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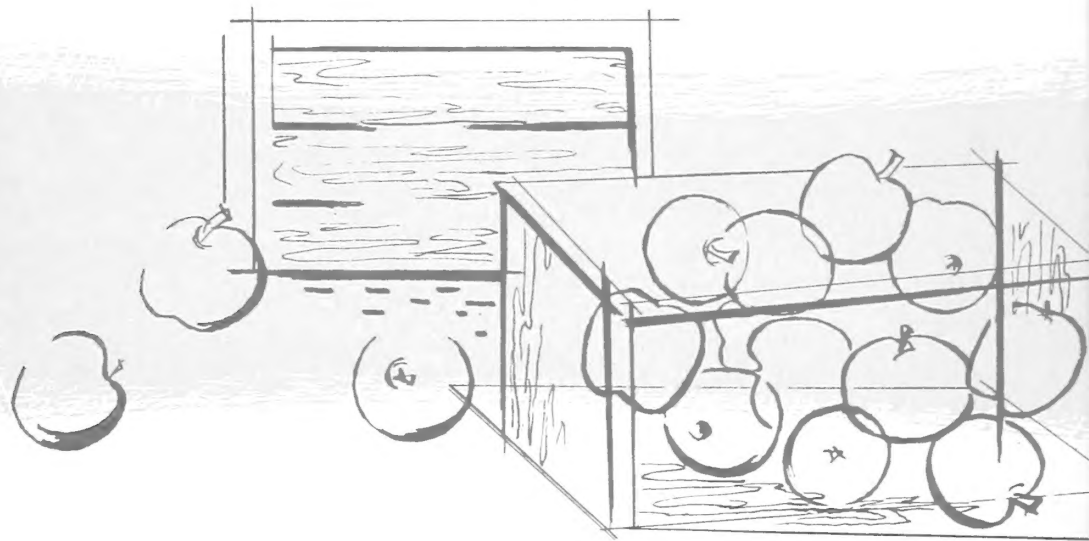
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# Comparative Costs of Handling

# APPLES

# at Packing and Storage Plants

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Marketing Research Division  
Agricultural Marketing Service  
United States Department of Agriculture

Marketing Research Report No.215



## PREFACE

This is the fifth report published by the Agricultural Marketing Service from data submitted by the Washington State Apple Commission in fulfillment of a research contract with the U. S. Department of Agriculture. The first four reports are Marketing Research Report No. 49, "Apple Handling Methods and Equipment in Pacific Northwest Apple Packing and Storage Houses;" Marketing Research Report No. 68, "Innovations in Apple Handling Methods and Equipment;" Marketing Research Report No. 71, "Handling Empty Apple Boxes in Pacific Northwest Packing and Storage Houses;" and Marketing Research Report No. 130, "The Effect of Apple Handling Methods on Storage Space Utilization." A final report summarizing the findings in these five is planned.

"Methods and Costs of Loading Apples in the Orchard in the Pacific Northwest," Marketing Research Report No. 55, published by the Agricultural Research Service of the Department in January 1954, summarizes another phase of the study.

Some of the results of this research are now available in summary form through the U. S. Department of Agriculture film entitled "Apple Handling Methods." Another film, entitled "Apple Packing Methods," summarizes studies of cleaning, sorting, sizing, packing, and other operations in preparing apples for market, which also were conducted by the Commission under a contract with the Department. Prints of these two films may be obtained on a loan basis from:

Agricultural Extension Service, College of Agriculture, Cornell University, Ithaca, N. Y.

Agricultural Extension Service, Colorado A. & M. College, Ft. Collins, Colo.

Visual Aids Service, University of Illinois, 713½ South Wright Street, Champaign, Ill.

The research contract under which this study was made was administered by William H. Elliott, head, Handling and Facilities Research Section, Transportation and Facilities Branch, Marketing Research Division, Agricultural Marketing Service.

The study was conducted under the supervision of Joseph F. Herrick, Jr., agricultural economist, of the Handling and Facilities Research Section.

Credit is due to Max E. Brunk, professor of marketing, Cornell University, and Frederick C. Winter, associate professor of industrial engineering, Columbia University, consultants to the Transportation and Facilities Branch, for their guidance and many valuable suggestions.

Washington, D. C.

March 1958

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Washington 25, D. C. Price 45 cents.





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## SUMMARY

In recent years, apple packinghouse operators in the Pacific Northwest have become concerned over increasing costs involved in receiving, packing, and loading out fruit. Many operators using conventional handling methods are searching for materials-handling equipment which will handle the same volume of fruit with fewer workers, at lower cost, and with minimum bruising and other damage to fruit. This report shows the relative labor and equipment costs of performing handling operations by use of various types of currently used equipment in 1- and 2-floor plants for different volumes of business. Because of the wide variations among plants, the costs for packing line operations, general supervision, and permanent facilities were excluded from the study.

Types and combinations of types of equipment considered in this report are: (1) Clamp-type 2-wheel hand trucks alone on 1 floor; (2) 36-box electric industrial clamp lift trucks on 1 floor; (3) 48-box electric industrial fork-lift trucks on 1 floor; (4) clamp-type 2-wheel hand trucks and belt conveyors on 2 floors; and (5) 24-box electric industrial clamp lift trucks and belt conveyors on 2 floors.

Plant layouts designed to handle 100,000, 200,000, and 400,000 boxes of apples stacked 12 high in storage were devised from a basic storage unit of 50,000 boxes. These layouts are not intended to represent typical, composite, or ideal designs, but units on the basis of which handling costs of actual plants may be computed.

The 36-box industrial clamp lift truck method was the most economical of the 5 methods in both 1- and 2-floor plants for the 3 volume levels considered, except in the 100,000-box plant; the 48-box industrial forklift truck method showed the lowest cost at this level. Compared with the industrial lift truck methods, labor and equipment costs were relatively high for those methods using clamp-type 2-wheel hand trucks in both 1- and 2-floor plants.

The lowest cost for 1- and 2-floor, 100,000-box plants was obtained with the 48-box industrial forklift truck method. All operations, except segregating packed boxes as they come off the packing line and stowing boxes in railroad cars, were performed by one forklift truck. Labor and equipment costs by this method amounted to \$4,139 per year. The cost difference, however, between this method and the next lowest cost method was relatively small. The next lowest cost method, at \$4,628 per year, was by use of two 36-box industrial clamp lift trucks. The highest cost method, at \$6,390 per year, was by use of 2-wheel hand trucks and belt conveyors in the 2-floor plant; of the 5 methods, this showed the highest labor cost. The 24-box industrial clamp lift truck and belt conveyor method had the highest equipment cost because 3 lift trucks-- 2 on the first floor and 1 on the second--are needed to perform daily handling operations during the peak receiving period. Total cost difference between the 2 methods used in the 2-floor plant was very small: The cost was \$6,390 for the method using hand trucks and conveyors vs. \$6,261 for the method using 24-box industrial lift trucks.

For the 200,000-box, 1- and 2-floor plants, the 36-box industrial clamp lift truck system was the lowest cost method, labor and equipment costs amounting

to \$6,393 per year. However, total costs by use of 48-box industrial forklift trucks, the next lowest cost method, were \$6,445, which was less than 1 percent greater. Three lift trucks were required by the lowest cost method and two by the next lowest cost method. In the 2-floor plant, labor and equipment costs for the 24-box lift truck and conveyor method were \$9,672 per year, which was \$1,524, or 14 percent, less than the cost of the clamp-type 2-wheel hand truck and belt conveyor method.

The method using the 36-box industrial clamp lift truck showed the lowest cost of the 5 methods in the 400,000-box plants also. Labor and equipment costs for this method were \$12,207 per year. Total costs for the 48-box industrial forklift truck system, the next lowest cost method, were \$12,411 per year; this is less than 2 percent greater than for the lowest cost method. Of the 5 methods, that using hand trucks and conveyors in the 2-floor plant had the highest cost, at \$21,763. This compares with \$16,676 for the 24-box industrial clamp lift truck and conveyor method.

