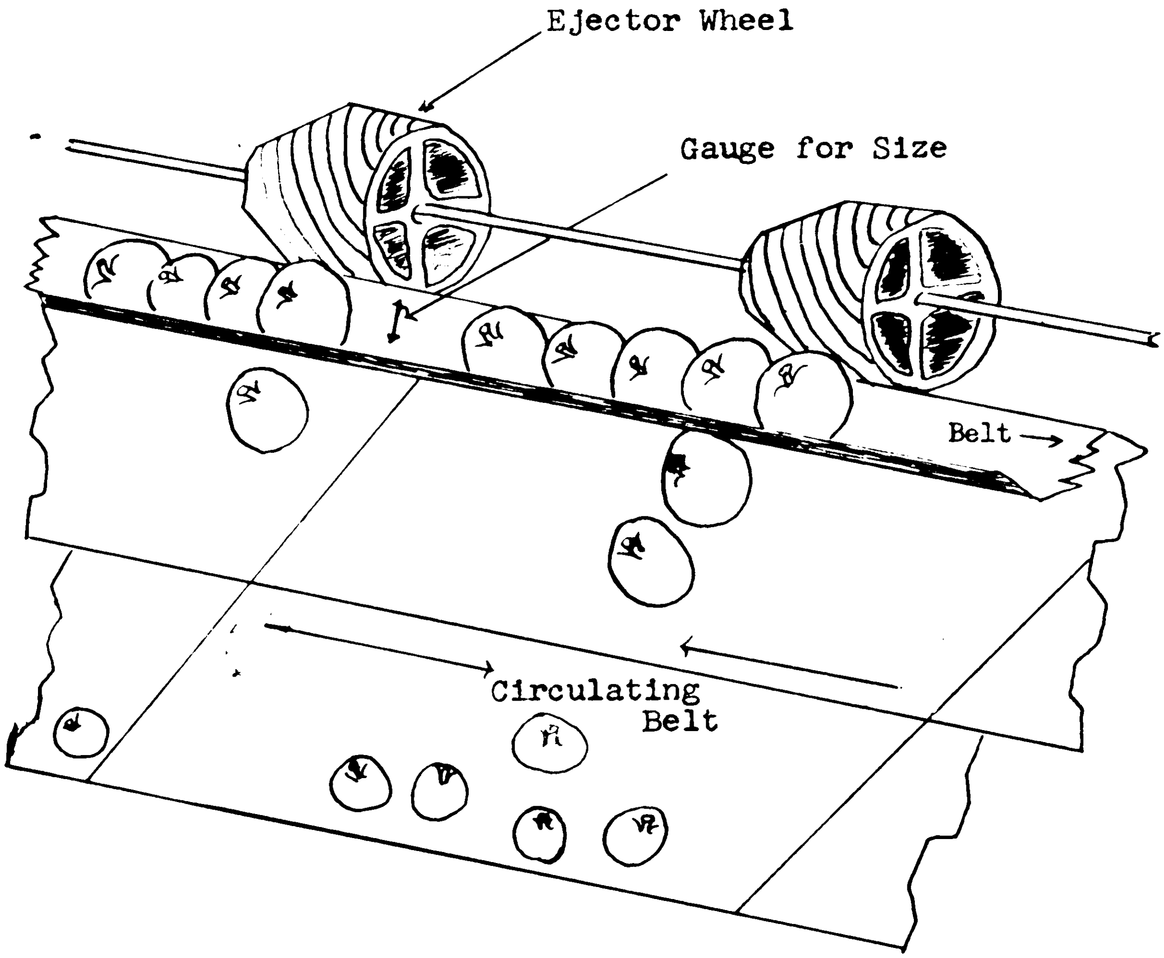
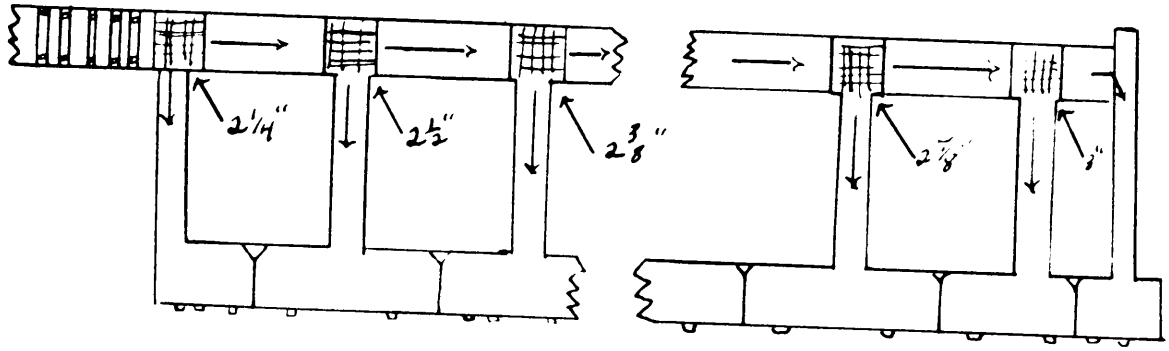
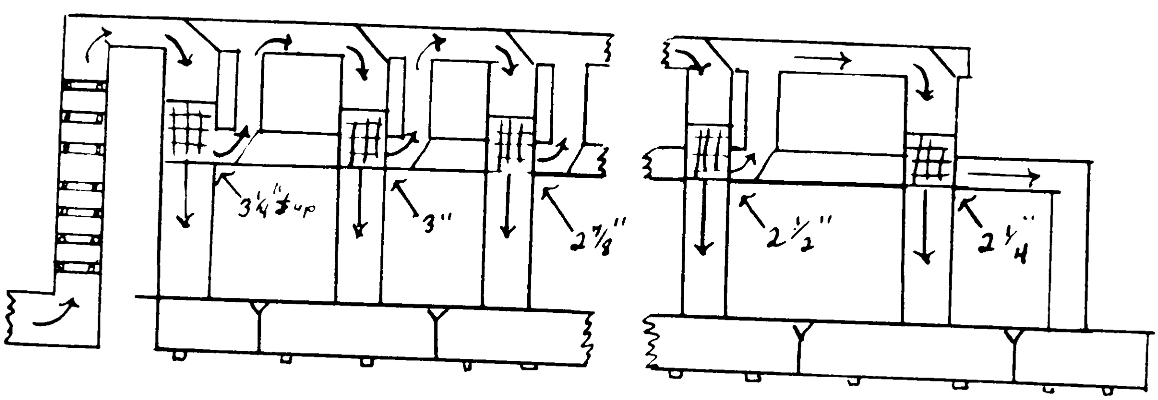


Figure 19. Sizing Apples on Basis of Dimensions with Beveled Wheels



Plant Layout A



Plant Layout B

Figure 20. Alternative Plant Layouts

and the smaller fruit removed last. Figure 20, Layout B. With this layout of sizing chains, the smaller apples drop through the chain onto a second conveyor belt while the larger fruit passes over the chain and moves directly to the packing station. The second belt conveys the smaller apples approximately two feet where they are picked up and shunted back to the first conveyor belt which conveys them four to six feet down the sizing line. At this point, the apples are shunted across a second sizing chain which removes the next largest size fruit. The fruit travels this pattern until all of the fruit has been separated into the desired sizes.

By the second arrangement, the fruit is conveyed from the sorting table over a series of sizing chains in a straight line. Figure 20, Layout A. With this arrangement, the smallest fruit is removed first, and each consecutively larger size is removed as the apples are conveyed over the sizing chains. The fruit appears to be subject to less bruising by this arrangement than by the preceding one because the fruit falls through the sizing chains only once. In essence, with the latter layout, the fruit is under control at all times except the one time it falls through the sizing chains.[1/]

When the sizing operation is done with a series of beveled wheels which eject the apples according to size, apples are diverted from the

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1/ "Without control" refers to the free fall or drop from one location to another. Equipment manufacturers are attempting to design all sizing units so that the fruit never moves over six or eight inches without control.

sorting table into single rows on two small belts forming a "V". Figure 19. These belts travel at different rates of speed so as to keep the longitudinal axis of the apples positioned correctly to the sizing wheels, and thus insuring greater accuracy of sizing. These belts convey the apples past a series of beveled wheels which are adjusted at various distances from the belts conveying the apples. Figure 19. As the apples move down the lane, the largest apples are removed first, and then each consecutively smaller size is removed as it comes into contact with one of the wheels. The apples may be ejected directly to the packing stations or to conveyor belts leading to the stations.

There is a difference of opinion among apple packers on the efficiency and effectiveness with which the various types of equipment can be used for sizing apples. It is not the intent of this study to over-rate or under-rate any particular piece of equipment, but to present an unbiased picture of the different types of equipment observed.

Equipment employing sizing chains was the most widely used type in this area. This type of equipment is manufactured by different companies in the eastern states. It may be purchased in single sizing units or in a series of units. The cost of this equipment depends largely on the width of the conveyors or sizing chains, and the number of sizing units in the line. There is also variation between manufacturers on the cost of this equipment. However, the cost appeared to be comparable between leading manufacturers of similar quality equipment.

For equipment of equal capacity, chain sizing equipment costs roughly 72 per cent as much as the weight sizing equipment.[1] The weight sizing equipment offers more flexibility in number of grades which can be packed at one time, and in the adjustment of sizes. The latter is especially important when apples are running heavy in one or two sizes. Weight sizing units require the diversion of the apples into single lanes before the apples move onto the sizing units, whereas the chain sizing equipment moves the apple directly from the conveyor belt to the sizing chain.[2] Some growers estimated the capacity of weight sizing equipment to be only 75 per cent of that of the chain sizing equipment where the number of tub units and sizing chains are equal. Thus, there is considerable difference in the cost per unit of capacity between these two types of equipment.

Equipment with beveled wheels for the sizing operation appeared to be comparable in cost to chain sizing equipment, but more comparable to weight sizing equipment with regard to capacity.

Although beyond the realm of this study, it appeared from general observation that several plant operators could reduce the cost of their sizing equipment by using less expensive equipment. It is felt that the latter half of the chain sizing lines could be one size smaller and still handle the same volume of fruit. Since a large

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1/ The cost of chain sizing equipment is based on units having eight sizing chains. Weight sizing equipment is based on eight-tub units.

2/ These conveyor belts vary in widths, but 18 and 30 inch belts were the most common sizes used in this area.

percentage of the fruit has been separated by the time it reaches the last chains, a smaller size should handle all of the fruit moving to this end of the sizing line.

Several apple packers reported having trouble sizing Red Delicious apples on chain sizing units because of their unique shape. The longitudinal axis (stem to blossom end) of this variety of apples is greater than the diameter. Both of these dimensions were about the same on other varieties. As a result, there is a tendency for some of the Red Delicious apples to ride over these chains.

It was learned from an engineer of a firm that manufactures and sells apple sizing equipment of both types, that an apple producer in a neighboring state had solved this problem by adding extra sizing chains to his packing line.1/ This apple grower found that the chain sizing unit failed to size accurately certain sizes of Red Delicious apples. For these sizes, he found that Red Delicious varieties should be sized 1/16 inch larger than normally sized for the box count. He solved the problem by adding three extra sizing chains to one side of the regular sizing unit. Figure 21. When packing Red Delicious varieties, he shunted the apples over the auxillary sizing chains. Other varieties of apples moved straight down the sizing line over the regular sizing chains. The same objective could be achieved by changing the sizing

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1/ This plant was not visited by the author of this thesis, but the engineer of the firm had observed the plant in operation. Since this firm sold both types, the information was believed to be unbiased.

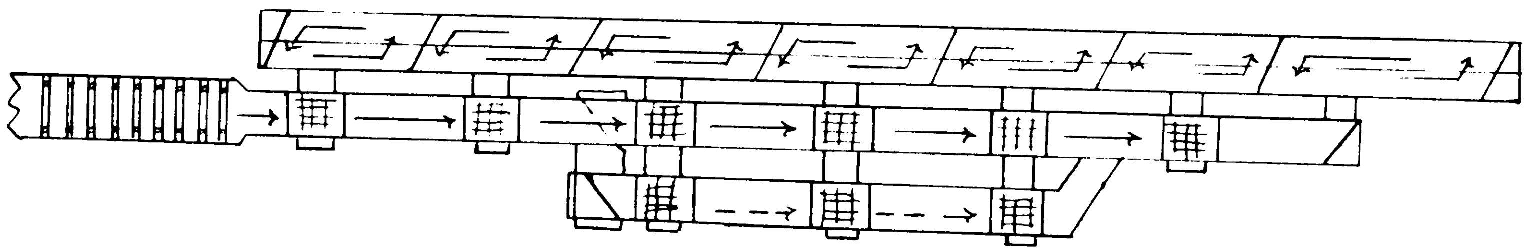

Figure 21. Extra Sizing Units Added to the Regular Sizing Unit For Sizing of Red Delicious Apples as well as Other Varieties From One Packing Line.

chains on the regular sizing line. However, this practice would require considerable time and would likely delay the packing house operation. Under the first system, it took only a few second to change the flow of the apples with shunts on the table conveying the apples from one sizing chain to another.

The chain sizer is probably more difficult to adjust from one size apple to another than any of the other types of sizing units. It involves removing a chain six to eight feet long and 24 to 30 inches wide, and replacing the chain with the desired size.[1/] This change not only requires a great deal of time, but also additional capital investment in chains if many different sizes of apples are packed. However, these chains do not require further adjustment after they have been put on the machine. By contrast, it is not unusual for the other types of machines to require several adjustments during normal operation to do an accurate job of sizing.

The weight-type sizing unit requires careful adjustment of the weighing mechanism to size apples properly. The weighing mechanism is very similar to the beam or balance scale, in that the weighing mechanism is regulated by changing the position of the weight on the beam or lever of the scale.

Sizing on the basis of weight appeared to be the most accurate method of sizing apples for the wrap-and-count Northwestern box

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1/ Size of these chains varies between different models of machines and different makes of machines, but the 24 to 30 inch chain is a common size used in this area.

because the filling of these containers is based on the number of apples packed in the container. There is a high correlation between the dimension and weight of apples, but the weights of specific sizes vary with varieties. Sizing on the basis of weight is not always the most desirable for packing containers designed for packing fruit sized by diameter. This is due to the fact that there is some variation between the diameters of apples of the same weight. As an illustration, one plant was observed sizing on basis of weight but packing face-and-fill bushel baskets which are based on diameter of apple instead of count. This plant was having considerable difficulty in getting the machine to size accurately. In face, many of the apples had to be checked with a hand gauge before placing them in the basket.

Work Methods and Equipment for Packing Containers

Four types of packing equipment were observed in this study; packing tables, packing bins, rotating tubs, and return-flow belts.

Packing tables were of various lengths and approximately three feet wide. Figure 22b. The tables were generally about six inches deep with the table on an incline from the side where the apples were conveyed onto the table to the side where the apples were removed for filling containers. The incline of the tables made it convenient for transferring the apples to the containers. Packing tables had small openings on the lower side for removal of fruit when packing "jumble containers" or filling tubs for face-and-fill bushel baskets. These tables also had one or two small belts on the side next to the sizing units to distribute the apples on the table.