Determination of the most efficient type or combination of types of equipment must be made on an individual-plant basis. It has been shown that the most economical method for the 1-floor, 100,000-box plant was by use of the 48-box industrial forklift truck. However, in many older plants, low ceilings and closely spaced posts or columns in storage areas restrict stacking heights to 9 or 10 boxes and interfere with the stacking arrangement; thus, the ability of this equipment to high-stack boxes cannot be used to good advantage.

Several factors must be considered in the wise selection of handling equipment for any given plant. Among these are: (1) Travel distances; (2) layout and design of plant; (3) necessary remodeling of plant, if any; (4) expected volume to be handled; (5) capital outlay for equipment; (6) maintenance of quality of fruit; and (7) available labor supply, particularly at the peak of harvest. The number and size of lots received from growers also may affect the decisions of some operators.

COMPARATIVE COSTS OF HANDLING APPLES AT  
PACKING AND STORAGE PLANTS

By Charles H. Meyer,  
agricultural economist  
Marketing Research Division

BACKGROUND AND BASIS OF THE STUDY

This report stems from the need of operators of apple packing and storage plants for ways of estimating plantwide handling costs when using different types of materials-handling equipment. Because of labor shortages, particularly during harvest, and increased wage rates for plant workers, many operators are searching for more efficient handling equipment which would enable them to maintain or increase the volume of fruit packed with fewer workers and at lower cost, and also to maintain optimum fruit quality. The object of this report, therefore, is to show relative efficiencies of currently used types of equipment, in plants of given design and layout and at different levels of operation.

The report employs data and information from Marketing Research Report No. 49, U. S. Department of Agriculture, "Apple Handling Methods and Equipment in Pacific Northwest Packing and Storage Houses." That report was designed to present ways, on an industrywide basis, for increasing the productivity of labor in fruit handling operations, making possible increases in the rates of performing critical operations during harvest periods, reductions in total labor costs, and maintenance of optimum fruit quality. This report develops cost and operating data applicable to individual plants.

Assumed Conditions Used to Compute Labor and  
Equipment Requirements and Costs

Estimated plantwide handling costs were computed for plant layouts of given dimensions, using standard data on the time required to perform the necessary operations with various types and combinations of types of equipment. Since several plant layouts were used for different types of handling equipment, the data given in this report may be adapted to most existing plants, with different volumes and methods of handling. In cases where volume and floor arrangements differ from those used here, plant operators can compute estimates by interpolation, adjusting the estimates on the basis of actual plant size and conditions.

For purposes of this report, the operations were limited to the following: (1) Receiving boxes of apples and moving them to storage or to

temporary supply bank in packing room; (2) moving unpacked boxes from storage to temporary supply bank; (3) moving boxes from temporary supply bank to packing line; (4) segregating packed boxes; (5) moving packed boxes from packing room to storage; (6) blocking out packed boxes in storage and moving them to shipping area; and (7) moving packed boxes from shipping area to railroad cars, and loading them. These include all handling operations typically performed in moving apples into, within, and out of apple packing and storage houses. Costs of the packing line, management, and permanent facilities are not considered here.

The scope was further limited to types and combinations of types of equipment currently used in 1- and 2-floor apple packing and storage houses. These are: (1) Clamp-type 2-wheel hand trucks alone, on 1 floor; (2) 36-box electric industrial clamp lift trucks, 1 floor; (3) 48-box electric industrial forklift trucks, 1 floor; (4) clamp-type 2-wheel hand trucks and belt conveyors 2 floors; and (5) 24-box electric industrial clamp lift trucks and belt conveyors, 2 floors (fig. 1-5).

The 24-box industrial clamp lift truck, being relatively light and maneuverable, was used instead of the 36-box industrial clamp lift truck in 2-floor plants. This lightweight truck can be used on a floor that has a fairly low floor-load capacity. Furthermore, the lightweight truck can maneuver more easily than larger trucks in storage rooms having columns and posts. The 36-box industrial clamp lift truck weighs about 40 percent more than the 24-box truck and requires about 20 percent more floor area to maneuver.



NEG. BN-4610

*Figure 1.--Clamp-type 2-wheel hand truck.*

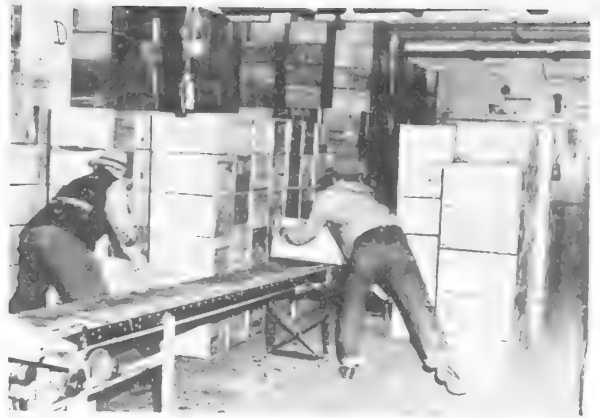


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*Figure 2.--36-box industrial clamp-type lift truck.*



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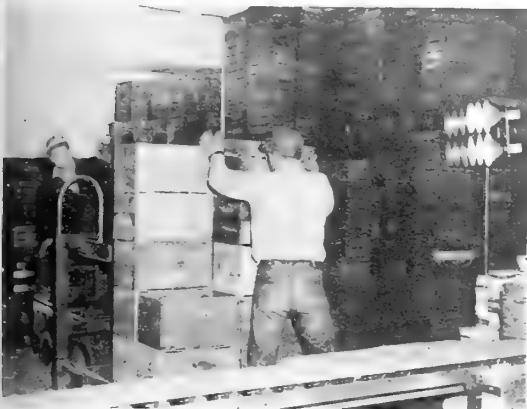


NEG. BN-5121

Figure 3.--48-box industrial forklift truck.

Figure 4.--Type of belt conveyor used with clamp-type 2-wheel hand trucks.

### Plant Layouts



NEG. BN-5122

Figure 5.--24-box electric industrial clamp-type lift truck.

The layouts for plants handling 100,000, 200,000, and 400,000 boxes a year were developed from a basic storage unit 88 feet wide and 100 feet long (fig. 6). With boxes stacked 12 high, this unit has a capacity of 50,000 boxes when clamp-type 2-wheel hand trucks are used. Because more floor area is needed for the 12-foot aisles required to operate industrial lift trucks, the capacity of the basic unit in 1-floor plants, with boxes stacked 12 high, is about 38,000 boxes. In 2-floor plants, using 24-box industrial lift trucks in 9-foot aisles, the unit capacity is slightly greater than 38,000 boxes.

These layouts represent packing and storage plant structures in general, to which existing standard time data can be applied. They are not intended to represent typical packing and storage plants, because there are over 250 plants of various sizes, designs, and ages in the State of Washington alone. Nor do they necessarily depict composite plants or ideal designs.

A simple way of increasing storage capacity would be to add rows of bays to the 88- by 100-foot standardized unit. This, however, would not serve the purpose of most plant operators. Although this study was limited to plants receiving 100,000, 200,000, and 400,000 boxes, conclusions may be drawn on the handling of smaller or greater quantities of fruit. It was assumed that an operator of a small plant would utilize his storage space to the fullest extent before expanding it or erecting a new structure. Other reasons considered for adhering to the 50,000-box unit were: (1) To retain partitions to permit refrigeration of storage areas as needed; (2) to permit changing

over to other types of handling equipment (in cases involving plant expansion) as volume of business and travel distances increased; and (3) to retain some semblance of prevailing structures.

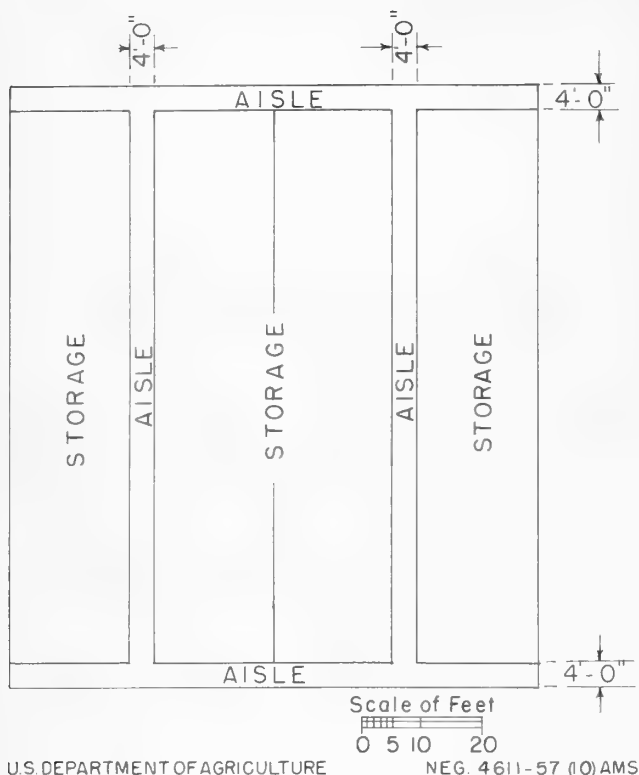


Figure 6.--Basic storage unit of 50,000-box capacity for clamp-type 2-wheel hand truck, when unpacked boxes are stacked 12 high.

storing boxes of apples by variety, size, and grade and for transit convenience were in identical or similar patterns for plants of any capacity; (6) plant layouts were used only for reference purposes and did not necessarily represent particular plants, or typical or composite plants; (7) methods and procedures were practical, and complied closely with prevailing industry practices; (8) travel was over fixed routes (aisles), although more direct, unobstructed routes might have been available; (9) average travel distances into and out of storage were used; (10) plant layouts provided sufficient storage space--the extra space resulting from continual shipment of fruit was ignored; (11) 1 packing line was provided for each 150,000 boxes of apples received--1 line in the 100,000-box plant, 2 in the 200,000-box plant, and 3 in the 400,000-box plant; (12) the standard Northwest apple box (10½ by 11½ by 18 inches) was used for handling both packed and unpacked fruit; and (13) weights per box of packed and unpacked fruit were assumed to be 50 and 35 pounds, respectively.

Uniformity was maintained in plant layouts to minimize the effect of differences in layout or travel distance. The same pattern of storage banks, entrances, exits, aisle arrangements, and direction of traffic flow was maintained throughout so that: (1) Few variables are introduced, and (2) comparisons of identical operations could be made.

Average travel distances to and from designated areas, volume handled and standard time values were applied to each phase of the operation cycle to calculate handling costs.

Assumptions inherent in the report for all packing and storage plants were: (1) Plant expansion was rectilinear in storage units of 88 by 100 feet; (2) 1- and 2-floor plant layouts of different dimensions arranged for utilization of various types of handling equipment, were applicable to most existing plants; (3) storage bays were free of obstructions, such as ducts or posts; (4) ceiling heights and structural strengths were adequate and safe for storage requirements; (5) areas for



## Cycles of Operations

Over 40 million boxes of apples (unpacked) are harvested for market each season in the State of Washington. Much of this volume received at packing and storage plants moves directly into storage. Later, the fruit is moved from storage to the packing room. Most of the 27 million boxes of fruit packed out from this volume is moved back into storage and later is moved out of storage and loaded for shipment to terminal markets. A large part of the work involved annually in handling operations in many older plants in the State is used to perform these cycles of operations.

Receiving.--In the Pacific Northwest, apples are received at packinghouses over a period of 4 to 6 weeks. Usually, receiving of fruit starts slowly. As the season progresses, receipts increase, reaching a peak 2 to 3 weeks after harvest begins. Receipts at most plants usually are heavy for 1 to 2 weeks, after which (for 2 to 3 weeks) they gradually decrease.

The daily volume of fruit received and moved directly to the packing room not only varies between different plant-size groups but within a single plant. However, most fruit received at plants is moved into cold storage before packing, even when the fruit is not to be held long.

The total elapsed time for performing cycles of operation involved in receiving fruit varied for plants of 100,000, 200,000, and 400,000 boxes.

Receiving is the most important handling operation. It includes "receiving to storage" and "receiving to temporary supply bank in packing room." In the analysis in this report, the assumed conditions associated with receiving fruit in all plants were:

- (1) Delivery to plants was in road trucks in lots of 288 boxes.
- (2) Unit loads were moved from stabilized truckbeds by handling equipment in 1-floor plants.
- (3) In 2-floor plants, boxes were placed, 1 at a time, on belt conveyors, and off-loaded into unit loads at the terminal ends of the conveyors.
- (4) In storage areas, boxes of loose fruit were stacked 12 high. When clamp-type 2-wheel hand trucks were used, boxes were high-piled manually from 6 to 12 high. So that like operations could be compared, and to limit the number of variables, the stacking height for the industrial clamp lift and forklift trucks was limited to 2 unit loads, or 12 boxes of unpacked fruit; both types of equipment are capable of tiering 3 unit loads.
- (5) Fruit was not segregated by variety and ownership.
- (6) Half of the boxes received at 2-floor plants was moved to the second floor.

Storage to packing room.--At most plants, fruit received is transferred into storage even though it is to be packed out within a few days. This pre-cooling removes the field heat from the fruit, slows down the ripening process, and gives the fruit a longer market life.

Because the movement of fruit from storage to packing room is not done under pressure of harvesting operations, the general practice is to spread it over a period which varies in length with the size of the crop, nature of the market, and practices in different localities.

Following are the assumed conditions applied to all plants and all types of equipment analyzed:

(1) All fruit was transferred from storage to a temporary supply bank in the packing room.

(2) In 2-floor plants, half of the fruit transferred to the packing room originated on the second floor.

Temporary supply bank to packing line.--Estimates indicate that about 35 percent of the total employees, exclusive of office workers, in apple packing and storage plants in the Pacific Northwest are engaged in physical handling operations, and 65 percent in packing-line operations. The activities of the latter group, consisting of dumping, cleaning, sorting, sizing, packing, labeling, lidding, and other operations in the packing line, are not within the scope of this report. 1/

Assumptions connected with movement of fruit from supply bank to packing line for all plants were:

(1) Fruit is moved from temporary supply bank to dumper by equipment used in each method of handling.

(2) Movement to the dumper was at a rate of 300 boxes per hour per packing line.

Segregating packed boxes.--Segregating packed boxes consisted in removing the boxes from the belt conveyor leading from the packing line and placing the boxes in separate stacks according to variety, size, and grade of the fruit. Some plants segregate fruit into individual sizes, while others group 2 or 3 sizes. Assumptions used in this report with respect to segregating packed boxes, in all plants, for all handling methods, were:

(1) In 1-floor plants, packed boxes were segregated and stacked into unit loads at the end of the packing line.

(2) In 2-floor plants, boxes returned to the second floor were segregated at the terminal end of the belt conveyor.

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1/ A study covering these operations is under way and a report on it is planned.

Packing room to storage.--Packed boxes of apples usually are not high-piled to the same height as unpacked boxes because of the increased height of the stack when the packed boxes are turned on their sides (the standard apple box is 1 inch wider than it is deep). Also, the need for storage space, at least during the latter part of the packing season, is not as great as during the harvest period.

The assumptions applicable to all plants and all types of equipment for moving packed boxes from the packing room back to storage were:

- (1) All fruit was moved into storage before shipment.
- (2) In 2-floor plants, half of the boxes were transferred to the second floor and half to the first floor.
- (3) Stacking height was 10 boxes for all types of handling equipment.

Storage to shipping area.--Apples originating in Pacific Northwest packing plants are loaded out of cold storage into refrigerated railroad cars or road trucks. Packed fruit often remains in storage several months before shipment. Occasionally, some plants load out fruit from the packing line; however, loading cars or trucks with fruit from the packing room is slow because the loading operation is paced by the rate at which boxes move from the packing line. The usual load consists of 798 standard boxes of apples.

The storage-to-shipping-area cycle of operations consists of searching through stacks to locate and break out the correct number of boxes by variety, grade, and size, and moving them to the shipping area. Assumptions relating to this cycle of operations were:

- (1) All fruit to be shipped was blocked out (placed in separate stacks) prior to actual loading.
- (2) Blocked-out fruit was moved to a shipping area near the loading-out point before loading.
- (3) In 2-floor plants, half the boxes originated on the second floor.