These tables were divided into sections of fixed sizes. The fixed size of each section appeared to be the primary cause of the greatest bottlenecks in packing house operations. There was a tendency for apples of one or more sizes to pile up on the table, while other sections of the table were empty. The dividers were usually stationary at mid-point on the table between conveyor belts transferring the apples from the sizing units. It is believed that movable dividers would provide a better distribution of apples on the tables. This could be done by having pins on the dividers which fit into holes in the tables at various intervals. Figure 14.

Packing bins were similar to packing tables except for the depth and method of distributing the apples. Packing bins were usually

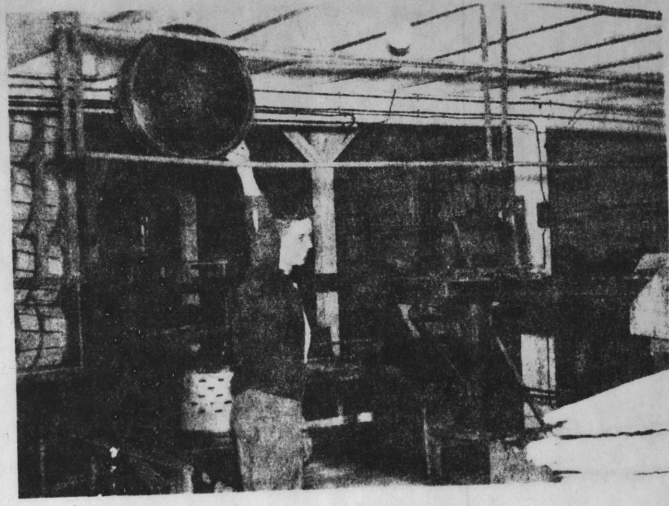

Figure 22a. Metal ring used in facing-and-filling bushel baskets.

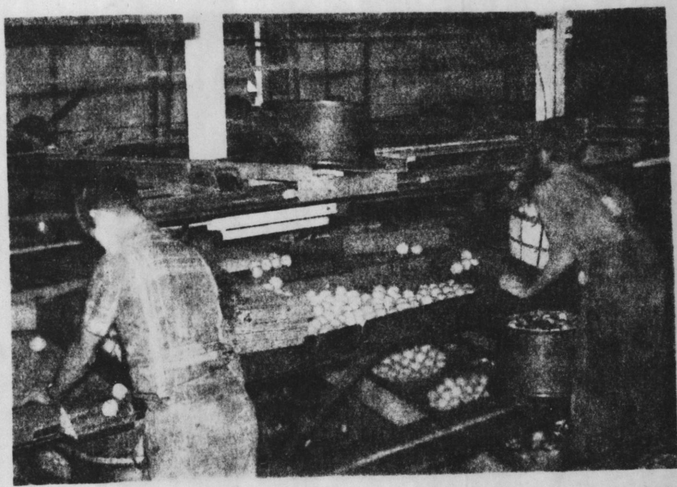

Figure 22b. Filling metal tubs for face-and-fill bushel basket from packing table.

Figure 23. Packing apple from return flow belt.

18 to 24 inches deep, and they held a larger volume of apples than a section on packing tables. The apples were shunted directly into these bins from the sizing unit.

Packing bins offered very little flexibility in packing different type containers. Each apple had to be lifted from the bin individually. Thus, these bins were best adapted to packing wrap-and-count Northwestern boxes than for other types of containers. However, it was often necessary to lift apples from the bottom of the bins for packing. Since these bins were relatively deep, the apples were also subjected to more bruising as they dropped into the bins from the sizing units.

Rotating tubs were 36 inches in diameter with bottoms that depressed as the weight of apples in them increased, keeping the apples about six inches from the top at all times. The depressing bottom resulted in less bruising of the apples, because they never dropped over six to eight inches whether the tubs were full or empty. These tubs hold roughly three bushels of apples. The apples have to be lifted individually from them for packing, which was perhaps the main disadvantage of the tub, even through the distance lifted was constant.

These tubs were used universally with weight-sizing equipment. Since minute adjustments can be made with the equipment, there appeared to be a better distribution of apples among the packers. Consequently, there were less delays in the packing operation with these tubs than with other packing equipment.

The return-flow belt is relatively new equipment, and only a few growers had adopted it at the time of this study. This equipment consists of two parallel belts, 12 to 18 inches wide, with movable dividers spaced at four to six feet intervals. Figure 23. These belts move in opposite directions, causing a circular flow of the fruit and thereby keep the fruit well distributed among the packers at all times.

The return-flow belt offers more flexibility than tables, bins or tubs, since any type of container can be filled from it. It has the advantage of permitting transfer of fruit from the belt into a jumble container without the use of hand labor. In addition, bagging equipment may be attached to the return flow belt for filling consumer bags.

Other equipment used in connection with filling containers at the packing stations were box stands for Northwestern boxes, metal rings, stands used in packing bushel baskets, and conveyors for removal of the packed containers. Two types of stands were used in packing Northwestern boxes, home-made wooden stands and manufactured metal stands. The metal stands were equipped with casters on the legs so that the packed container could be rolled from the packing station to the conveyor. However, several packers interviewed had a preference for the wooden stand because the metal stand with casters tends to roll around while the container is filled. The wooden stand is more difficult to move from one packing station to another, and the packed boxes must be lifted manually and placed on the conveyor leading to the lidding station.

Plants packing face-and-fill bushel baskets generally had wooden benches positioned parallel to the packing stations to hold packaging materials and equipment for filling the metal tubs. These benches were approximately two feet high and of various lengths. Some plants also had metal stands for holding the metal rings while building the face of the basket. These stands consisted of a vertical metal pipe about four feet high with a base and a revolving top. The revolving top on these stands permitted turning the lid during the facing operation. Other plants placed the metal rings on the packing tables for facing. There did not appear to be any significant difference in the two methods of building the face for the basket. Stands were necessary in plants where apples were selected from spacer belts between the sizing units and packing stations since the metal ring cannot be placed on the moving belts.

Power conveyors were usually used for the movement of packed containers from the packing stations. However, some of the smaller plants did the operation manually. The initial cost of manufactured power conveyors is relatively high, but many of the plant operators observed in this study built their own. Thus, their cost was considerably lower than the manufactured price of these conveyors.

Power conveyors can be used for movement of different types of containers as well as of packaging material from one work area to another. These conveyors were observed transferring packed containers horizontally as well as on an incline. When transferring containers up an incline, angle irons or bars are attached to the conveyor chain at various intervals to prevent slipping.

Packaging of Apples

Packaging consists of placing the apples in containers firmly and uniformly for protection of the fruit and convenience in handling.

As indicated previously, the various sizes of apples are accumulated at the packing station for packaging. This operation must be carried on with a minimum of delay for efficient use of equipment and labor. If the packing operation is not done at a sufficiently rapid rate to utilize fully all the equipment and labor used in this operation, operating costs result.

The rate of the preceding operations (dumping, sorting, etc.) may also be determined by the rate at which fruit is packed, and by the type of equipment utilized at the packing station. For example, the biggest bottleneck in the plant operation in several plants appeared to be at the packing station. This problem was created primarily by having too much fruit of one size moving to one packing station at which there was room for only one or two people to work. When this happened, the fruit could not be removed fast enough to prevent slowing down or stopping other operations in the plant. Hence, some growers were faced with increased operating cost because they could not fully utilize the services of all of their employees at all times. Yet, it is imperative that the packing operation be done without stoppages to maintain overall efficiency in plant operation.

Variations in methods of filling containers are followed in Virginia, but basically the operation consists of obtaining an empty container, placing a liner in the container, and filling the container with apples.

The process of filling face-and-fill bushel baskets involves more operations than does the packing of wrap-and-count Northwestern boxes. Six separate operations are performed in filling bushel baskets: (1) building a ring face, (2) placing a basket liner over the filled ring face, (3) placing a metal tub over the basket liner, (4) filling the tub with apples, (5) removing the tub, and (6) placing a basket over the liner. The filling of a Northwestern box only requires placing a liner in the box, and then placing the apples in the box. For clarity and better understanding of these operations, they will be discussed separately in more detail.

Facing and Filling Bushel Baskets: Building the ring face for the bushel basket requires the following operations: obtaining a metal ring face from an overhead conveyor, inserting a paper fringe in it, and building the face from selected apples. Figure 22a.

This operation was usually done by women stationed by the spacer belts between the sizing units and the packing stations. These women placed the metal ring on a stand by the spacer belts and filled it with apples from the belt. As each face was built, it was placed in a wooden chute which transferred it to the workers filling the tubs. These chutes passed under the packing stations. Packers removed the filled ring face from the chutes below the table and placed them on a bench by the side of the packing table. A basket liner was first placed over the filled ring face and then a metal tub was placed over the liner. Then, the metal tub was positioned so that it could be filled by opening a small door on the lower side of the packing table and raking the apples into the tub. As the tub was filled, shredded oil paper[1] was added. The tub was frequently shaken so the apples would be firmly packed in the tub. When the tub was full, it was generally placed on a power conveyor leading to a basket turner.[2] Before the basket was placed on the filled tub, the metal tub was removed and the basket (inverted) was placed over the liner and the faced lid of apples. Then, the basket was moved through a manually operated machine (referred to as a basket turner) which turned the basket to an upright position for removal of the metal ring and for lidding.

<u>Packing Northwestern Boxes</u>: Packing of Northwestern boxes involved obtaining a box, placing it on a box stand, adjusting the liner in the box, wrapping each individual apple and placing it in the box in a pattern determined by the size of the apples being packed. When the box was full, the packers stamped the box count on it and placed it on a conveyor leading to a lidder.

<u>Packaging Material</u>: Empty boxes were transferred from a temporary storage area, or assembling area, by one of the following methods:

1/ Shredded oil paper is added to prevent storage scald.

2/ Some plants moved the filled tub to the basket turner manually.

manually, on wooden chutes, on gravity conveyors, or on a mechanical monorail conveyor. Monorail conveyors appeared to be the most desirable method of doing this operation, but they required considerable capital investment. Because of the investment, a relatively high volume of apples packed is required to justify the use of this equipment. In fact, only the largest plants observed in this study used monorails. The greatest advantage of the monorail was that it provided a sufficient quantity of packaging materials available to the packers at all times and in an easily accessible position.

Cost: Information on the cost of packaging materials was obtained from different apple growers and from sales agencies for these items. Packaging materials composed one of the most important direct costs incurred in packing apples. The size of operation did not appear to have any appreciable influence on the cost of this material. However, as shown in Table 1 of Appendix D, there was a great deal of variation in cost for different types of packing containers.

Factors Affecting Labor Efficiency in Packing Containers

Equipment: Labor appeared to be utilized more effectively in packing Northwestern boxes from rotating tubs than with any other type of equipment. The average time requirement for plants packing from rotating tubs was 4.02 man-minutes per box, as compared to 4.59 man-minutes per box when packing from tables, and 5.00 man-minutes per box when packing from bins. This difference in favor of rotating tubs was due to the constant distance between the fruit and the packers at all times and a better distribution of apples among the packers. The distance to the fruit when packing from tables varied more than when packing from tubs, but not as much as when packing from bins.

The average time for facing and filling bushel baskets from packing tables was 5.15 man-minutes per bushel as compared to 5.32 man-minutes per bushel when packing from bins. However, the latter time measurement was for only one plant and may not be representative of the bin method.

Method of Paying Packers: Employees packing Northwestern boxes were paid on a piece-rate basis in all plants studied. Employees packing face-and-fill bushel baskets were observed under both an hourly and a piece-rate method of payment. The method of paying workers had a significant influence on the time requirements for facing and filling bushel baskets. By the piece-rate basis, it took an average of 1.57 man-minutes per bushel. When the same operation was done on an hourly basis, it took an average of 2.37 man-minutes per bushel, or 66 per cent more time. However, the fruit was not handled with as much care when done on a piece-rate basis.

Size of Plant: The large plants had the lowest average labor requirements for packing Northwestern boxes. The average labor requirements for the large plants were 3.78 man-minutes per box compared to 4.98 man-minutes per box in the medium-size plants. This difference was accounted for by the larger plants using mostly transient labor, whereas most of the workers in the medium-size plants were local packers.

Transient packers normally possessed more skill in packing and required less time for the operation than did local packers. For example, packing of Northwestern boxes in medium-size plants was observed by both local and transient workers. The average labor requirements for the plant using transient labor were 3.67 man-minutes per bushel as compared to 6.00 man-minutes per bushel in a plant using local packers. Both of these groups of packers were packing from packing tables. Thus, equipment was comparable in both plants.

Only one small plant included in this study was packing Northwestern boxes. Therefore, it was omitted from the above comparison, but the labor requirements in this plant were less than in the medium-size plants. Labor requirements were also less in this small plant than in some of the large plants.

Increase in scale of operation did not result in lower labor requirements in facing and filling bushel baskets. In fact, the small plants had lower labor requirements for this job than did any of the other plants. The small plants had average labor requirements of 4.84 man-minutes per bushel as compared to 5.25 man-minutes per bushel in the medium-size plants and 5.15 man-minutes per bushel in the large plants. This difference appeared to be due mostly to management in the plant. The smaller plant had fewer workers to supervise, and management appeared to be more effective.

Labor Requirements and Cost for Packing Northwestern Boxes as Compared to Bushel Baskets

The labor requirements for packing Northwestern boxes were essentially the same as the labor requirements for facing and filling bushel baskets. The average labor requirements for packing Northwestern boxes were 4.43 man-minutes per box. The average labor requirements for packing bushel baskets (including facing) were 4.89 man-minutes per bushel. Thus, there was very little difference in the labor requirements for packing these two containers, but there was a wide variation in labor cost. This difference was due primarily to the method of paying the packers. Packers of Northwestern boxes were paid on a piece-rate basis, whereas packers of face-and-fill bushel baskets were paid mostly on an hourly basis. Labor cost for packing face-and-fill bushel baskets was 4.40 cents per bushel, and the cost for packing Northwestern boxes was 11 cents per box. It was not uncommon for packers of Northwestern boxes to make from $1.50 to $2.00 per hour as compared to 50 to 60 cents per hour for packers of face-and-fill bushel baskets.

Work Methods and Equipment for Lidding Containers

Only two types of containers were observed in this study, but several methods of lidding the containers were followed. Lidding Northwestern boxes was done manually, and with non-automatic, semi-automatic, and automatic lidding machines. Lidding bushel baskets was done manually except for a manually operated basket turner used in turning the inverted basket of fruit to an upright position. Small hand tools were also used for fastening the wire loops on the basket to the lid extensions, but the entire operation could very well be considered a manual one.

Lidding bushel baskets consisted essentially of turning the basket of fruit to an upright position for removal of the metal face, placing oiled paper, lid liner, and the lid on the basket. Then, the lid was fastened by inserting the lid extensions into the basket handles and attaching the wire loops on the lids to the wire loops on the basket.

The most common method of lidding Northwestern boxes was done manually with the aid of a box lid clamp and nail dispenser. The box lid clamp consists of a stand about 36 inches high with a clamp on it which holds the lid in place for nailing. This clamp was operated by a foot pedal on a ratchet. After the packed box was placed on the stand for lidding, the lid was placed on the box. Then, the lid was pressed down by pressing a foot pedal and held in place for nailing.