Shipping area to carrier and load.--This operation consists of moving fruit from the shipping area to truck or car door or a stacking point within the carrier, preparing the manifest, and stowing the boxes in the carrier. Assumptions relating to this operation were:

- (1) The 5-high stacks of packed boxes were moved with clamp-type 2-wheel hand trucks from the shipping area to the work face (the stacks being stowed in the carrier).
- (2) Unit loads were moved from shipping area to carrier door by industrial clamp lift trucks and manually loaded in the carrier.

(3) Each pallet load was moved by 48-box industrial forklift truck from shipping area to carrier door and placed on a pallet dolly, which was pushed to the work face; boxes were stowed in the carrier by hand.

(4) There was complete manifesting (counting each box).

(5) A carload or truckload consisted of 798 boxes stacked.

#### Computation of Labor Requirements and Costs

When fruit is moved into, within, and out of storage, each box of apples is handled one or more times in each operation, depending on the types of handling equipment used. Excluding packing line and office workers, from 5 to 60 workers are required each day by each of the 250 or more packing plants in Washington State during the peak operating period--the time when fruit is received, stored, packed, and shipped in greatest volume.

Because plant workers are hired for not less than one 8-hour day, labor inputs in this report are based on the number of workers needed daily to perform all handling operations. The numbers of workers required for the assumed workloads were sufficient to perform all handling operations as well as miscellaneous jobs such as picking up debris and loose apples from floors, (house-keeping), servicing the handling equipment, and bringing up supplies to packing rooms. Various sizes of crews were used to compute total labor inputs for each plant. Crew size for each plant and type of equipment was based on daily workloads for specified periods of operation throughout the season. Labor inputs are in terms of man-days. To illustrate: In computing total man-days of labor required for the season when using clamp-type 2-wheel hand trucks alone, the crew for the 200,000-box, 1-floor plant varied from 4 workers for the first 3 days to 20 workers for the period when fruit was received in greatest volume and all other operations were performed. In computing man-hour requirements two 15-minute rest periods were allowed, one in the morning and one in the afternoon.

Wage rates used in this report to calculate labor costs were based on research conducted by the Washington State Apple Commission in 1951-52. The "current" hourly wage rate used for unskilled workers was \$1.15 and for semi-skilled workers (industrial truck operators) \$1.30. The "assumed" wage rates were 25 cents an hour higher, or \$1.40 and \$1.55, respectively. Labor costs given in the report are based on the "current" wage rates, unless otherwise specified.

#### Computation of Equipment Requirements and Costs

The amount of equipment required to perform handling operations for different volumes of fruit (100,000, 200,000, and 400,000 boxes) in plants of given design and layout presented herein was based on daily needs during the peak operating periods. For example, in the 1-floor, 200,000-box plant, during the 8-day peak operating period when fruit is received in greatest volume and all other operations are performed, three 36-box industrial clamp lift trucks

were assumed to be needed. Other equipment required included: (1) Five truckbed stabilizers, needed to permit operation of industrial lift trucks onto and off road truckbeds; (2) 8,320 board feet of 1- by 4-inch lumber for dunnage strips, for use between unit loads to stabilize stacks in storage; (3) 200 feet of roller conveyor, to aid in packing room handling operations; and (4) 8 clamp-type 2-wheel hand trucks, needed as standby equipment in case of breakdown of 1 or more of the industrial lift trucks.

Equipment costs were divided into ownership and operating costs. Ownership costs include depreciation, taxes, interest, and insurance. Operating costs included grease, oil, electricity, and labor and parts for maintenance, repairs, overhaul of equipment, and inspection and servicing. Theoretically, equipment not used and protected from the weather does not accumulate operating costs. However, some wasting of the equipment is incurred through deterioration of such parts as tires and batteries, and is recognized in the depreciation rates.

### Depreciation Allowances

Depreciation rates, including allowances for obsolescence, were estimated for each synthesized plant from the assumed annual hours of use of each piece of equipment. These rates were not necessarily the same as those used by plant operators in determining their costs.

Since the amount of time during which equipment is used is influenced by plant layout and volume handled, individual depreciation rates were computed for each equipment type for each size of plant. 2/ To illustrate: The annual use (time used productively) of the three 36-box industrial clamp lift trucks required for the 1-floor, 200,000-box plant totaled 367 machine-hours per truck; in the 1-floor, 100,000-box plant, each of the 2 trucks required was used about 275 machine-hours. Thus, on the basis of hours of use, the latter 2 trucks had the greater life expectancy. In other reports in this series, average hourly rates were used to compute equipment costs for individual operations, such as receiving, moving boxes from storage to packing room, and loading out.

### Interest, Taxes, and Insurance

An interest rate of 5 percent is used by many Washington State apple plants to estimate their capital costs. This is the rate for money borrowed for investment purposes, or the expected rate of return on an investment. An interest rate of 5 percent was used in this report in computing interest costs.

Research in the Pacific Northwest area disclosed that the combined taxes and insurance rates in municipalities and rural areas were, respectively, 1.8 percent and 2 percent. A rate of 2 percent was used to compute ownership costs for these items.

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2/ Depreciation was computed by the straight-line method.

### Operating Costs

Operating costs, like ownership costs, vary between plants for identical types of equipment. Costs of operating different types of equipment for each plant discussed in this report are based on the number of hours the equipment was assumed to be used over the season.

Because most plants have sufficient equipment to handle peak workloads promptly, annual hours of use may differ from the assumptions used herein. In such cases, plant operators can compute their estimated annual operating costs by determining the number of hours the equipment is used, and following the method described.

#### LABOR REQUIREMENTS AND TOTAL COSTS FOR 100,000-BOX PLANTS

For purposes of analyses, certain assumptions were made about the operation of the synthesized plants. These covered the operating period, the receiving period, the receiving rate, the volume of fruit moved directly to the packing room, and the volume of fruit shipped daily.

The duration of the operating period was assumed to be 91 days for the 100,000-box plants (fig. 7). During this period, all fruit was assumed to be

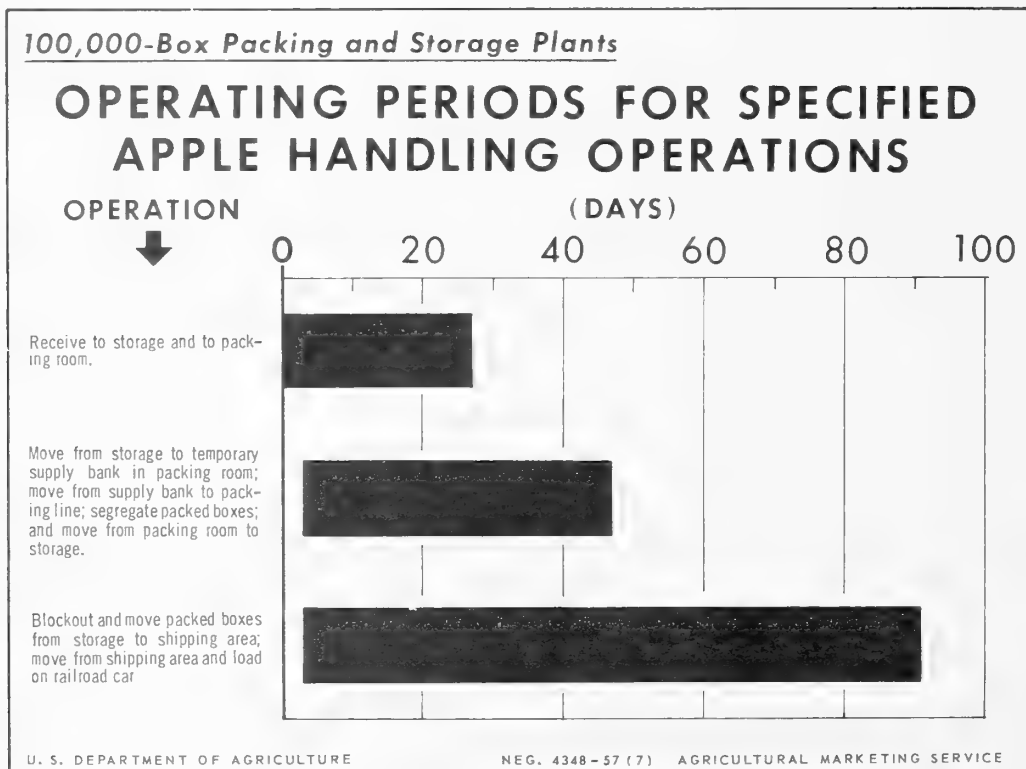


Figure 7

received in the first 27 days. For the first 3 days, 2,500 boxes per day were assumed to be received and moved into storage. The receiving rate for the next 9 days was 3,000 boxes per day, 500 of which were moved directly to the temporary supply bank in the packing room. A 7-day peak receiving period followed, during which 6,000 boxes were received daily (twice the daily volume of the preceding 9 days), 1,000 boxes of which were moved to the packing room and 5,000 to storage. The number of boxes for the remaining 8 days of the receiving period was 3,000 per day, with 500 moving directly to the packing room.

The packing period covered 44 days. It began on the 4th day and ended on the 47th day of the operating period. For the first 9 days of the packing period, and from the 16th to the 24th day, of the 2,250 boxes dumped per day, 1,750 boxes were moved from storage to the temporary supply bank in the packing room. During the peak receiving period, 1,250 boxes per day were moved from storage to the supply bank in the packing room. For the remainder of the packing period (20 days), 2,250 boxes per day were moved from storage to the supply bank. Throughout the packing period, 2,250 unpacked boxes of apples per day were moved from the temporary supply bank to the packing line. With a packout of 70 percent, 1,575 packed boxes of fruit per day were segregated and moved back to storage.

It was assumed that the shipping period began on the 4th day and ended on the 91st day. For this 88-day period, 798 boxes per day, or 1 carload equivalent, were blocked out in storage, moved to the shipping area, and loaded into a railroad car or truck.

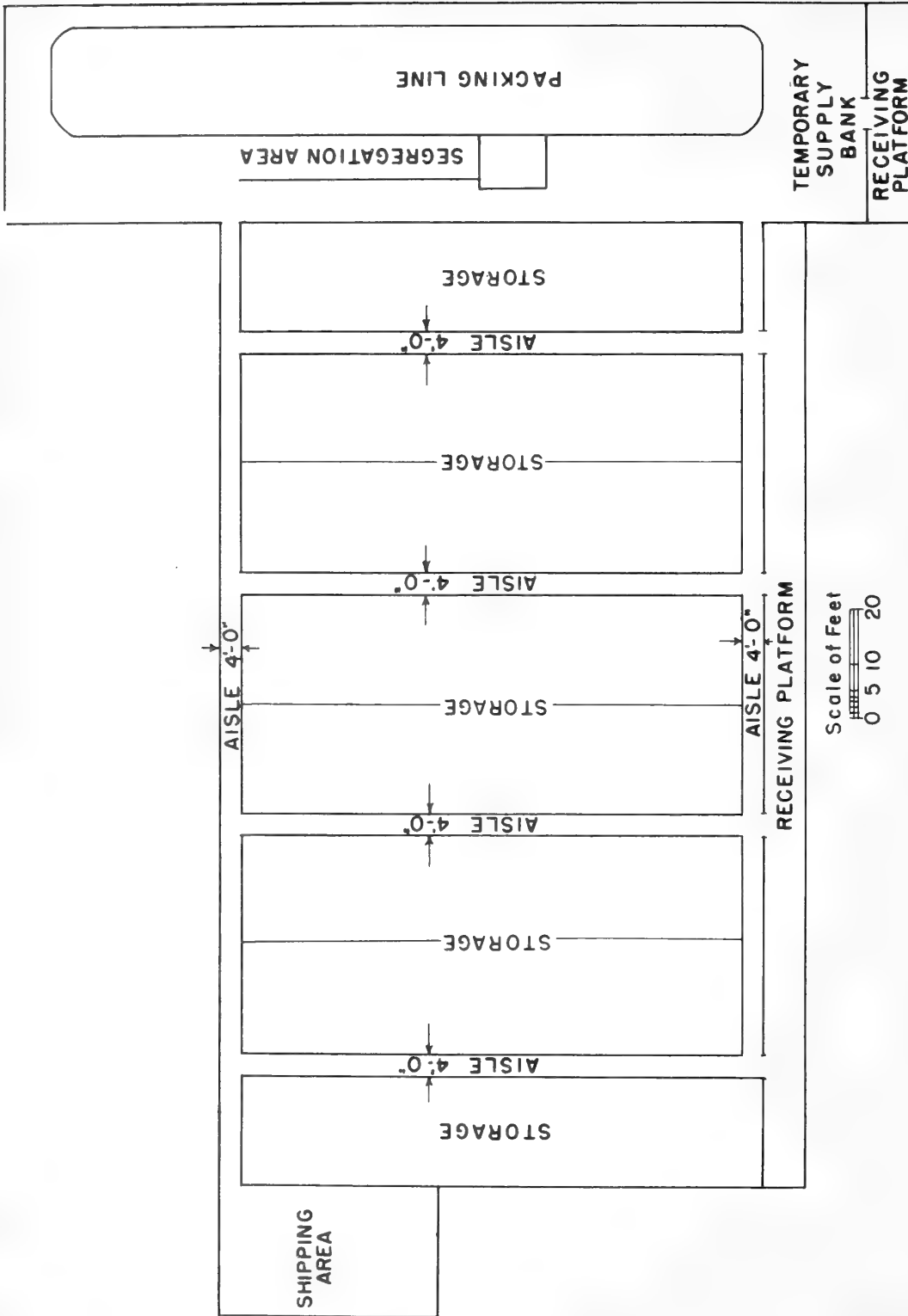
### Single-Floor Plant

Figure 8 shows the floor plan of the 1-floor, 100,000-box packing and storage plant used to compute labor inputs and labor and equipment costs for the clamp-type 2-wheel hand truck method of handling apples. For fast movement of fruit to and from storage banks--banks are 20 boxes across--2 main aisles and 4 cross aisles, all 4 feet wide, are provided. Four entrances for receiving fruit minimize travel distance between the motortruck bringing in fruit and the storage areas.

The floor plan of the 1-floor, 100,000-box plant for the industrial lift truck systems of handling is shown in figure 9. Because of relatively large overall size of unit loads and equipment, 12-foot aisles were provided to give space to maneuver the equipment. Only 2 entrances from receiving area to storage were required, as fruit was assumed to be stored to a depth of 36 boxes by both 36-box industrial clamp lift trucks and 48-box industrial forklift trucks.

### Clamp-Type 2-Wheel Hand Trucks

The clamp-type 2-wheel hand truck has been a standard type of equipment for many years in apple packing and storage plants. The hand truck is convenient for handling the standard apple box, and it has low ownership and