The nail dispenser was a small box with slots in it. By occasionally shaking the box, the nails dropped into place with the points hanging down. These boxes were suspended above and within reach of the worker nailing the lid on the box.

Non-automatic, semi-automatic and automatic machines were used in some plants for lidding Northwestern boxes. All of these machines required placing the pads and lids on the boxes by hand.[1/] The basic difference in these machines was the manner in which the boxes were fed into and removed from the machines. Boxes were fed into and ejected medhanically by the automatic lidding machine. The semi-automatic machine required placing the boxes into the machine manually, but the boxes were removed from the machine mechanically. The automatic machines were positioned between two sections of the conveyor, so that each box moved through the machine without being manually lifted. The non-automatic machines did not allow the box to pass through. Therefore, it was necessary to place these machines on one side of the conveyor from which each box was removed manually and placed into the machine for lidding. After the boxes were lidded, they were then lifted from the machine and placed back on the conveyor for movement to temporary storage or the loading dock.

1/ On certain types of these machines, the ends of the lid were placed in horizontal slots in the machine above the box and the box was mechanically raised during the operation.

Effect of Size of Plant on Labor Efficiency

The efficiency of labor in lidding bushel baskets did not appear to be associated with the size of plant, but the efficiency of lidding was affected by the size of operation in plants packing Northwestern boxes. The average time required for lidding Northwestern boxes was 0.69 man-minutes per bushel as compared to 1.12 man-minutes per bushel for lidding bushel baskets. The Northwestern box is a type of container which can be lidded mechanically with very little hand labor, whereas lidding bushel baskets is primarily a manual operation. There are also additional operations required in lidding bushel baskets.

Northwestern Boxes: Considerable variation in labor requirements for the lidding operation was found among the different size plants packing Northwestern boxes. Considerable variation in labor requirements was also found within each size plant. The larger plants tended to use automatic lidding machines, while the smaller plants performed the operation manually with or without various mechanical aids (box lid clamps, nail dispensers, etc.). The relative efficiency of performing the operation in each size plant was largely determined by the output of the plant since a work crew and equipment were required for the operation whether performing at maximum capacity or not. Thus, the scale at which a plant operated did affect efficiency. For example, the time requirements for lidding Northwestern boxes ranged from 0.19 man-minute per bushel in Plant Number 7 to 1.50 man-minutes per bushel in Plant Number 4. Plant Number 7 was a large plant using an automatic machine, and Plant Number 4 was a medium-size plant using a non-automatic lidding machine. The operator in Plant Number 7 was lidding approximately 200 boxes per man-hour as compared to 45 boxes per man-hour in Plant Number 4. The lidder in Plant Number 7 was busy most of the time, whereas the lidder in Plant Number 4 was idle a considerable portion of the time.

The average labor requirement for lidding Northwestern boxes in the large plants was 0.29 man-minute per container as compared to 0.99 man-minute per container in the medium-size plants and 0.69 man-minute in the small plants. The large plants were able to effect considerable saving in labor by utilizing automatic and semi-automatic equipment. The medium and small plants used less equipment, and the efficiency of these plants was largely determined by output of plant, work methods used, and size of lidding crews.

<u>Bushel Baskets</u>: Lidding bushel baskets was largely a manual operation. Therefore, efficiency in the use of labor is largely determined by work methods used and obtaining balance in the size of crew. No significant difference was found in time requirements among the different size plants. The variation in labor requirements within each size group was considerable, which indicated that the size of crew and work method used influenced the efficiency of labor. The large plants packing bushel baskets had an average labor requirement of 1.15 man-minutes per bushel as compared to 1.04 man-minutes per bushel in the medium-size plants and 1.16 man-minutes per bushel in the small plants.

Effect of Work Methods, Equipment and Experience on Time Requirements for Lidding Containers

Northwestern Boxes: Time studies[1] revealed that there was a significant difference in the time requirements for lidding Northwestern boxes by different methods[2] and between experienced and inexperienced workers. As shown in Table 3, there was more variation between the skilled and unskilled workers in doing this job with a box lid clamp and nail dispenser than with any of the other methods. This difference was due primarily to the skill in handling containers when the box lid clamp was used as compared to other methods. The least difference between the skilled and unskilled worker in time requirement per box was with the automatic lidding machine. Thus, the findings indicate that as the number of times a box is handled dacreases and the less the worker is required to do, the margin between the time requirements for the skilled and unskilled worker becomes less.

In lidding by hand, both the inexperienced and experienced workers were more efficient when using only a nail dispenser than when using a box lid clamp and a nail dispenser. Table 3. The former method required less time because the box did not have to be lifted from a conveyor to the box lid clamp. Movement of the box from the conveyor

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1/ Time observation supplemented with unpublished data collected during 1953 and 1954 packing season in Virginia by R. L. Chambliss, Jr., Associate Professor of Agricultural Economics, Virginia Polytechnic Institute, Blacksburg, Virginia.

2/ Work methods are associated with type of equipment used.

to the box lid clamp required additional time. The lidder also had to pick up a lid to place on the box after it was placed on the stand. When the box was lidded by hand, the lidder normally had a lid in hand ready to place on the box by the time the box reached the lidding station.

The nail dispenser reduced the time requirements for all hand lidding methods for both the experienced and inexperienced workers. For instance, by adding the nail dispenser, the experienced worker using the box lid clamp was able to reduce the time requirements for this operation from 0.74 to 0.42 man-minute per box. Table 3.

Lidding with semi-automatic and automatic machines required less time than by any of the hand methods. Table 3. It was also found that experience did not affect efficiency as much as it did in the methods of lidding by hand. The lidding rate of the automatic machine was about twice that of the semi-automatic machine. Since both of these machines require an operator at all times, the relative efficiency in a particular plant is determined by the hourly output of the plant.

The automatic and semi-automatic lidding machines require sizeable capital investment for ownership. Thus, the fixed cost (depreciation, interest on investment, taxes, etc.) for these machines is relatively high and would be prohibitive unless lidding a sufficient volume to justify the investment required to own and operate them. The cost of owning and operating the semi-automatic and automatic machines is shown in Figure 24 and Tables 1 and 2 of the Appendix E.

Due to higher initial cost of the automatic lidding machine, the fixed cost of owning and operating it is higher than for the semi-automatic machine. However, when the volume of fruit to be lidded annually becomes greater than 60,000 bushels, the automatic lidding machine is more economical to use than the semi-automatic machine.

Table 3. Comparison of Time Required for Skilled and Unskilled Workers to Lid Northwestern Boxes by Various Methods, Selected Virginia Packing Sheds, 1953-1956.

Method	Time Requirement in Man-Minutes Per Box		
	Experienced Lidder	Inexperienced Lidder	Average
By hand	----	1.85	----
By hand and box lid clamp	0.74	----	----
By hand and nail dispenser	0.28	1.20	0.74
By hand with nail dispenser, box lid clamp	0.42	2.12	1.27
Semi-automatic machine	0.08	0.21	0.15
Automatic Lidding machine	0.06	0.08	0.07

The cost of lidding Northwestern boxes by a professional lidder on a piece-rate basis (1.25 cents per box) is shown by the horizontal line in Figure 24. Since these workers were paid on a piece-rate basis, it was assumed that the cost of lidding manually would be the same regardless of the number of boxes lidded annually.1/

1/ Professional lidders were paid 1.25 cents for lidding Northwestern boxes manually in this area during the 1956 packing season.

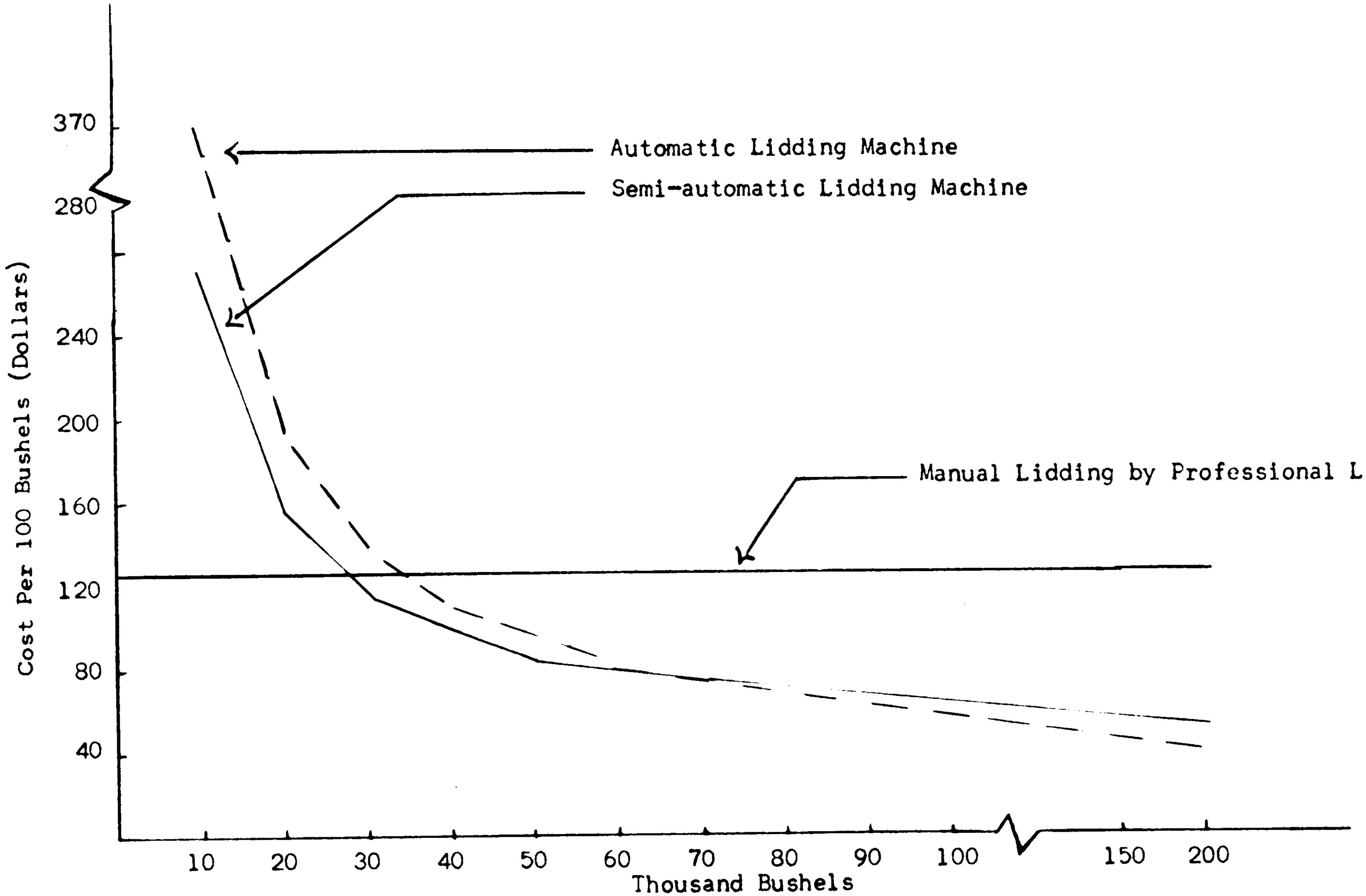

Figure 24. Comparison of Cost of Lidding Northwestern Boxes by Various Methods

Based on the findings of this study, it appears economical to substitute the semi-automatic machine for hand lidding if the machine is used at or near its capacity when lidding 35,000 bushels annually. Since the initial cost of the automatic machine was higher than that of the semi-automatic machine, it would require lidding approximately 40,000 bushels annually to enable the plant operator to use this machine instead of hiring the boxes lidded on a piece-rate basis. Figure 24.

Bushel Baskets: As indicated previously, there was very little variation in the labor requirements for lidding bushel baskets between different size plants. However, considerable variation occurred within plants of each size group. The plant using the most labor for this operation had five workers assigned to the job. In this plant, one worker placed the empty basket over the basket liner, one worker moved the inverted basket through the basket turner, one worker spread shredded oil paper on the apples, and two workers put the lid on the basket. No worker in the crew was employed fully at any time and it appeared that the crew size could have been reduced to four and possibly three men without reducing the total output. It required an average of 1.50 man-minutes per bushel in this plant to lid a container as compared to 0.67 man-minutes per bushel in one of the smaller plants where one man did the entire operation.

It appeared that one man was the most efficient size crew for this operation. It required an average of 0.94 man-minutes per bushel for one worker to perform the lidding operation. Plants using two workers had an average labor requirement of 1.00 man-minute per bushel. However, it must be pointed out that the output of one man is limited, and thus the crew size must be regulated to the output of the plant.

Cost of Lidding Containers

Bushel Baskets: The total cost of lidding bushel baskets varied directly with the labor requirement, as this was primarily a manual operation. Perhaps, a charge should be allocated to this operation for the cost of the basket turner and small hand tools, but these machines are relatively cheap and would not have a significant influence on the cost per bushel lidded. Thus, with a wage rate of 60 cents per hour, the cost of lidding bushel baskets ranged from 0.67 cent to 1.5 cents per bushel.

Northwestern Boxes: The average cost for lidding Northwestern boxes with the automatic and semi-automatic machines was roughly 0.7 cent per box. This cost was based on the volume of fruit lidded in each of the plants using these machines.

As shown in Tables 1 and 2 of the Appendix E, increase in size of operation would have a significant influence on the cost of lidding containers with automatic and semi-automatic machines. This cost would range from 3.7 cents to 0.39 cent per bushel as the volume of fruit increased from 10,000 to 200,000 bushels, if used with the same labor efficiency as found in this study.

The cost of equipment (box lid clamp, nail dispenser, hammer, etc.) for lidding Northwestern boxes manually would be infinitesimal on a per-box basis. Therefore, no charge was made for the use of this equipment in determining the cost for lidding boxes manually. Thus, the cost varies directly with the time requirements if workers are paid on an hourly basis.1/ Thus, it was found that the cost of lidding boxes with inexperienced lidders ranged from 1.2 cents to 2.1 cents per box.2/

1/ Experienced lidders were paid at the rate of 1.25 cents per box in the plants covered.

2/ Based on a wage rate of 60¢ per hour.

Work Methods and Equipment for Movement of Packed Containers to Temporary Storage, Cold Storage or Loading Dock

Packed containers were transported to temporary storage, loading dock or cold storage by various methods and types of equipment. The types of equipment used included: industrial fork-lift trucks, gravity conveyors, two-wheel hand-clamp trucks, and power chain conveyors.

The work methods employing power chain conveyors was the predominant one observed for this operation. Power conveyors were normally positioned to receive the containers directly from the lidding machine or lidding station without lifting the containers except in plants lidding Northwestern boxes manually with the box lid clamp. When the box lid clamp was used, the packed container was removed from the conveyor, lidded and placed back on the conveyor.1/

Power conveyors are like gravity conveyors--once they are full, the distance moved should not have a significant influence on the time requirements for the operation. The number of workers used in removing fruit from the conveyor and stacking it in temporary storage, cold storage, or movement to loading dock, had a significant influence on the labor requirements for this operation. For instance, Plant Number 8 had three workers removing containers from a power conveyor at the rate of 150 containers per hour and stacking them in temporary

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1/ Some lidders placed the lidded containers on the floor or a pallet for movement to temporary storage, cold storage, or loading dock with a two-wheel clamp truck, hand-jack truck, or industrial fork-lift instead of the power chain conveyor.

storage. Plant Number 3 had two workers removing 200 bushels per hour from a power conveyor and stacking one size in temporary storage and one size on a road truck. It is readily seen there was a wide variation in the number of bushels handled by these workers. This operation normally requires one or more workers to remain at a given place regardless of the containers packed, because these workers do not have sufficient time to perform other jobs in the plant during the intervals of time between containers, even though these workers are often idle a considerable portion of the time. Thus, the number of containers packed as well as the number of workers had a direct bearing on the efficiency of performing this operation.

One plant was observed where the boxes moved from an automatic lidding machine down a power chain conveyor a short distance. Then, one worker removed the packed containers from the conveyor and stacked them on the floor in units of five boxes.1/ When five boxes accumulated beside the power conveyor, two workers with hand-clamp trucks transported 160 bushels per man-hour 30 to 35 feet to a temporary storage area.

This plant used an industrial clamp-lift truck for the receiving operation, and could have used it for removal of packed fruit if the plant had been laid out properly. Using the industrial clamp-lift truck would have eliminated the two workers with hand-clamp trucks.

1/ Numbers were painted on the floor corresponding to each box count for segregation of the packed fruit.

By this method, the packed containers would have been stacked in unit loads of 24 or 30 boxes from the power conveyor.

Since most plants used power conveyors for this job, only a limited number of observations were made of this operation using other equipment and work methods. However, this job is a material handling operation and very similar to the receiving operation. The labor requirements for this operation are essentially the same as those for receiving fruit except for the additional personnel required to segregate the fruit according to size. Plants packing Northwestern boxes normally packed more sizes and required more workers for segregation of the fruit than plants packing bushel baskets. Since the different work methods and equipment for the receiving operation were discussed thoroughly in a previous section, the different methods and equipment for removal of packed containers will not be discussed further in this section.

Effect of Scale of Operation on Labor Efficiency

The size of plant was not directly associated with labor efficiency for this operation. It required an average of 0.83 man-minute per bushel in the large plants as compared to 0.96 man-minute per bushel in the medium-size plants and 0.84 man-minute per bushel in the small plants. Thus, there was very little difference in labor requirements between the large and small plant for the number of bushels handled in performing this job. The large plants used from two to four workers for this operation; the medium-size plants used one or two workers;

while only one worker was used in the small plants. The worker removing packed containers from the lidding station also lidded the containers in some of the small plants.

Time studies revealed that it was possible to handle more Northwestern boxes than bushel baskets per man-minute with material handling equipment. However, the average time requirements for movement of packed containers to temporary storage were greater in plants packing Northwestern boxes than in those packing bushel baskets. The average time for plants packing Northwestern boxes was 1.00 man-minute per box as compared to 0.74 man-minute for plants packing bushel baskets.

The labor requirement for this job in the large plants ranged from 0.60 man-minute per bushel to 1.06 man-minutes per bushel. The plant requiring the most time for this operation used three workers. One worker removed the lidded containers from the lidding stand and placed them on a gravity conveyor leading to the temporary storage area. Then two workers removed the containers from the conveyor and stacked them by size, grade, and variety. The plant using labor most efficiently in doing this operation used a power chain conveyor for transferring the packed containers to the temporary storage area and the loading dock. One worker removed one size of fruit from the conveyor and stacked it in temporary storage. The second worker removed another size from the conveyor and stacked it on a road truck for transporting to commercial cold storage.

The time requirements for this operation in the medium-size plants ranged from 0.54 man-minute per container to 1.50 man-minutes per container. The plant requiring the most time used a power conveyor and two workers for this job. However, the output of the plant was such that two workers were idle most of the time. As a result, the labor requirements for this operation were high in relation to other plants using similar equipment. The plant requiring the least amount of labor for this operation had the lidding machine positioned close to the loading dock, thereby requiring very little labor or equipment for movement of the packed containers to the loading dock.

The time requirements for transfer of the packed containers from lidding station to temporary storage varied from 0.56 man-minute per bushel to 1.33 man-minutes per bushel in the small plants. The plant requiring the most time did this operation manually, whereas the plant requiring the least time did the operation with power chain conveyor. In essence, one plant was substituting capital for labor in performing this operation.

Based on the findings of this study, it is concluded that increase in scale of operation was not as important as the number of bushels packed, method of handling the containers, and the number of workers assigned to the job. It appeared that greater efficiencies could be obtained in most plants by adjusting the crew more in line with the volume of fruit packed.

LABOR AND EQUIPMENT REQUIREMENTS, AND COST BY PLANTS

Total Labor Requirements by Different Methods, Types of Equipment and Size of Operation

This study showed the labor requirements for packing apples to vary widely between plants packing in the same type of containers and between plants packing in different types of containers. The average labor requirements for plants packing Northwestern boxes were 14.35 man-minutes per box as compared to 16.20 man-minutes per bushel for plants packing bushel baskets. Plants packing Northwestern boxes had slightly lower labor requirements because they tended to be more mechanized and used different methods of paying packers.

The time requirements for packing Northwestern boxes ranged from 11.40 man-minutes per box in Plant Number 7 to 19.61 man-minutes per box in Plant Number 10. Table 4. Plant Number 7 was the largest and most mechanized plant included in this study. It was equipped with an automatic destacker, automatic dumper, weight sizing units, power conveyors and an automatic lidding machine. The output of this plant was sufficient to permit substitution of equipment for labor economically and to utilize the labor required to operate the equipment efficiently. For example, one man with a machine did all the lidding from 17 packers, while, in some of the smaller plants, one man was required to remain at a machine to lid the boxes from only four packers.

Management also appeared to be very effective in Plant Number 7. One man did most of the supervision, but the owner made frequent inspections

Table 4. Labor in Man-Minutes Used for Different Operations in Packing Houses with Largest Part of Output Consisting of Wrap-and-Count Boxes, Northwestern Boxes, Virginia Apple Packing Houses, Fall 1956

Packing House Operation

PLANT	Mov. Fruit to Dumping Sta. Dumping & Rem. F. C.	Grading (Sorting)	Handling Table Sorts Culls and Ciders	Face and Filling	Lidding	Removal of Packed Containers	Misc. and Floating Pers.	Plant Foreman	Total
	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.
1	.34	1.72	5.34	5.00	1.00	1.00	.69	.34	15.43
2	.55	2.42	3.85	3.50	.35	1.06	.98	.33	13.04
4	.41	2.05	1.68	6.00	1.50	1.50	1.39	.41	14.94
6	.51	2.40	2.31	3.67	.92	.92	1.20	.45	12.38
7	.25	2.16	3.48	3.23	.19	.75	1.17	.17	11.40
9	.54	3.24	3.19	4.62	.33	.99	1.60	.27	14.78
10	1.16	4.95	3.00	5.20	.52	1.03	3.26	.49	19.61
13	1.34	2.68	2.31	4.20	.70	.78	.67	.67	13.35
T	5.10	21.62	25.16	35.42	5.51	8.03	10.96	3.13	114.87
A	.63	2.70	3.15	4.43	.69	1.00	1.37	.39	14.35

of the plant, which probably had a direct influence on the output of the workers.

Plant Number 10 was an ill-designed plant with the equipment poorly arranged. This plant had a tremendous floor space with the equipment spread out over a wide area. The equipment was arranged so that the apples had to be conveyed great distances, making several turns, resulting in inefficient use of equipment as well as of building space. With this type of plant layout, management also became a very difficult problem. In fact, management appeared to be much less effective in this plant than in the other plants included in this study.

The labor requirements for plants packing face-and-fill bushel baskets ranged from 12.87 man-minutes per bushel in Plant Number 15 to 20.04 man-minutes per bushel in Plant Number 14. Table 5. Both of these plants were considered small. The overall efficiency of Plant Number 15 appeared to be greater than that of Plant Number 14. Some of this difference was due to the sizing equipment; i.e., the output of Plant Number 14 was limited to some extent by the capacity of the sizing equipment. However, management appeared to be the biggest factor contributing to the greater efficiency in Plant Number 15.

Most of the supervision in Plant Number 15 was done by a woman who did a very effective job in shifting workers between operations as the need arose. This woman seemed to do a better job than the average man in this size plant. This may have been due to the fact that most of the employees were women.

Table 5. Labor in Man-Minutes Used for Different Operations in Packing Houses with Largest Part of Output Consisting of Face-and-Fill Bushel Baskets, Virginia Apple Packing Houses, Fall 1956

PLANT	Packing House Operation								
	Mov. Fruit to Dumping Sta. Dumping & Rem. F. C.	Grading (Sorting)	Handling Table Sorts Culls and Ciders	Face and Filling	Lidding	Removal of Packed Containers	Misc. and Floating Pers.	Plant Foreman	Total
	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.
3	.72	3.12	3.90	5.10	1.50	.60 1/	1.44	.36	16.74
5	.92	1.84	4.36	5.25	.75	.75	1.39	.46	15.72
8	.81	3.75	5.25	5.20	.80	.75	1.64	.23	18.43
12	1.30	2.60	3.33	5.35	1.07	.56	.64	.65	15.50
14	1.84	4.60	5.45	5.32	1.33	.67		.83	20.04
11	.72	2.66	3.00	4.68	1.08	.54	.75	.67	14.10
15	.80	2.40	2.22	3.99	1.33	1.33		.80	12.87
T	7.11	20.97	27.51	34.89	7.86	5.20	5.86	4.00	113.40
A	1.02	3.00	3.93	4.98	1.12	.74	.84	.57	16.20

1/ Baskets moved to loading dock on power conveyor, one man stacked Extra Fancy on Road Truck and one man stacked C-grade in temporary storage.

Effect of Scale of Operation on Labor Requirements for Packing Apples

Northwestern Boxes: The size of operation did not have any significant influence on the total labor requirements for plants packing Northwestern boxes. The average labor requirements were 13.07 man-minutes per box for the large plants, 15.78 man-minutes per box in the medium-size plants, and 13.55 man-minutes per box for the small plants. The labor requirements for the large plants ranged from 11.40 to 14.78 man-minutes per box. The labor requirements in the medium-size plants ranged from 12.32 to 19.61 man-minutes per box. Only one small plant was observed packing Northwestern boxes, but the labor requirements for this plant were 13.35 man-minutes per box.

It is easily seem that there were more variations within each group of plants than between various size plants. Therefore, it appeared that other factors had a greater influence on the labor requirements for packing Northwestern boxes than did the size of operation.

Bushel Baskets: The total labor requirements for packing face-and-fill bushel baskets were 17.58 man-minutes per bushel in large plants, 14.92 man-minutes per bushel in medium-size plants, and 16.13 man-minutes per bushel in the small plants. The labor requirements in the large plants ranged from 16.74 to 18.43 man-minutes per bushel. The labor requirements in the medium-size plants ranged from 14.10 to 15.72 man-minutes per bushel. The labor requirements in the small plants ranged from 12.87 to 20.04 man-minutes per bushel.

One can see that there was no significant difference in the time requirements within the large and medium-size plants, but that there was wide variation within the small plants. On the other hand, there was a significant difference in the average labor requirements between the large and medium-size plants, whereas there was very little difference between the large and small plants. Based on these findings, it could be concluded that increase in size of operation had a significant influence on the labor requirements up to a certain point. However, since the small plants overlapped both the large and medium-size plants, it is felt that these differences were due to work methods, equipment, management, and layout of the plants.

Table 6. Labor Requirements in Man-Minutes Per Bushel for Different Size Plants to Pack Bushel Units of Apples, Virginia Apple Packing Houses, Fall 1956.

Packing House Operation

PLANT	Mov. Fruit to Dumping Sta. Dumping & Rem. F. C.	Grading (Sorting)	Handling Table Sorts Culls and Ciders	Face and Filling	Lidding	Removal of Packed Containers	Misc. and Floating Pers.	Plant Foreman	Total
	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.	Minutes Per Bu.
				Small Plants					
14	1.84	4.60	5.45	5.32	1.33	.67		.83	20.04
15	.80	2.40	2.22	3.99	1.33	1.33		.80	12.87
13*	1.34	2.68	2.31	4.20	.70	.78	.67	.67	13.35
12	1.30	2.60	3.33	5.35	1.07	.56	.64	.65	15.50
T	5.28	12.28	13.31	18.86	4.43	3.34	1.31	2.95	61.76
A	1.32	3.07	3.32	4.71	1.11	.84	.66	.74	15.77
				Medium-Size Plants					
5	.92	1.84	4.36	5.25	.75	.75	1.39	.46	15.72
4*	.41	2.05	1.68	6.00	1.50	1.50	1.39	.41	14.94
11	.72	2.66	3.00	4.68	1.08	.54	.75	.67	14.10
10*	1.16	4.95	3.00	5.20	.52	1.03	3.26	.49	19.61
1*	.34	1.72	5.34	5.00	1.00	1.00	.69	.34	15.43
6*	.45	2.40	2.31	3.67	.92	.92	1.20	.45	12.32
T	4.00	15.62	19.69	29.80	5.77	5.74	8.68	2.82	92.12
A	.66	2.60	3.28	4.96	.96	.96	1.45	.47	15.35
				Large Plants					
7*	.25	2.16	3.48	3.23	.19	.75	1.17	.17	11.40
2*	.55	2.42	3.85	3.50	.35	1.06	.98	.33	13.04
8	.81	3.75	5.25	5.20	.80	.75	1.64	.23	18.43
3	.72	3.12	3.90	5.10	1.50	.60	1.44	.36	16.74
9*	.54	3.24	3.19	4.62	.33	.99	1.60	.27	14.78
T	2.87	14.69	19.67	21.65	3.17	4.15	6.83	1.36	74.39
A	.57	2.93	3.93	4.33	.63	.83	1.37	.23	14.87

* Denotes Plant Packing Northwestern Boxes
T Total Labor Requirements for Operation
A Average Labor Requirements for Operation

Cost Associated with Ownership

The owner of a packing house is faced with two types of cost: fixed cost and variable cost. In general, fixed cost will include such factors as depreciation of the plant and equipment, taxes, interest, insurance, and salaries of permanently employed personnel. Direct or variation cost is generally considered short-run in nature and changes in direct relation to the output of the plant. These costs are frequently referred to as operational costs and include such factors as: labor inputs, fuel and oil, packaging material, repairs, and maintenance of the equipment. These costs fluctuate in direct relation to the hours the plant is in operation and to the output of the plant.

Fixed cost generally occurs regardless of the output of the plant. Such costs are fixed and cannot be lessened by the plant remaining idle; thus, the per-unit fixed cost decreases as the output of the plant increases. The extent to which such economies may be gained through increasing the output of a given plant will depend upon the maximum capacity of the plant.