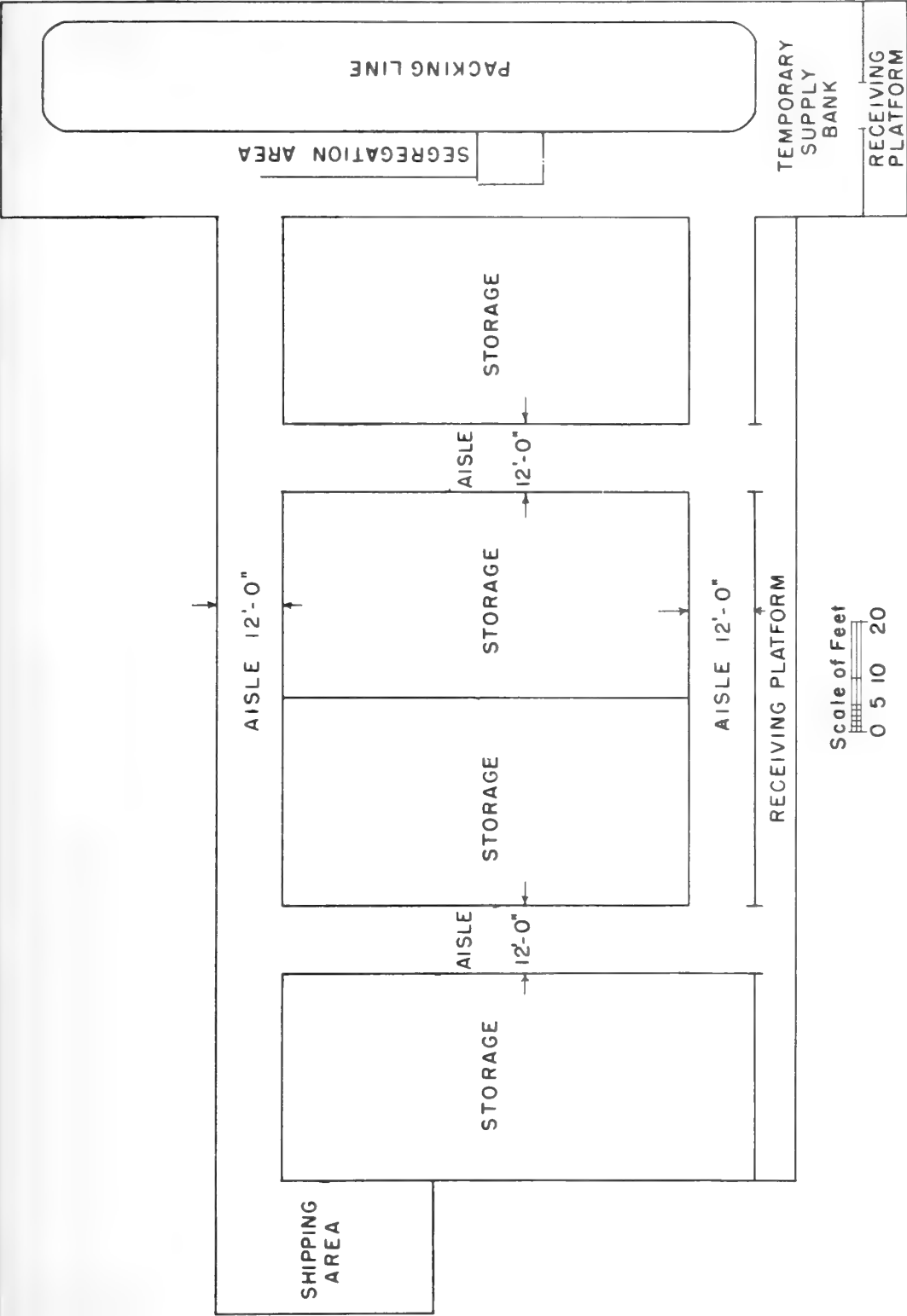


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Figure 8.--Assumed plant layout for a single floor 100,000-box apple packing and storage plant when clamp-type 2-wheel hand trucks are used, unpacked boxes stacked 12 high in storage.





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Figure 9.--Assumed plant layout for a single floor 100,000-box apple packing and storage plant when industrial lift trucks are used, unpacked boxes are stacked 12 high in storage.

operating costs. However, labor costs of using 2-wheel hand trucks are relatively high.

Labor requirements and costs.--Table 1 shows the estimated number of workers required daily for specified periods and the man-days of labor required to perform all handling operations by the 2-wheel hand-truck method in the 1-floor, 100,000-box plant for the 91-day operating period.

Table 1.--Estimated number of workers and man-days of labor required to perform handling operations for a 91-day season by use of clamp-type 2-wheel hand trucks in a 1-floor, 100,000-box apple packing and storage plant

Period	Days of operation 1/	Workers per day 2/	Total labor required
	Number	Number	Man-days
1st to 3rd day . . . . .	3	4	12
4th to 27th day . . . . .	24	12	288
28th to 47th day . . . . .	20	9	180
48th to 91st day . . . . .	44	2	88
Total . . . . .	91	-	568

1/ Eight hours per day.

2/ Unskilled workers.

In the analysis of this method, it was assumed that the crews would range from 2 to 12 workers and be employed for 568 man-days. Apples were received at the rate of 2,500 boxes per day for the first 3 days; they were moved into storage and high-piled by a 4-man crew. Of the total time, 288 man-days were required for the remainder of the receiving period (24 days) to: (1) Receive 77,500 boxes into storage and 15,500 boxes to the temporary supply bank in the packing room; (2) transfer 38,500 boxes from storage to temporary supply bank; (3) transfer 54,000 boxes from temporary supply bank to packing line; (4) segregate 37,800 packed boxes and move them to storage; and (5) block out 19,000 boxes in storage and transfer them to shipping area and then to railroad cars or trucks, and load them. For 20 days after the receiving period, 180 man-days of labor were required to transfer 46,000 boxes from storage to supply bank and then to packing line; segregate 32,200 packed boxes and move them to storage; and block out 16,000 boxes in storage and ship them out. Two men were required to block out 35,000 boxes in storage and ship them during the remaining 44 days.

It was assumed that unskilled labor was used to perform all handling operations in the clamp-type 2-wheel hand truck system. Total labor cost for 568 man-days, using a "current" wage rate of \$1.15 per hour, was \$5,225.

Equipment requirements and costs.--Equipment requirements for the 100,000-box plant for the 2-wheel hand truck method were based on daily needs of the 7-day peak operating period (table 2). Fourteen 2-wheel hand trucks were required; 9 were used for handling boxes and 5 were held in reserve in case of breakdown or other emergency. Ten 10-foot sections of roller conveyor were used in the packing room to accumulate unpacked boxes at the end of the packing line and to segregate packed boxes. These were the only types of equipment assumed to be required to perform all handling operations.

Ownership and operating costs of the above equipment for the season amounted to \$165.82. Of this, \$153.52, or 93 percent, was for ownership costs and \$12.30 for operating costs, which were mainly for maintenance.

Table 2.--Ownership and operating costs for specified types of materials-handling equipment required by clamp-type 2-wheel hand truck method in a 1-floor, 100,000-box apple packing and storage plant

Type and amount of equipment	Replace- ment cost <sup>1/</sup>	Assumed: life	Ownership cost per year				Oper- ating cost per year <sup>2/</sup>	Total ownership and oper- ating cost per year
			Depre- ciation:	Inter- est at 5 per- cent	Insur- ance and taxes at 2 per- cent	Total		
14 clamp-type 2-wheel hand trucks . . . . .	1,037.40	20	51.87	25.94	20.75	98.56	9.80	108.36
100 feet of roller conveyor, 11 floor supports, 1 curved section . . . . .	492.25	15	32.82	12.30	9.84	54.96	2.50	57.46
<b>Total . . . . .</b>	<b>1,529.65</b>		<b>84.69</b>	<b>38.24</b>	<b>30.59</b>	<b>153.52</b>	<b>12.30</b>	<b>165.82</b>

<sup>1/</sup> Total replacement cost f.o.b. Washington State points.

<sup>2/</sup> Consists only of maintenance.

Labor and equipment costs.--When the clamp-type 2-wheel hand truck method was used in the 1-floor, 100,000-box plant, total annual labor and equipment costs for handling operations were \$5,391. Over 97 percent, or \$5,225, of the total was for labor, and about 4 percent covered ownership and operating costs of hand trucks and roller conveyors.

### 36-Box Industrial Clamp Lift Trucks

In the 1-floor, 100,000-box plant employing 36-box industrial clamp lift trucks, all handling operations, except segregating packed boxes and loading them into railroad cars or trucks, were performed by industrial lift trucks. Fruit was moved from stabilized truckbeds to storage and stacked, or to a temporary supply bank in the packing room. Fruit being shipped was blocked out in storage, transferred to the shipping area and to the railroad car or truck door by industrial clamp lift trucks, and manually loaded into the carriers.

Labor requirements and costs.--The number of workers used daily for specified periods of time and total man-days of labor required to perform all handling operations with 36-box industrial clamp lift trucks are shown in table 3. Total labor required for the 91 days was 311 man-days.

Table 3.--Estimated number of workers and man-days of labor required to perform handling operations for a 91-day season by use of 36-box industrial clamp lift trucks in a 1-floor, 100,000-box apple packing and storage plant

Period	Days of operation 1/ Number	Workers per day		Total labor required Man-days
		Semi- skilled 2/ Number	Un- skilled 3/ Number	
1st to 3rd day . . . . .	3	1	-	3
4th to 27th day . . . . .	24	2	3	120
28th to 47th day . . . . .	20	2	3	100
48th to 91st day . . . . .	44	1	1	88
<b>Total . . . . .</b>	<b>91</b>	<b>-</b>	<b>-</b>	<b>311</b>

- 1/ Eight hours per day.
- 2/ Clamp lift truck operators.
- 3/ Car loaders and segregators.