Fixed Cost

Depreciation: Depreciation allowances were made on buildings and packing house equipment due to wear and obsolescence of these items. The straight-line method of depreciation was used in this study. Equipment was depreciated on the basis of 15 years and buildings on a basis of 20 and 35 years. Pole and frame buildings[1] were depreciated on a 20-year basis and cinder-block buildings were depreciated on a 35-year basis.

In order to analyze the cost of owning and operating equipment and buildings on a comparable basis, replacement cost of buildings and equipment was used. The replacement cost of equipment was obtained from manufacturers. The replacement cost of the buildings was based on estimates obtained from the Department of Agricultural Engineering, Virginia Polytechnic Institute.

The estimated replacement costs of various type buildings are as follows:

1. Cinder-block construction with concrete or wood floors @ $2.50 per square foot of floor space.

2. Frame construction sheeted on inside, with concrete or wood floors @ $2.50 per square foot of floor space.

3. Frame construction, not sheeted on inside with concrete or wood floors @ $2.00 per square foot of floor space.

4. Pole-type construction, concrete floor @ $1.50 per square foot of floor space.

Most packing houses had one main floor with a second floor or attic under part of the roof for storage of packaging material. The cost for this additional space in the buildings was based on an estimate of the additional cost for this added construction in each of the plants

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1/ Technically, most of the frame buildings were of modified frame construction in that they were not finished on the inside and the studdings were spaced farther apart than would be recommended for a frame building.

individually. Since this added construction required only building the walls higher and putting in an extra floor, the cost for this space was figured from 15 to 33 1/3 per cent of the cost for the first floor.

Some packing houses were constructed jointly with cold storage facilities or buildings for other types of farm storage. In such cases, the replacement cost was based on the square feet of floor space devoted to the packing house operation.

A few of the packing houses were used for packing peaches during the summer months. Since peaches matured before the main crop of apples, they did not interfere with the apple packing operation during the fall months.[1/] Building and equipment cost for plants having this type of operation were prorated on the amount of use by each enterprise. For example, if one-third of the annual operating time of the plant was devoted to peaches, one-third of the building and equipment cost was charged to peaches assuming all of the building and equipment was used for peaches; otherwise, the fractional part of each was charged to peaches.

<u>Interest</u>: Anyone with capital in a capitalistic society can invest it or lend it to others and obtain a reasonable return for its use. On the other hand, anyone who borrows money must pay for the privilege of using the money. Thus, it is necessary to charge a percentage of

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1/ Some plants also packed a limited quantity of summer apples during the late summer months, but the chief apple packing operation was done during the fall months.

the capital invested in building and equipment as an expense of doing business. The rates returned on an investment vary with the type investment, and cost of borrowing money will vary between borrowers and lending agencies. Six per cent per annum was the most common rate charged by lending agencies on farm loans in this area at the time of this study. Therefore, an interest rate of six per cent was used as a basis of computing the cost of interest on various items of equipment and building.

Insurance and Taxes: These two items of fixed cost were omitted from the cost of operating plants because the cost of these items varies among counties, towns, cities, and individual plant owners.

Insurance rates for packing houses and equipment vary because of a number of factors such as: type of contruction, location of plant, accessibility to fire protection equipment, and the location of the plant relative to other fire hazards in the surrounding area. Some plant owners also desire a higher coverage of insurance than others which affects the total cost of insurance. In some plants, a night watchman is used to clean up and check for fires during the night. All of these factors will have an influence on the cost of insurance.

Taxes are generally lower in rural areas than in municipal areas, but there are wide variations in tax rates and also assesment rates within both rural and municipal areas. Therefore, it was felt that meaningful charges could not be established for these items of expense.

Operating Cost

Packing house equipment was powered with electric motors in all of the plants studied. Therefore, the main item of operating expense for equipment in the plants was electricity. Energy cost for electric motors was relatively low. A schedule of the rates for electricity was obtained from the Appalachian Electric Power Company, Christiansburg, Virginia. Table 1 of Appendix F. The rates of consumption for the various size electric motors were obtained from a study conducted by Pennsylvania State University.[1/] Table 1 of Appendix F. Since several of the plants were operated from the same electric meter as the dwelling, it was difficult to determine the exact cost of electricity for the various packing houses. Most plants would be in the high consumption bracket, paying 1.5 cents per kilowatt hour. This rate was used in deriving the cost of operating electric motors in this study. The cost of electricity for the various motors in the plants was calculated, but the total cost of electricity for the plants could not be determined in exact terms because of the electricity required for lights in the plants. Therefore, the cost of electricity was based on estimates received from each individual plant operator.

The cost of gasoline, oil, and lubrication was relatively small for the plants included in this study. Plants having industrial lift trucks estimated the cost of oil and gasoline for these machines to be

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1/ Adapted from unpublished data by William Butz, Pennsylvania State University.

approximately 11 cents per hour. This cost varied to some extent depending on the size or capacity of the machine; however, such variations were so slight that the effect on the per-unit cost of handling would be negligible.

Oil and lubrication for other equipment in the plants varied depending on the size of the plant and hours of annual operation. This cost ranged from five to ten dollars in most plants. Based on these costs, a standard rate, five dollars, seven and one-half dollars, and ten dollars, was charged to each respective size plant, small, medium, and large.

Maintenance and Repairs

Equipment: Most of the maintenance and repair work on apple packing house equipment was done during the non-packing season. However, some maintenance was frequently required during the packing season. The cost of maintenance was estimated by questioning plant operators and by referring to maintenance and repair rates used in the study by the Washington State Apple Commission and United States Department of Agriculture on apple handling equipment.[1/] Based on this information, it was determined that 20 per cent of other direct costs of operating the equipment would be a reliable figure to use for all types of packing

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1/ E. W. Carlsen, et. al., "Apple Handling Methods and Equipment in Pacific Northwest Packing and Storage Houses", Research Report No. 49, United States Department of Agriculture, Production Marketing Association, Washington 25, D. C., June 1953.

house equipment. This is slightly lower than estimates for repairs and maintenance used in some studies of cost and ownership of farm machinery; however, since apple packing equipment is protected from the weather, it was felt that this type of equipment would require less repairs and maintenance. Although the rate established may be slightly high or low for some particular piece of equipment, it is believed that this cost will adequately cover all minor repairs and maintenance jobs. However, it does not include major modifications or rebuilding of plant equipment.

Common repair jobs include such items as: replacing new brushes on the cleaner, splicing belts, replacing worn sprocket wheels, replacing broken rollers, etc. Most of these items have a relatively long period of usage, and repairs are infrequent. Perhaps brushes on the cleaner are the most frequently replaced items. Some growers had two cleaners in their plants: the better machine was used for picked fruit, and the other machine was used for "drop" apples. It was a common practice among these plant operators to replace the brushes on the better machine at intervals of one to two years to replace the brushes on the old machine with the brushes from the better machine.

<u>Building</u>: A charge for maintenance and repairs for buildings was based on estimates of engineers. Concrete buildings do not generally require much repairing except for the roof. Frame and pole-type buildings will normally require more repairs and maintenance than do concrete buildings. A rate of 1.75 per cent of the replacement cost was placed on frame and pole-type buildings, and 1.50 per cent of replacement cost on concrete buildings.

Labor Cost, Equipment and Building Cost by Different Methods, Types of Equipment and Size of Business

As pointed out previously in this thesis, the size of plants did not have a significant influence on labor requirements for the different packing house operations. Labor costs were very similar to labor requirements in regards to size of business, but there was a difference in the unit cost of equipment and buildings among the various size plants; i.e., the smaller plants tended to have a larger capital investment per bushel of fruit dumped than did the larger plants.

The average annual cost of buildings and equipment for all plants was 6.34 cents per bushel dumped. This cost ranged from 3.10 cents in Plant Number 2 to 21.88 cents per bushel in Plant Number 13. These two plants had different types of equipment and buildings. Plant Number 2 was a cinder-block building equipped with a chain sizing unit. Plant Number 13 was a frame building equipped with sizing equipment that sized on the basis of weight of the apples. Plant Number 2 had roughly four times the capital investment in buildings, and one-third more capital investment in equipment.[1] However, Plant Number 2 dumped 125,000 bushels of apples during the 1956 packing season as compared to 10,000 bushels in Plant Number 13, or approximately 12 times more apples. Thus, the difference in volume explained the variation in unit cost of buildings and equipment in these two plants.

1/ Capital investment in building and equipment based on replacement cost.

The average cost of buildings and equipment in the large plants was 4.13 cents per bushel dumped as compared to 5.12 cents per bushel in the medium-size plants, and 10.20 cents per bushel in the small plant. Thus, it is easily seen that size of plants had a significant influence in the cost of equipment and buildings per bushel dumped.

The average labor cost for all plants included in this study was 19.00 cents per bushel. Plants packing face-and-fill bushel baskets had an average labor cost of 15.77 cents per bushel, Table 7, as compared to 21.83 cents per bushel for plants packing Northwestern boxes. Table 8. Most of this difference was due to the method of paying the packers and differences in wage rates, as labor requirements per bushel dumped were less in plants packing Northwestern boxes than in plants packing bushel baskets. As indicated previously, all plants, except one, packing bushel baskets paid their employees on an hourly basis, whereas plants packing Northwestern boxes paid their employees on a piece-rate basis.

The labor cost for packing Northwestern boxes varied from 18.20 cents per box in Plant Number 2 to 25.25 cents per box in Plant Number 10. Both of these plants had chain sizers for the sizing operation and packed from packing tables. Plant Number 2 appeared to be well planned and laid out, whereas Plant Number 10 was poorly laid out. Management also appeared to be much more effective in Plant Number 2. Perhaps, there were other factors which had an influence on the labor cost in these two plants, but the above factors were considered to be the most important.

The total labor cost for plants packing bushel baskets ranged from 12.45 cents per bushel in Plant Number 15 to 20.80 in Plant Number 14.

Most of this difference was due to management in the plants, but some was due to the equipment. Plant Number 14 was equipped with sizing equipment which slowed the operation of the entire plant, whereas Plant Number 15 had sizing equipment of sufficient capacity for the other operations of the plant.

A comparison of operating cost by plant operations is shown in Table 7 for plants packing bushel baskets, and in Table 8 for plants packing Northwestern boxes.

Comparison of labor, equipment and building cost by size of plants is shown in Figure 25 and in Table 9.

Table 7. Total Labor Cost by Operation for Each Packing House with Largest Part of Output Consisting of Face-and-Fill Bushel Baskets, Virginia Apple Packing Houses, Fall 1956.

Packing House Operation

PLANT	Mov. Fruit to Dumping Sta. Dumping & Rem. F. C.	Grading (Sorting)	Handling Table Sorts Culls and Ciders	Face and Filling	Lidding	Removal of Packed Containers	Misc. and Floating Pers.	Plant Foreman	Total
	Cost Per Bushel (cents)	Cost Per Bushel (cents)	Cost Per Bushel (cents)	Cost Per Bushel (cents)	Cost Per Bushel (cents)	Cost Per Bushel (cents)	Cost Per Bushel (cents)	Cost Per Bushel (cents)	Cost Per Bushel (cents)
3	.72	2.20	3.47	4.41	1.40	.60	1.33	1.22	15.35
5	.92	1.53	4.36	4.38	.75	.75	1.31	1.19	15.19
8	.81	3.70	4.86	4.60	.80	.75	1.52	.78	17.82
12	1.30	2.17	3.33	4.81	1.07	.56	.64	1.31	15.19
14	1.84	3.83	5.45	4.88	1.33	.67	.92	1.88	20.80
11	.72	2.22	3.00	4.42	.99	.54	.75	.98	13.62
15	.80	2.00	1.85	3.33	1.33	1.33		1.81	12.45
T	7.11	17.65	26.32	30.83	7.67	5.20	6.47	9.17	110.42
A	1.02	2.52	3.76	4.40	1.10	.74	.92	1.31	15.77

Note: All labor cost allocated on basis of number of male and female employees assigned to each operation.
All grades of bushel baskets faced and filled included in arriving at above figures.

Table 8. Total Labor Cost by Operation for Each Packing House with Largest Part of Output Consisting of Wrap-and-Count Northwestern Boxes, Virginia Apple Packing Houses, Fall 1956.

Packing House Operation

PLANT	Mov. Fruit to Dumping Sta- Dumping & Rem. F. C.	Grading (Sorting)	Handling Table Sorts Culls and Ciders	Face and Filling	Lidding	Removal of Packed Containers	Misc. and Floating Pers.	Plant Foreman	Total
	Cost Per Bushel (cents)	Cost Per Bushel (cents)	Cost Per Bushel (cents)	Cost Per Bushel (cents)	Cost Per Bushel (cents)	Cost Per Bushel (cents)	Cost Per Bushel (cents)	Cost Per Bushel (cents)	Cost Per Bushel (cents)
1	.34	1.43	5.04	11.00	1.66	1.00	3.22	.88	24.57
2	.55	1.71	1.54	11.00	.58	1.06	.77	.99	18.20
4	.41	2.46	1.40	11.00	2.49	1.50	2.46	1.06	22.78
6	.45	2.33	2.31	11.00	1.53	.92	1.06	1.36	20.96
7	.25	2.40	3.48	11.00	.32	.72	1.10	.52	19.79
9	.54	3.60	3.19	11.00	.55	.99	1.46	.82	22.15
10	1.16	4.13	2.75	11.00	.86	1.03	3.06	1.26	25.25
13	1.34	2.23	2.31	11.00	1.16	.70	.67	1.51	20.92
T	5.04	20.29	22.02	88.00	9.15	7.92	13.80	8.40	174.62
A	.63	2.54	2.75	11.00	1.14	.99	1.72	1.05	21.83

Note: All labor cost allocated on basis of number of male and female employees assigned to each operation except packing of containers. Standard rate of 11 cents per box was allocated to Northwestern boxes.

Table 9. Labor, Equipment, and Building Cost Per Bushel by Plants and Size of Plant, Virginia Apple Packing Houses, Fall 1956*

Size of Plant**	Plant Number	Labor Cost	Equipment Cost	Building Cost	Total
Large					
	3**	15.35	1.83	1.90	19.08
	8**	17.82	1.63	2.22	21.67
	2 *	18.20	1.46	1.64	21.30
	9 *	22.15	2.10	1.99	26.24
	7 *	19.79	3.80	1.95	25.54
Average		18.66	2.16	1.97	22.76
Medium					
	11**	13.62	1.91	1.12	16.65
	5**	15.19	.98	1.70	17.87
	1*	24.57	3.75	2.00	30.32
	10*	25.25	3.64	8.13	37.02
	6*	20.96	2.68	2.55	26.19
	4*	22.78	3.29	1.83	28.40
Average		20.32	2.71	2.89	26.07
Small					
	15**	12.45	2.57	3.94	18.96
	14**	20.80	2.94	2.70	26.44
	12**	15.19	3.65	3.12	21.96
	13*	20.92	15.20	6.68	42.80
Average		17.34	6.09	4.11	27.55

* Denotes plants packing Northwestern Boxes.
** Denotes plants packing bushel baskets.