When this method was used in the 1-floor plant, crew size varied from 1 to 5 workers for the 91-day period. In receiving 2,500 boxes per day into storage the first 3 days of operation, only 1 truck operator was needed. Five men--2 truck operators, 1 segregator, and 2 car loaders--were used for 24 days (120 man-days) to: (1) Receive and move 77,500 boxes into storage and 15,500 boxes to a temporary supply bank in the packing room; (2) move 38,500 boxes from storage to temporary supply bank; (3) move 54,000 boxes

from temporary supply bank to packing line; (4) segregate 37,800 packed boxes by grade, size, and variety, and move them back to storage; and (5) block out 19,000 boxes in storage and move them to the shipping area and to railroad cars or trucks and load them. Five workers--2 lift-truck operators, 1 segregator, and 2 car loaders--are used for 20 days to move 46,000 boxes from storage to temporary supply bank to packing line; segregate 32,200 packed boxes and move them to storage; and block out 16,000 boxes in storage and ship them. Only 1 car loader and 1 lift-truck operator are used for the remaining 44 days to block out and ship 35,000 boxes. The lift truck operator assisted with car loading.

Total labor cost to perform handling operations for the season by the 36-box industrial clamp lift truck method in the 1-floor, 100,000-box plant was \$3,023. Of this, \$1,404 was paid to lift-truck operators for 135 man-days of work, and \$1,619 for 176 man-days of labor used to segregate packed boxes and load them into railroad cars or trucks.

Equipment requirements and costs.--Based on a daily workload for the 7-day peak operating period, two 36-box industrial clamp lift trucks, 4,160 board feet of 1- by 4-inch lumber for dunnage strips (used to tier unit loads in storage), 3 metal-frame, wedge-shaped truckbed stabilizers (as truck is backed up, frame pries end of truckbed to even height with loading platform to allow industrial lift trucks to operate on truckbed), and ten 10-foot sections of roller conveyor were needed for the 36-box industrial clamp lift truck system in the 1-floor, 100,000-box plant (table 4).

Costs of ownership and operation for all equipment assumed to be required by this method amount to \$1,604.57 annually. Of this amount, 93 percent was for ownership. Eighty-nine percent of the total cost, or \$1,434.16, was for the 2 industrial clamp lift trucks. Cost for six 2-wheel hand trucks--retained for emergency use--of \$45.24 is included in the total.

Labor and equipment costs.--Labor and equipment costs for performing handling operations with 36-box industrial clamp lift trucks in the 1-floor, 100,000-box plant amounted to \$4,628 per year. Of this, \$3,023, or 65 percent, was for labor and \$1,605, or 35 percent, for equipment.

#### 48-Box Industrial Forklift Truck

Only one 48-box industrial forklift truck was required in the 1-floor, 100,000-box plant. However, 6 clamp-type 2-wheel hand trucks were retained for emergency use in the event of a breakdown of the lift truck. One worker was assumed to be needed to segregate packed boxes, and 2 workers to load fruit into railroad cars or trucks.

Labor requirements and costs.--The 48-box industrial forklift truck method in the 1-floor, 100,000-box plant required 267 man-days of labor to perform all handling operations (table 5). Of this, 176 man-days were worked by 1 segregator and 2 car loaders. The truck operator was required throughout the 91-day season.

Table 4.--Ownership and operating costs for specified types of materials-handling equipment required by 36-box industrial clamp lift truck method in a 1-floor, 100,000-box apple packing and storage plant

Equipment type	Amount of equipment		Assumed life		Ownership cost per year		Operating cost per year		Total		
	Number	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	
36-box industrial clamp lift truck (2,000-lb. capacity, electric):											
Machine	2	7,134.00	20	356.70							
Clamp attachment	2	1,254.00	20	62.70							
Battery	2	2,184.00	7½	291.20							
Charger	2	900.00	20	45.00							
Freight		656.00		32.80							
Total		12,128.00		788.40		303.20	242.56	1,334.16	50.00	100.00	1,434.16
Dunnage strips	4,160										
Truckbed stabilizer	3	150.00	15	10.00							
Roller conveyor, including 11 floor supports, 1 curve section	100 ft.	492.25	15	32.82	12.30	9.84	54.96	2.50	2.50	57.46	
Clamp-type 2-wheel hand truck 3/4	6	444.60	20	22.23	11.12	8.89	42.24	3.00	3.00	45.24	
Grand total		13,422.85		895.05	335.57	268.45	1,499.07	50.00	55.50	105.50	1,604.57

1/ Based on delivered cost in Washington State.  
 2/ Electricity at \$0.01 per kilowatt hour.  
 3/ For standby use in event of breakdown of industrial lift trucks.

Table 5.--Estimated number of workers and man-days of labor required to perform handling operations for a 91-day season by use of 48-box industrial forklift truck in a 1-floor, 100,000-box apple packing and storage plant

Period	Days of operation 1/	Workers per day		Total labor required
		Semi-skilled 2/	Unskilled 3/	
	Number	Number	Number	Man-days
1st to 3rd day . . . .	3	1	-	3
4th to 27th day . . . .	24	1	3	96
28th to 47th day . . . .	20	1	3	80
48th to 91st day . . . .	44	1	1	88
Total . . . . .	91	-	-	267

- 1/ Eight hours per day.
- 2/ Forklift truck operator.
- 3/ Car loaders and segregators.

Total crew size varied from 1 worker for the first 3 days of operation to 4 for the next 44 days, which covered the remainder of the receiving period and all of the packing period. Only the forklift truck operator was assumed to be needed for the first 3 days to receive 2,500 boxes per day into storage. The 4-man crew was used for the next 44 days to: (1) Receive 92,500 boxes (77,500 boxes to storage and 15,500 to temporary supply bank); (2) move 84,500 boxes from storage to temporary supply bank; (3) move 100,000 boxes from temporary supply bank to packing line; (4) segregate 70,000 packed boxes and move them to storage; and (5) block out 35,000 boxes in storage, move them to the shipping area, and to railroad cars or trucks, and load them. For the remaining 44 days, 1 truck operator and 1 car loader were used to ship out a carload equivalent a day, or a total of 35,000 boxes for the period.

Total labor cost for the season, using the industrial forklift truck method, was \$2,566, of which \$946 was paid to the forklift truck operator and \$1,620 to the segregator and car loaders.

Equipment requirements and costs.--As shown in table 6, it was assumed that, in addition to one 48-box industrial forklift truck, there were needed during the peak operating period 1,580 pallets, 3 truckbed stabilizers, ten 10-foot sections of roller conveyor, 2 pallet dollies for carloading, and 6 clamp-type 2-wheel hand trucks (for emergency use) to perform daily handling operations by this method.

Table 6.--Ownership and operating costs for specified types of materials-handling equipment required by 48-box industrial forklift truck method in a 1-floor, 100,000-box apple packing and storage plant

Equipment type	Amount of equipment	Replacement cost	Assumed life	Ownership cost per year		Operating cost per year		Total		
				Dollars	Years	Dollars	Dollars		Dollars	Dollars
48-box industrial forklift truck	1	4,729.00	20	479.96	181.78	145.42	807.16	31.23	67.60	874.76
(4,000-lb. capacity, electric)	1	1,397.00	7½	186.26	118.50	94.80	529.30		3/ 26.60	555.90
Machine	1	690.00	20	34.50						
Battery	1	455.00		22.75						
Charger	1									
Freight										
Total		7,271.00		479.96	181.78	145.42	807.16	31.23	67.60	874.76
Pallets, 48-box (40- by 48-in.)	1,580	4,740.00	15	316.00	118.50	94.80	529.30		3/ 26.60	555.90
Roller conveyor, including 11 floor supports, 1 curve section, 100 ft.		492.25	15	32.82	12.30	9.84	54.96		2.50	57.46
Trucked stabilizers	3	150.00	15	10.00	3.75	3.00	16.75			16.75
Pallet dolly for loading out.	2	85.70	5	17.14	2.14	1.71	20.99		2.00	22.99
Clamp-type 2-wheel hand truck	6	444.60	20	22.23	11.12	8.89	42.24		3.00	45.24
Grand total		13,183.55		878.15	329.59	263.66	1,471.40	31.23	70.47	1,573.10

1/ Based on delivered cost in Washington State.  
 2/ Electricity at \$0.01 per kilowatt hour.  
 3/ Maintenance cost assumed to be \$0.25 per pallet over a life of 15 years.  
 4/ For standby use in event of breakdown of industrial forklift truck.