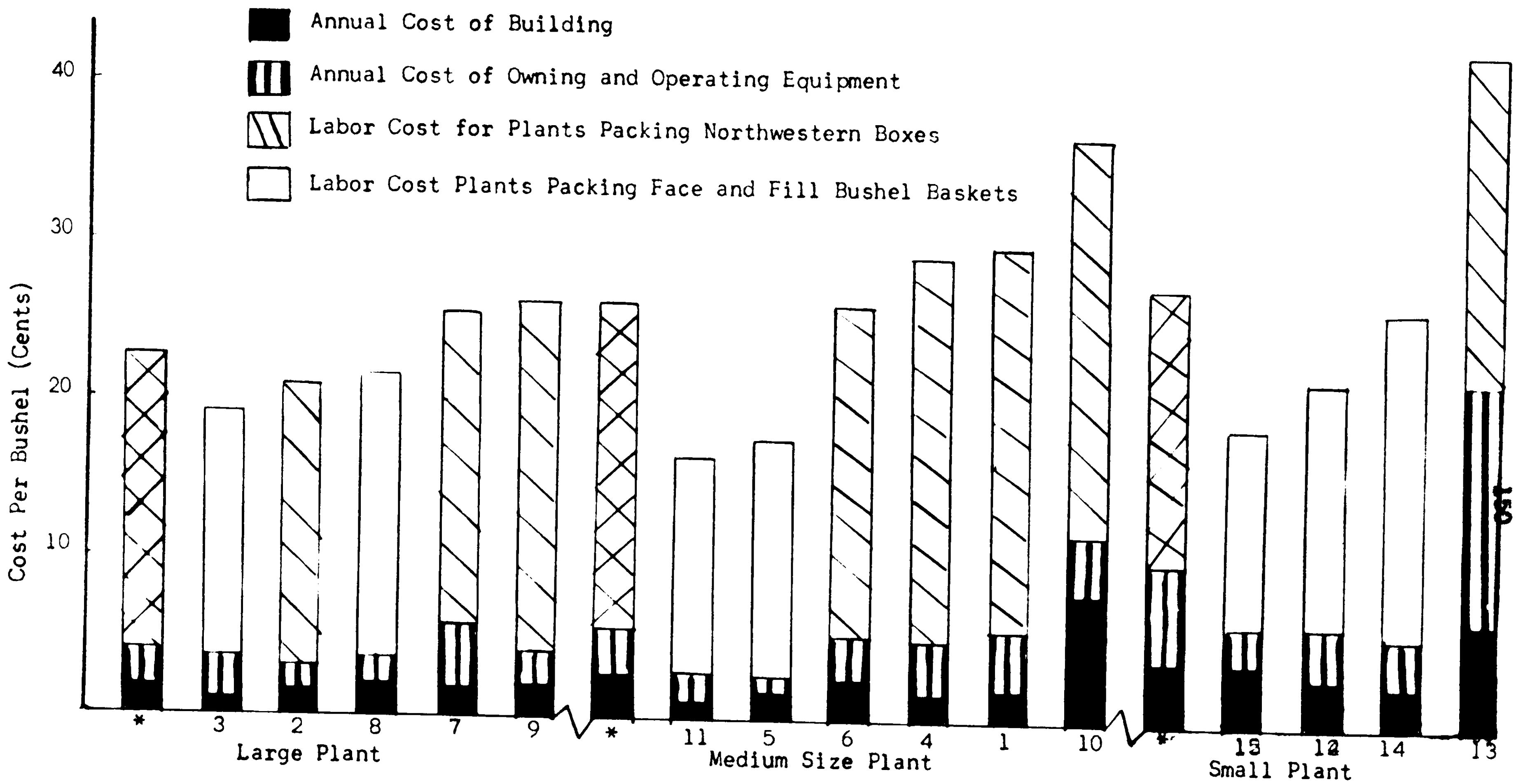

Figure 25. Cost Per Bushel (Labor, Equipment, and Building) All Operations Except Packing and Subsequent Operations Involving Handling of Packed Fruit on Basis of Volume Dumped, Labor Cost for Packing, Lidding, and Handling of Packed Fruit on Basis of Volume Dumped, Labor Cost for Packing, Lidding, and Handling of Packed Fruit Based on Bushel Packed.

* Denotes Average for Each Group of Plants

SUMMARY

Factors Affecting Cost of Packing Apples

This study was undertaken to determine the effect of different work methods, types of equipment, and the size of operation on the cost of packing apples in bushel units. The information in this study was based on plants packing from 9,000 to 108,000 bushels of apples during the 1956 packing season. The data collected at these plants revealed wide variations in methods of handling and packing apples which had significant influences on the cost of packing house operations. To determine the relative influence of these factors on the cost of packing apples, each of the major packing house operations was considered separately.

The most efficient method of receiving apples at the plant was with the industrial clamp-lift and industrial fork-lift trucks, handling unit loads of 24 and 60 field crates respectively, but the fixed cost of these machines limited their use to the larger plants. Gravity conveyors were the most widely used equipment for this operation in the smaller plants in Virginia. However, the findings indicated that the two-wheel hand-clamp truck was the most economical and efficient method of performing this operation in plants having insufficient volume to warrant the use of industrial lift trucks.

The size of business did not have a significant influence on the cost of the receiving operation except in the plants using industrial clamp-lift trucks and industrial fork-lift trucks. In these plants, the average cost per unit of fruit handled decreased with increase in scale of operation.

This study showed that the most efficient method of transferring fruit from the temporary storage area to the dumping station, dumping, and removing empty field crates was by hand, when the rate of dumping did not exceed 150 bushels per hour and when the fruit was moved less than 10 feet. If fruit was moved distances greater than 10 feet, a two-man crew, using a two-wheel hand-clamp truck, was most efficient when dumping less than 300 bushels per hour.

The automatic dumper without the automatic destacker is slower than most hand dumping methods, and is an inefficient method, as well as a costly method, because three men (the number used in most hand dumping methods) are required to perform the operation. On the other hand, this study showed the automatic destacker and automatic dumper used jointly to be efficient and economical to operate when dumping at a rate of 360 bushels per hour and 70,000 bushels per season, as only two men are required to operate this equipment.

It was only when the automatic dumping machines were used for this operation that an increase in scale of operation had a significant influence on the cost of doing this job. This was due to the fact that with hand dumping methods the cost of labor increased in a direct relation to the volume dumped and the cost of equipment used was negligible.

The grading operation was done mostly from reverse-roll tables. The efficiency of this operation depended largely upon the quality of the tree-run fruit, grading standards of the plant, and the quality of management. The influence of these three factors was well illustrated in the plant doing the operation most efficiently. In this plant, the tree-run fruit was of excellent quality, grading standards were high, and management was very effective. It was impossible to determine the exact influence of each of these factors, but management appeared to be highly important.

It appeared that many plant operators would do a more efficient and effective job of grading if the sorting tables were divided into lanes. By this arrangement, each sorter would be responsible for only a small part of the table instead of the entire table.

Table sorts, culls and cider apples were handled in basically the same manner in all plants. The degree of labor efficiency achieved in doing this job depended largely upon the volume of fruit going into these grades and the number of workers assigned to it. In most plants it appeared that one man could collect this fruit and transport it to a storage area with a two-wheel hand-clamp truck more efficiently than by any other method observed.

Two basic types of equipment are used in Virginia for sizing apples: dimensional sizer and weight sizer. Dimensional sizers are of two types: chain sizer and beveled-wheel sizer. The chain sizer was the predominant type used in this area. Dimensional chain sizers are cheaper and have a greater capacity than the weight sizer. The beveled-wheel sizer appeared to be comparable to the weight sizer in capacity and comparable to the chain sizer in cost.

Each of these sizers had some desirable and undesirable features. The weight-type sizer appeared to be more desirable for sizing Red

Delicious apples, especially for box-count packs. However, the weight-type sizer was not as desirable as the chain sizer for other varieties, or for packs requiring apples to be sized on the basis of the diameter of the apples.

Four types of packing equipment were used in Virginia: packing tables, packing bins, rotating tubs, and return-flow belts. This study revealed that more Northwestern boxes were packed per man-hour from rotating tubs than from other equipment, but tables and reverse-flow belts were more efficient for packing bushel baskets.

Packers of Northwestern boxes were paid universally on a piece-rate basis. The most common rate paid was 11 cents per box. Packers of face-and-fill bushel baskets were paid on an hourly basis, except in one plant in which they were paid on a piece-rate basis. The average cost of facing and filling bushel baskets, at current wage rates, was 4.40 cents per bushel.

The labor requirements for packing Northwestern boxes were 4.43 man-minutes per box, while the labor requirements for bushel baskets were 4.98 man-minutes per bushel. It is readily seen that labor requirements were slightly higher for the face-and-fill bushel basket, but this difference is felt to be primarily due to the method of paying the packers. Since packers of Northwestern boxes were paid on a piece-rate basis, they worked at a much faster rate than workers facing and filling bushel baskets.

This study only included two types of containers, but several methods were followed in the lidding operation. Bushel baskets were lidded manually except for the use of a manually operated basket turner for turning the inverted baskets to an upright position for lidding.

Small hand tools were also used for this operation, but the entire operation could be considered a manual one.

Lidding Northwestern boxes was done with and without mechanical aid. The most efficient method of lidding these boxes was with the automatic lidding machine, but the high capital requirements for these machines prohibit their use in the smaller plants. Thus, the smaller plants must rely on lidding boxes with or without the use of nail dispensers and box-lid clamps. This study showed that lidding by hand with the aid of the nail dispenser was a more efficient method than with the aid of the box lid clamp and nail dispenser.

Increase in scale of operation had a significant influence on the cost of lidding with semi-automatic and automatic machines. With an increase in scale of operation, the cost per box lidded decreased.

This study revealed that lidding approximately 35,000 bushels annually would be required to justify owning and operating the semi-automatic lidding machine. The automatic lidding machine would require lidding approximately 40,000 bushels annually.

Movement of packed containers to temporary storage, cold storage or the loading dock was done by various methods and types of equipment. Work methods using the power chain conveyor predominanted. The labor requirements for this job depended largely upon the method of handling the packed container and the type of containers. Plants packing Northwestern boxes normally packed more sizes than did plants packing bushel baskets. Consequently, there were more sizes of fruit to segregate when packing in Northwestern boxes and,therefore, slightly more labor was required for this operation. However, the volume of fruit packed and the number of workers assigned to this job largely determined how efficiently it was done. The workers in some plants were idle a considerable portion of the time and could have often handled a larger volume of fruit.

The biggest bottleneck in plant operation in several of these plants was found to occur at the packing station. This problem was created by having too much fruit of one size moving to one packing station at which there was room for only one or two workers. As a result, some workers had more work to do than they could accomplish, while others were idle. It is believed that this problem could be overcome by having more flexibility in the size of packing stations and effective management in regulating the size of fruit dumped.

The total labor requirements for plants packing face-and-fill bushel baskets were 16.20 man-minutes per bushel as compared to 14.35 man-minutes per box for plants packing Northwestern boxes. Most of this difference was due to the method of paying packers. In addition, there were more plants in the small size group packing bushel baskets, which fact perhaps had a slight influence on the total labor requirements.

The total cost of labor for plants packing face-and fill bushel baskets was 15.77 cents per bushel. The total labor cost for plants packing Northwestern boxes was 21.83 cents per box. This variation was attributed primarily to a difference in the method of paying packers of Northwestern boxes.

The total cost (labor, equipment and building) for plants packing bushel baskets was 20.83 cents per bushel as compared to 29.73 cents per box for plants packing Northwestern boxes. Most of this difference was due to labor cost, but the average capital investment in plant and equipment was higher in plants packing Northwestern boxes. Perhaps, this was due to the sample of plants selected, but plants packing Northwestern boxes tended to be more mechanized and better equipped than plants packing bushel baskets.

CONCLUSION

It appears that many apple growers in Virginia are "penny wise and dollar foolish". Several apple growers are attempting to pack apples with obsolete and antiquated equipment of poor design which increases their operating cost. It is not uncommon for many growers to lose several hundred dollars worth of fruit each year due to inadequate facilities for harvesting and packing their crop when it has reached the proper stage of maturity. In many instances, such losses could be reduced if proper facilities for handling and packing the fruit were available. Savings of this nature would probably more than offset the added capital investment in buildings and equipment needed by growers adequately to handle their crop.

On the other hand, there are some plant operators who think that all they need to do is to mechanize their operation. As pointed out previously in this thesis, some operations can be performed more efficiently manually than with mechanical equipment. Proper work methods, balance in crew size for each operation, and balance in capacity of equipment for various plant operations, were found to be most important in operational efficiency of the plants.

Based on the findings of this study, it is concluded that increase in size of plants had very little influence on the labor requirements for packing apples in plants ranging from 9,000 to 100,000 bushels. However, the smaller plants had a higher total cost per bushel packed than did the larger plants because of higher per-unit fixed cost in equipment and buildings.

This study indicated that many plant operators in Virginia could increase the efficiency of their operations by the following practices:

1. Use of two-wheel hand-clamp trucks instead of gravity conveyors for the following plant operations: receiving fruit, transporting fruit from temporary storage to the dumping station, and movement of packed fruit from the lidding station to temporary storage or the loading dock.

2. Adjustment of crew size to maintain balance within each operation. For instance, multiples of three men were shown to be most efficient in the receiving operation when gravity conveyors were used.

3. Dividing the sorting tables into lanes and assigning sorters to specific lanes. This would not only increase the efficiency of the sorters, but would also lead to improvement in the quality of their work.

4. Providing sorting tables of sufficient width so that center lanes could be used for second-grade fruit. Also provide chutes on the side for removal of cull apples.

5. Maintaining balance in the capacity of equipment and crews between various operations in the plant. For example, if the maximum output of any operation in the plant is 100 bushels per hour, the output of the entire plant will be limited to 100 bushels per hour even if other parts of the plant are able to handle 300 bushels per hour.

6. Providing movable divider boards instead of stationary dividers on the packing tables. This practice would aid in preventing apples from piling up at one or two packing stations while others are practically empty.

7. Arrangement for effective utilization of equipment and building space. This involves arranging equipment so that crew interference and non-productive effort is minimized.

8. Substitution of lidding machines for hand lidding of boxes if volume is sufficient. The annual volume required for substituting machines for hand labor at present costs and wage rates is approximately 35,000 bushels for the semi-automatic machine and 40,000 bushels for the automatic machine.

9. Use only a nail dispenser in hand lidding Northwestern boxes. (The use of a box lid clamp lowered the efficiency of both experienced and inexperienced workers.)

10. Visiting other plants to observe and seek improvements in equipment, plant layouts, methods of handling and packing apples, etc. This practice is followed by many of the larger plant operators, and it appears to pay big dividends for the time, money and effort spent.

It was beyond the scope of this study and will require further research, but it appeared that many apple growers in Virginia would profit by having cold storage facilities on their farms. This arrangement would permit packing orders directly from storage, and would increase the keeping qualities and market value of apples. Perhaps more important, cold storage facilities would permit growers to harvest their apples more timely, and reduce losses due to adverse weather conditions.

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APPENDIX A

Labor and Wage Rates For Operation Virginia Apple Packing Houses, Fall 1956

Labor For Operation of Packing Houses

Most of the labor force used in packing sheds was recruited from local sources, except for workers packing Northwestern boxes. The latter workers and their supervisors were recruited largely from Florida, and packed other fruits and vegetable during other seasons of the year. Since most of these workers specialized in packing other fruits and vegetables, they possessed more skill and speed in packing than the local workers. However, several growers stated that the work of such transient labor was not as satisfactory as local employees. They maintained these packers did not pack the apples as well as local packers and had a tendency to move on to other jobs when the peak of the packing season was over. Some operators also reported a tendency of transient labor to quit during the peak of the packing season because of minor grievances, or even due to dissensions among crew members. In an effort to overcome these problems, some growers paid the packers a bonus of one cent for each box packed if they worked all season.

A large part of the local help comes from families of workers kept on the farms as year-round employees. These workers are generally furnished a house, garden, milk cow and other living perquisites in addition to their usual wages. During the non-harvest season, the regular farm workers are assigned to various jobs on the farm such as: pruning trees, spraying trees, and miscellaneous repair jobs on buildings and equipment. The more experienced of these workers who have lived on the farms for relatively long periods of time are generally assigned to some position with greater responsibility such as: orchard foreman, plant maintenance man, or in charge of sales to local customers and truckers. Most of the labor force in a packing house requires a relatively high degree of physical stamina and experience. However, some jobs such as unloading field crates from road trucks, stacking packed containers, and catching cull apples, require less skill than physical stamina. Other jobs such as dumping tree-run fruit from field crates, grading apples, packaging apples, etc., require workers of good physical condition and experience for satisfactory performance. For instance, the worker responsible for the dumping operation is often required to work at a fairly rapid rate from eight to ten hours a day. He also must appreciate the capacity of the plant, work load of other workers in the plant, and regulate his rate of dumping accordingly.

Workers assigned to the task of grading (or sorting) must have an understanding of the established standards for the grades to be packed. These workers are responsible for inspecting each apple and removal of objectionable fruit as the apples move past them on the sorting table. This job requires physical stamina and coordination. These workers sit or stand at a sorting table eight to ten hours per day which becomes very fatiguing as they must focus their eyes on the moving apples and coordinate the movement of their hands with their eyes. Most plant operators give their employees a ten-minute break during the morning and afternoon. This practice of providing some rest for the employees seemed to improve their efficiency.

Although the grading operation does become an arduous task, it must be done effectively to meet the established standards for the various grades of apples. Experience and aptitudes appeared to be the most important prerequisites for this job. The most experienced or best graders are normally assigned to a position on the end of the sorting table, and make the final inspection of the fruit.

The workers packing Northwestern boxes probably possessed more skill and experience than any other groups in the plant. The process of learning to grasp a sheet of wrapping paper, place an apple in it, twist the paper around the apple, and place the apple in the box, requires several hours of practice to become proficient.

Wage Rates

Data were collected in the packing houses in physical terms--i.e., man-minutes required per bushels for the major packing house operations. However, for clarity and presentation in more meaningful terms to the reader, cost in monetary terms was also applied to the various operations.

One of the objectives of this study was to compare the cost of packing apples for various size operations. In order to make comparisons on a similar basis, it was necessary to establish a standard wage rate for the various packing houses.

The workers observed in this study were paid by various methods. The most common method of paying regular packing house employees was on an hourly basis. Some employees were also paid a bonus at the end of the year's business in addition to their regular wages, but this information was not available when the data for this study were collected.

Wage rates for regular plant employees observed in this study ranged from 50 cents to $1.00 an hour for women and from 60 cents to $1.00 an hour for men. However, based on a weighted average of all workers employed in the 20 plants, the average wage rate for men was 71.5 cents an hour and for women was 60.8 cents an hour. The most common wage rate paid was 60 cents an hour for men and 50 cents an hour for women. Variation in wage rates paid by the plants appeared to be due to the location of the plant and whether the workers lived on the farm of the plant operator. Plants observed within corporate limits of towns paid $1.00 per hour to both male and female employees. Plants located on farms paid different rates, but the plants located nearer industrial centers generally paid higher wages to their employees than plants located further from industrial centers.

Since 60 cents an hour for men and 50 cents an hour for women were the most common wage rates paid during the 1956 packing season in the plants included in this study, these wage rates were used in computing labor cost for workers performing various jobs in the plants, except for those jobs requiring a greater degree of skill of for those jobs done on a piece-rate basis. These wage rates may appear slightly low, but most of these workers received other perquisites. In addition, most of these workers received year-around employment, while other workers were employed for only eight weeks during the packing season and must seek other employment during other seasons of the year.

Industrial fork-lift and clamp-lift truck operators, workers operating automatic lidding machines, packers of Northwestern boxes, and hand lidders of Northwestern boxes generally require considerably more skill and experience than other workers in the plant. Industrial lift truck operators and men operating automatic and hand lidding machines for Northwestern boxes were paid from 70 cents to $1.20 an hour, depending upon the location of the plant. Based on these wage rates, it was decided that one dollar per hour would be the most satisfactory standard to use in computing the labor costs for performance of these jobs.

The wage rate for packing Northwestern boxes ranged from 10 to 12 cents, but 11 cents per box was the prevalent rate paid. Packers with more experience and skill usually packed 150 to 175 boxes per ten-hour day, and packers with less skill and experience packed from 100 to 125 boxes in the same period of time. These packers generally have an agreement among themselves to rotate packing stations every half-hour or hour, so that each packer will spend an equal amount of time at each packing station. Since these workers were paid universally on a piece-rate basis, the wage rate for this operation was computed for each plant on the basis of 11 cents per container.

Since the plants in this study were classified as large, medium, and small, it was found necessary to compute the cost of plant foremen in these plants on the basis of each group of plants individually. Several of the larger plants hired a plant foreman in addition to the general foreman, whereas in the medium and small size plants the supervision was generally done by the owner. Since most of the plant supervision in the smaller plants was done by the owner of the plants, their wage rate was based on what these growers thought it would cost them to hire a plant foreman, assuming one could be found to do the job. These growers estimated different amounts, but, based on an average of their estimates, $85 per week for medium size plants and $75 per week for small plants appeared to be reasonable wage rates. Thus, these wage rates were used in computing costs of plant foremen in the small and medium size plants.

Wage rates paid to plant foremen in larger plants ranged from $100.00 to $125.00 per week. Most of the foremen worked in the plants only during the apple packing season. However, some of the foremen worked for the owners of the plants on a yearly basis. The wage rates for foremen working on a yearly basis were approximately the same as for those who worked only during the harvest season. Based on wage rates paid to the foremen in the larger plants, $115 per week was felt to be the appropriate change to use.

Some of the larger plants hired a state inspector in addition to the other employees. The services of these inspectors cost the plant operator $110 per week. Since the main function of these inspectors was to inspect the fruit, the cost of the inspector was charged to the grading operation. Perhaps, part of this cost should have been prcrated to the sizing operation, but the sizing operation was done mechanically, and no labor cost was charged to it directly.

There are likely to be variations from the preceding allocation of labor cost in apple packing houses in future years, but the degree of such variation would be impossible to determine. With increased plantings of young trees during recent years, more trees coming into production, and a decreasing supply of farm labor, it is anticipated that the cost of packing house labor is likely to be higher in future years (assuming the same level of industrial activity and wage rates in future years). However, the extent of any future increase in wage rates is at best a guess. Therefore, the wage rates in the preceding section were used for computing labor cost for the various packing house operations in this study.

APPENDIX B

Cost of Receiving Apples With Various Types of Equipment and Different Rates of Annual Use, Virginia Apple Packing Houses, Fall 1956

Table 1. Cost of Receiving Various Volumes of Fruit at Different Wage Rates With Two-Wheel Hand-Clamp Truck Selected Virginia Apple Packing Houses Fall 1956

Thousand Bushels Handled Annually	Est. No. of Trucks required	Ownership 1/ and operating Cost Per 100 Bushels	Labor Cost Per 100 Bu. 2/			Cost Per 100 Bu.		
			A	B	C	A'	B'	C'
		(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)
10	1	.13	.23	.38	.57	.36	.51	.70
20	1	.07	.23	.38	.57	.30	.45	.64
30	2	.08	.25	.42	.63	.33	.50	.71
40	2	.06	.25	.42	.63	.31	.48	.69
50	2	.05	.25	.42	.63	.30	.47	.68
60	3	.06	.28	.46	.69	.34	.52	.75
70	3	.05	.28	.46	.69	.33	.51	.74
80	3	.05	.28	.46	.69	.33	.51	.74
90	3	.04	.28	.46	.69	.32	.50	.73
100	3	.04	.28	.46	.69	.32	.50	.73
150	4	.03	.31	.51	.76	.34	.54	.79
200	4	.02	.31	.51	.76	.33	.53	.78

1/ Initial cost of clamp truck $100 ownership and operating cost includes: depreciation (15 years-straight line method), interest six per cent of average capital investment, repairs and maintenance estimated at $2.50 per truck annually.

2/ Labor cost based on three different wage rates (A) 60 cents an hour (B) $1.00 an hour and (C) $1.50 an hour.

Table 2. Comparison of Ownership and Operation of 2,000 pound Industrial Clamp Lift Truck at Various Levels of Annual Use[1/] Virginia Apple Packing Houses, Fall 1956

Thousand Bushels Handled Annually[5/]	Equipment Cost Per 100 Bushels		Labor Cost Per 100 Bu.[4/]			Total Cost Per 100 Bushels Handled		
	Fixed Cost[2/]	Operating[3/]	A	B	C	A'	B'	C'
	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)
10	3.44	.03	.16	.25	.35	3.63	3.72	3.82
20	1.72	.03	.16	.25	.35	1.91	1.98	2.10
30	1.15	.03	.16	.25	.35	1.33	1.43	1.53
40	.86	.03	.16	.25	.35	1.05	1.14	1.25
50	.67	.03	.16	.25	.35	.86	.95	1.05
60	.57	.03	.16	.25	.35	.76	.85	.95
70	.49	.03	.16	.25	.35	.68	.77	.87
80	.43	.03	.16	.25	.35	.62	.71	.81
90	.38	.03	.16	.25	.35	.57	.66	.76
100	.34	.03	.16	.25	.35	.53	.62	.72
150	.23	.03	.16	.25	.35	.42	.51	.61
200	.17	.03	.16	.25	.35	.36	.45	.55

1/ Cost based on gasoline operated machine at $3560

2/ Fixed cost includes depreciation (straight line--15 years) and interest at six per cent of the average capital investment. Insurance and taxes omitted because of variation from area to area.

3/ Operating cost includes repairs maintenance, gas, and oil. Gas and oil based on information obtained from owner of this machine (eight cents an hour). Repairs and maintenance estimated at 20 per cent of operating cost.

4/ Labor cost figured at three different wage rates: (A) clamp lift operator at $1.00 an hour and road truck driver at 60 cents an hour. (B) clamp lift operator at $1.50 an hour and road truck driver at $1.00 an hour and (C) $2.00 an hour for fork lift operator and $1.50 an hour for road truck driver.

5/ Volume over 130,000 bushels projected.

Table 3. Comparison of Ownership and Operation of 2000 Pound Industrial Fork Lift at Various Levels of Annual Use[1] Virginia Apple Packing Houses, Fall 1956

Thousand Bushels Handled Annually[5]	Equipment Cost Per 100 Bushels: Fixed Cost[2]	Equipment Cost Per 100 Bushels: Operating Cost[3]	Cost of Pallets Per 100 Bu. Handled	Labor Cost[4] Per 100 Bushels: A	Labor Cost Per 100 Bushels: B	Labor Cost Per 100 Bushels: C	Total Cost Per 100 Bushels: A'	Total Cost Per 100 Bushels: B'	Total Cost Per 100 Bushels: C'
	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)
10	2.80	.03	.11	.32	.50	.70	3.26	3.47	3.67
20	1.40	.03	.07	.32	.50	.70	1.82	2.03	2.23
30	.93	.03	.07	.32	.50	.70	1.35	1.56	1.76
40	.70	.03	.05	.32	.50	.70	1.10	1.31	1.51
50	.56	.03	.04	.32	.50	.70	.95	1.16	1.36
60	.47	.03	.04	.32	.50	.70	.86	1.07	1.27
70	.40	.03	.04	.32	.50	.70	.79	1.00	1.20
80	.35	.03	.04	.32	.50	.70	.74	.95	1.15
90	.31	.03	.04	.32	.50	.70	.70	.91	1.11
100	.28	.03	.04	.32	.50	.70	.67	.88	1.08
150	.19	.03	.03	.32	.50	.70	.57	.78	.98
200	.14	.03	.03	.32	.50	.70	.52	.73	.93

1/ Cost based on gasoline operated machine at $2900.

2/ Fixed cost includes depreciation (straight line - 15 years) and interest at six per cent of average capital investment. Insurance and taxes omitted because of variation from area to area.

3/ Operating cost includes repairs, maintenance, gas and oil. Gas and oil based on information obtained from owner of this machine. (Ten cents per hour). Repairs and maintenance estimated at 20 per cent of operating cost.

4/ Labor cost figured at three different rates : (A) fork lift operator at $1.00 an hour and road truck driver at 60 cents an hour, (B) clamp lift operator at $1.50 an hour and road truck driver at $1.00 an hour and (C) $2.00 an hour for fork lift operator and 1.50 an hour for road truck driver.

5/ Volume over 100,000 bushels projected.

Table 4. Comparison of Ownership and Operation of 4,000 Pound Industrial Fork Lift at Various Levels of Annual Use(1) In Virginia Apple Packing Houses, Fall 1956

Thousand Bushels Handled Annually 5/	Equipment Cost Per 100 Bushels		Cost of Pallets Per 100 Bu. Handled	Labor Cost 4/ Per 100 Bushels			Total Cost Per 100 Bushels		
	Fixed Cost 2/	Operating Cost 3/		A	B	C	A'	B'	C'
	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)
10	4.04	.04	.11	.11	.18	.25	4.30	4.37	4.44
20	2.02	.04	.07	.11	.18	.25	2.24	2.31	2.39
30	1.35	.04	.07	.11	.18	.25	1.57	1.64	1.71
40	1.01	.04	.05	.11	.18	.25	1.21	1.28	1.35
50	.81	.04	.04	.11	.18	.25	.98	1.05	1.12
60	.67	.04	.04	.11	.18	.25	.86	.93	1.00
70	.58	.04	.04	.11	.18	.25	.77	.84	.91
80	.51	.04	.04	.11	.18	.25	.70	.77	.84
90	.45	.04	.04	.11	.18	.25	.64	.71	.78
100	.40	.04	.04	.11	.18	.25	.59	.66	.73
150	.27	.04	.03	.11	.18	.25	.45	.52	.59
200	.20	.04	.03	.11	.18	.25	.38	.45	.52

1/ Cost based on gasoline operated machine at $4042.

2/ Fixed cost includes depreciation (straight line--15 years) and interest at six per cent of average capital investment. Insurance and taxes omitted because of variation from area to area.

3/ Operating cost includes repairs, maintenance, gas and oil. Gas and oil based on information obtained on similar size machine. (Ten cents per hour). Repairs and maintenance estimated at 20 per cent of operating cost.

4/ Labor cost figured at three different rates : (A) fork lift operator at $1.00 an hour and road truck driver at 60 cents an hour, (B) clamp lift operator at $1.50 an hour and road truck driver at $1.00 an hour and (C) $2.00 an hour for fork lift operator and $1.50 an hour for road truck driver. Labor cost projected on basis of labor cost of 6000 pound capacity truck observed.

Table 5. Comparison of Ownership and Operation of 6000 Pound Industrial Fork Lift at Various Levels of Annual Use[1/] Virginia Packing Houses, Fall 1956

Thousand Bushels Handled Annually	Equipment Cost Per 100 Bushels: Fixed Cost[2/]	Equipment Cost Per 100 Bushels: Operating Cost[3/]	Cost of Pallets Per 100 Bu. Handled	Labor Cost[4/] Per 100 Bushels: A	Labor Cost Per 100 Bushels: B	Labor Cost Per 100 Bushels: C	Total Cost Per 100 Bushels: A'	Total Cost Per 100 Bushels: B'	Total Cost Per 100 Bushels: C'
	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)
10	5.80	.04	.11	.11	.18	.25	6.06	6.13	6.20
20	2.90	.04	.07	.11	.18	.25	3.12	3.19	3.26
30	1.93	.04	.07	.11	.18	.25	2.15	2.22	2.29
40	1.45	.04	.05	.11	.18	.25	1.65	1.72	1.79
50	1.16	.04	.04	.11	.18	.25	1.35	1.42	1.49
60	.97	.04	.04	.11	.18	.25	1.16	1.23	1.30
70	.83	.04	.04	.11	.18	.25	1.02	1.09	1.16
80	.73	.04	.04	.11	.18	.25	.92	.99	1.06
90	.64	.04	.04	.11	.18	.25	.83	.90	.97
100	.58	.04	.04	.11	.18	.25	.77	.84	.91
150	.39	.04	.03	.11	.18	.25	.57	.64	.71
200	.29	.04	.03	.11	.18	.25	.47	.54	.61

1/ Cost based on gasoline operated machine at $6000. Cost estimated above volume of 48,000 bushels annually.

2/ Fixed cost includes depreciation (straight line--15 years) and interest at six per cent of average capital investment. Insurance and taxes omitted because of variation from area to area.

3/ Operating cost includes repairs, maintenance, gas and oil. Bas and oil based on information obtained from owner of this machine. (ten cents per hour). Repairs and maintenance estimated at 20 per cent of operating cost.

4/ Labor cost figured at three different rates : (A) fork lift operator at $1.00 an hour and road truck driver at 60 cents an hour, (B) clamp lift operator at $1.50 an hour and road truck driver at $1.00 an hour and (C) $2.00 an hour for fork lift operator and $1.50 an hour for road truck driver.

APPENDIX C

Cost of Dumping Fruit With Automatic Dumper, Automatic Destacker and Automatic Dumper at Different Levels of Annual Use, Virginia Apple Packing Houses, Fall 1956

Table 1. Cost of Dumping Field Crates With Automatic Dumper Without Destacker at Various Levels of Use and at Different Wage Rates[1] Virginia Apple Packing Houses Fall 1956

Thousand Bushels Dumped Annually	Equipment Cost Per 100 Bushels		Labor Cost Per 100 Bushels Dumped[4]			Total Cost Per 100 Bushels Dumped		
	Fixed[2] Cost	Operating [3] Cost	A	B	C	A'	B'	C'
	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)
10	2.54	.01	.82	1.36	2.05	3.37	3.91	4.60
20	1.77	.01	.82	1.36	2.05	2.60	3.14	3.83
30	.85	.01	.82	1.36	2.05	1.68	2.22	2.91
40	.64	.01	.82	1.36	2.05	1.47	2.01	2.70
50	.50	.01	.82	1.36	2.05	1.33	1.87	2.56
60	.42	.01	.82	1.36	2.05	1.25	1.79	2.48
70	.36	.01	.82	1.36	2.05	1.19	1.73	2.42
80	.31	.01	.82	1.36	2.05	1.14	1.68	2.37
90	.28	.01	.82	1.36	2.05	1.11	1.65	2.33
100	.25	.01	.82	1.36	2.05	1.08	1.62	2.30
150	.17	.01	.82	1.36	2.05	1.00	1.55	2.23
200	.13	.01	.82	1.36	2.05	.96	1.51	2.19

1/ Cost of machine based on replacement cost $1600

2/ Fixed cost includes depreciation (15 years--straight line method) and interest at six per cent of average capital investment.

3/ Operating cost includes repair, maintenance, oil and electricity. Repairs, maintenance and oil estimated at two cents per hour of operation. Electricity based on operation of 1 H.P. meter at an estimated cost of one cent per hour of operation. Machine dumping at rate of 220 bushels per hour.

4/ Labor cost figured at three different wage rates : (A) 60 cents an hour, (B) $1.00 an hour, and (C) $1.50 an hour. Labor cost includes three workers . one worker placing boxes on conveyor leading to dumper, one worked feeding boxes into machine and one worker stacking empty field crates. Dumping 220 field crates per hour (Dumping rate based on time studies under normal operating conditions).

Table 2. Cost of Dumping Field Crates With an Automatic Destacker and Dumping Machine at Various Level of Annual Use and at Different Wage Rates 1/ Virginia Apple Packing Houses Fall 1956

Thousand Bushels Dumped Annually	Equipment Cost Per 100 Bushels		Labor Cost Per 100 Bushels Dumped 4/			Total Cost Per 100 Bushels Dumped		
	Fixed 2/ Cost	Operating 3/ Cost	A	B	C	A'	B'	C'
	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)
10	4.06	.02	.33	.56	.83	4.41	4.64	4.91
20	2.03	.02	.33	.56	.83	2.38	2.61	2.88
30	1.35	.02	.33	.56	.83	1.70	1.93	2.20
40	1.02	.02	.33	.56	.83	1.37	1.60	1.87
50	.81	.02	.33	.56	.83	1.16	1.39	1.66
60	.68	.02	.33	.56	.83	1.03	1.26	1.53
70	.58	.02	.33	.56	.83	.93	1.16	1.43
80	.51	.02	.33	.56	.83	.86	1.09	1.36
90	.45	.02	.33	.56	.83	.80	1.03	1.29
100	.40	.02	.33	.56	.83	.75	.98	1.25
150	.27	.02	.33	.56	.83	.62	.85	1.12
200	.21	.02	.33	.56	.83	.56	.79	1.06

1/ Cost of machines based on replacement cost. Box dumper $1600 and destacker $2600

2/ Fixed cost includes depreciation (15 years--straight line method) and interest figured at six per cent of average capital investment in machines.

3/ Operating cost includes repairs, maintenance, oil, and electricity. Repairs, maintenance and oil estimated at four cents per hour of operation. Electricity based on operation of 2-one H.P. motors.

4/ Labor cost figured at three different wage rates: (A) 60 cents an hour, (B) $1.00 and (C) $1.50 per hour. Labor cost includes two workers: one placing on floor chain conveyor or leading to machine and one man stacking empty field crates. Dumping 360 field crates per hour. (Dumping rate based on time studies under normal operating condition).

APPENDIX D

Cost Packing Material, Virginia Packing Houses, Fall 1956

Table 1. Packaging Material Cost, Virginia Packing House Fall 1956

Type of Pack and Item	Cost Per Unit (Cents)	
Wrap and Count Northwestern Box		
Shook Material	55.5	
Assemble Box	2.25	
Nail to assemble box and put lid on	2.00	
Liner for boxes	5.30	
Wrapping	8.00	
Total		73.05
Face and Fill Bushel Basket (Tub Bottom)		
Bushel Basket including lid	42.50	
Basket lines (Purple)	5.19	
Basket Lid Cushion	4.64	
Shredded oil paper (25¢ per lb.)	3.00	
Total		55.33
Face and Fill Bushel Basket (Stare or flat Bottom)		
Bushel Basket including lid	38.33	
Basket Liner (Plain)	4.87	
Basket Lid Cushion	4.64	
Shredded oil paper (25¢ per lb.)	3.00	
Total		50.84
Tray Pack in Fiberboard Cartons (200 lb. test wt.)		
Tray Pack Container (unassembled)	31.0	
Fiber trays (assuming five per box) 4.3 ea.	21.5	
Staples	.4	
Total		52.9
Nine Five-pound consumer bags in Master Carton		
Master Carton (unassembled)	21.10	
Divider	6.30	
Nine five-pound bags (Printed) 2.5 ea.	22.5	
Bag Closures or staples	.4	
		50.30

APPENDIX E

Table 1

Cost of Owning and Operating Semi-Automatic and Automatic
Lidding Machines at Various Levels of Annual Use.
Virginia Apple Packing House, Fall 1956

Table 1. Estimated Cost of Owning and Operating Automatic Lidding Machine Virginia Apple Packing House, Fall 1956

Boxes Lidded Per Season	Fixed Cost 1/ Per 100 Bu.	Direct Cost 2/ Per 100 Bu.	Total Cost Per 100 Bu.
(Bushels)	(Dollars)	(Dollars)	(Dollars)
10,000	3.48	.22	3.70
20,000	1.74	.22	1.96
30,000	1.16	.22	1.38
40,000	.87	.22	1.09
50,000	.70	.22	.92
60,000	.58	.22	.80
70,000	.50	.22	.72
80,000	.44	.22	.66
90,000	.39	.22	.61
100,000	.35	.22	.57
150,000	.23	.22	.45
200,000	.17	.22	.39

1/ Fixed cost based on automatic machine at cost of $3600, fixed cost includes depreciation (15 years) and interest at six per cent of average capital investment in machine. Insurance and taxes omitted because of variation among different areas.

2/ Direct cost based on time observations, lidding at rate of 100 boxes per 7 minutes, however, due to delays in operation 20 per cent allowance was made. This cost included labor ($1.00 per hour), electricity (5 H.P. Motor - 1.5 cent per Kwhr.). Maintenance and repairs based on 10 per cent of Labor and Electricity cost.

Table 2. Estimated Cost Owning and Operating Semi-Automatic Lidding Machine Virginia Apple Packing House, Fall 1956

Boxes Lidded Per Season	Fixed Cost[1] Per 100 Bu.	Direct Cost[2] Per 100 Bu.	Total Owning and Operating Cost Per 100 Bu.
(Bushels)	(Dollars)	(Dollars)	(Dollars)
10,000	2.32	.40	2.72
20,000	1.16	.40	1.56
30,000	.77	.40	1.17
40,000	.58	.40	.98
50,000	.46	.40	.86
60,000	.39	.40	.79
70,000	.33	.40	.73
80,000	.29	.40	.69
90,000	.26	.40	.66
100,000	.23	.40	.63
150,000	.15	.40	.55
200,000	.12	.40	.52

1/ Fixed cost based on semi-automatic lidding machine at cost of $2400. Fixed cost included depreciation (15 years) and interest at six per cent of average capital investment in machine. Taxes and insurance omitted because of variation among different areas.

2/ Direct cost based on time observations lidding at rate of 100 boxes per 17.5 minutes ; however, due to unavoidable delays 20 per cent allowance was made. This cost included labor ($1.00 per hour), electricity(3 H.P. motor - 1.5 cents per Kwhr) Maintenance and repairs based on 10 per cent of labor and electricity cost.

APPENDIX F

Power Consumption for Various Size Electric Motors and Monthly Rates for Electricity, Christianburg, Virginia, 1956

Table 1. Average Electric Power Consumption for Various Size Motors[1] a Monthly Rates

	Rated Horsepower						
	1/8	1/4	1/3	1/2	3/4	1	1 1/2
	Re# Kwh/	Re# Kwh/	Re# Kwh/	Re# Kwh/	Re# Kwh/	Re# Kwh/	Re# Kwh/
Average Load	.12	.19	.22	.27	.53	.62	1.11
Theoretical Load	.09	.19	.25	.37	.56	.75	1.20
75% Theoretical Load	.68	.14	.19	.28	.42	.56	.90

	Rated Horsepower						
	2	3	5	7 1/2	10	15	20
	Re# Kwh/	Re# Kwh/	Re# Kwh/	Re# Kwh/	Re# Kwh/	Re# Kwh/	Re# Kwh/
Average Load	1.41	2.00	4.29	4.32	7.19	7.75	9.31
Theoretical Load	1.49	2.24	3.73	5.60	7.46	11.19	14.92
75% Theoretical Load	1.12	1.68	2.80	4.20	5.60	8.39	11.19

Note: Use 75% of theoretical load
Adapted from unpublished data, by William Butw, Pennsylvania State University
Wattage drawn at time of reading

Monthly Electric Rates of Appalachian Power Company, Christiansburg, Virginia. Effective on all bills rendered on and after May 1, 1956

For the first 40 Kwhrs used per month -- 5.0 cents per Kwhr
For the next 40 " " " " -- 4.0 " " "
For the next 120 " " " " -- 2.7 " " "
For all over 200 " " " " -- 1.5 " " "

APPENDIX G

Estimated Cost of Buildings, Virginia Apple Packing Houses, Fall 1956

Table 1. Estimated Annual Fixed Cost of Buildings Based on Replacement Cost Virginia Apple Packing Houses Fall 1956

Plant	Type of Construction	Estimated Replacement Cost 1/	Annual Cost of Ownership: Depreciation	Repairs	Interest	Total	Cost Per Bushel Dumped (Cents)	Cost Per Bushel Packed (Cents)
1	Frame	$5,771.60	$288.58	$101.00	$173.15	$562.73	2.00	4.73
2	Cinder Block	27,945.00	798.43	419.18	838.35	2,052.96	1.64	2.23
3	Frame	18,982.50	635.91	222.57	569.48	1,240.02	1.90	3.00
4	Frame	7,247.70	362.38	126.83	217.43	706.64	1.83	3.81
5	Frame	8,730.75	436.53	152.79	261.92	680.99	1.70	2.96
7	Frame	26,806.50	1,340.33	469.11	804.20	2,613.64	1.95	2.41
8	Pole	22,809.60	1,140.48	399.17	684.29	2,223.94	2.22	2.61
9	Frame	39,900.00	1,845.52	645.81	1,107.11	3.598.44	1.99	3.60
10	Cinder Block	98,477.50	2,813.64	1,477.16	2,954.33	7.245.13	8.13	14.44
12	Frame	5,760.00	149.00	50.40	86.40	280.80	3.12	4.12
14	Frame	4,989.25	249.46	87.31	149.68	486.45	2.70	3.24
11	Frame	4,320.00	172.80	60.48	103.68	336.96	1.12	1.34
15	Frame	6,480.00	324.00	113.40	194.40	631.80	3.94	5.26
6	Frame	12,360.00	525.30	183.85	313.65	1,022.80	2.55	2.55
3	Frame	6,856.60	342.83	119.99	205.69	668.51	1.90	7.82

Plant Number 3,9,5,11,6 and 12 packed peaches in addition to apples. Building cost in these plants prorated on basis of annual use by each enterprise. Above figures include charge prorated to apples.

1/ Based on estimates furnished by Dept. of Agric. Eng. V.P.I. on cost per square foot of replacing various type buildings.