Practically all equipment costs for this method were for the industrial forklift truck and pallets. Of the total cost of \$1,573.10, 91 percent was for the 1,580 pallets and forklift truck. Ninety-four percent of the total, or \$1,471.40 was for ownership costs of depreciation, interest, insurance, and taxes for all equipment, and 6 percent, or \$101.70, for power and maintenance.

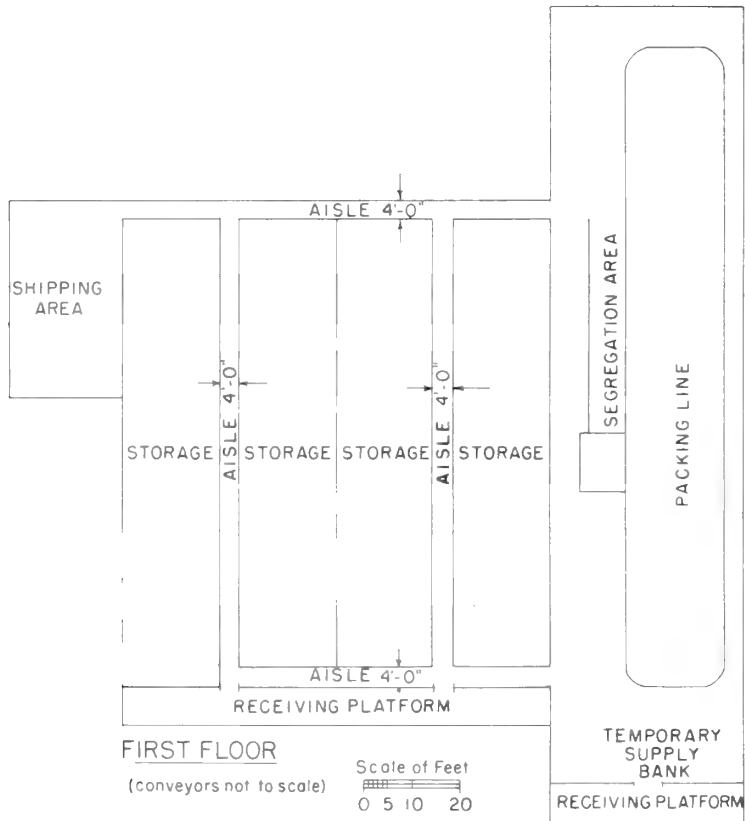
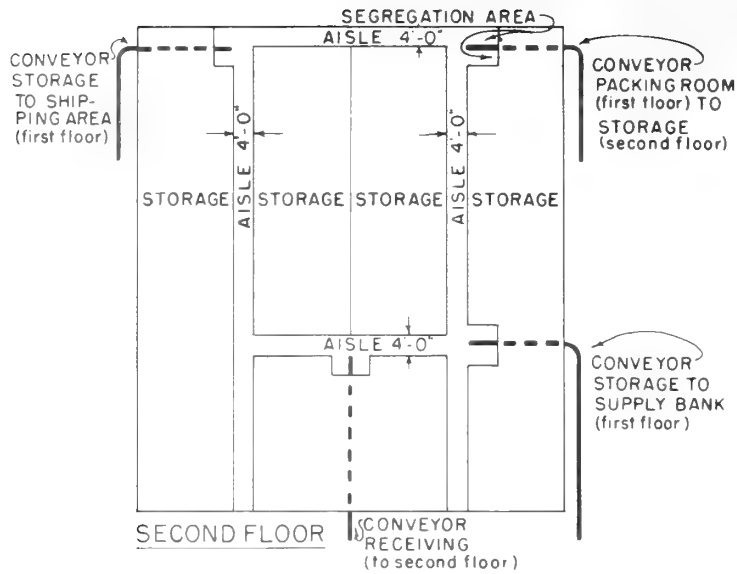
Labor and equipment costs.--Labor and equipment costs for all handling operations involved in moving apples into, within, and out of a 100,000-box, 1-floor plant, using the 48-box industrial forklift truck method, were calculated at \$4,139 per year. Of this, \$2,566, or 62 percent, was for labor and \$1,573, or 38 percent, was for equipment.

### Two-Floor Plant

A larger volume of apples has been received in Pacific Northwest packing plants by use of belt conveyors and clamp-type 2-wheel hand trucks than with any other type of equipment. The belt conveyor still is used extensively in multistory plants for moving fruit between floors. In some of these plants, the 24-box industrial clamp lift truck has replaced 2-wheel hand trucks.

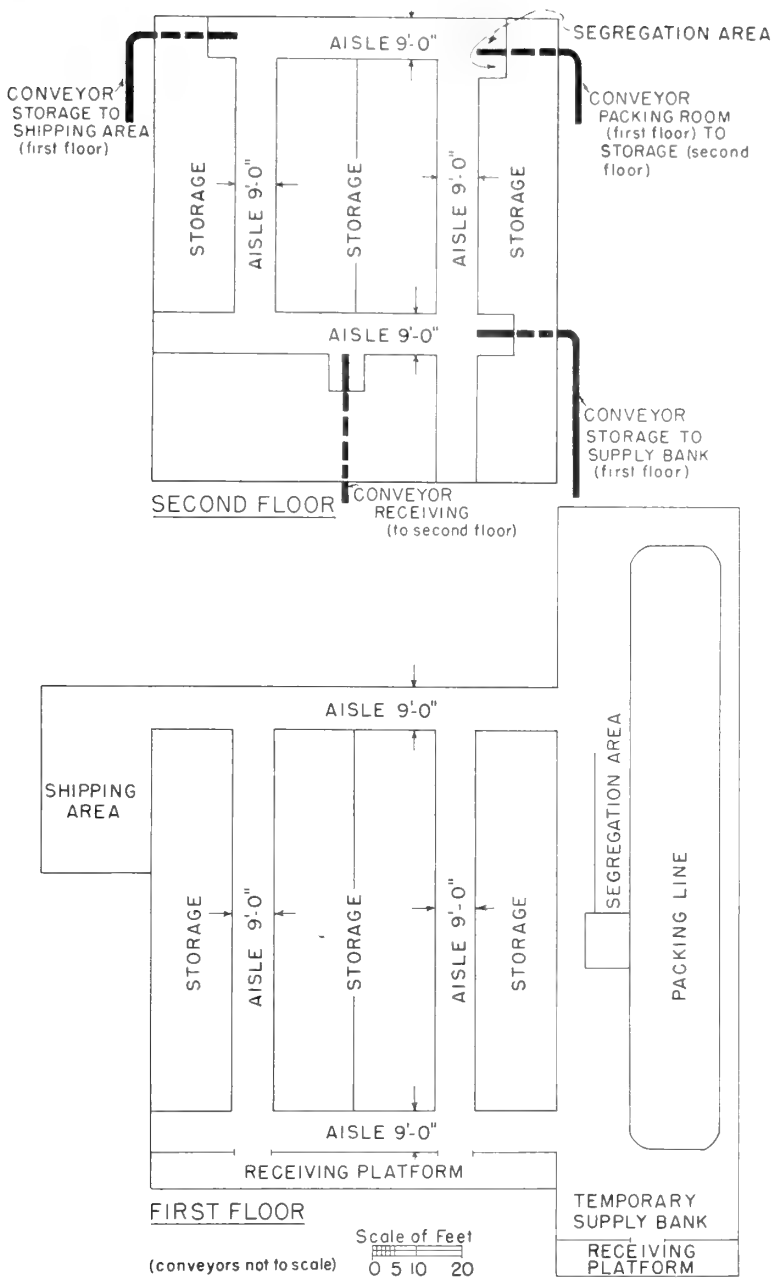
In devising the 2-story, 100,000-box plant, one 88- by 100-foot storage unit was placed over another. Figure 10 shows the floor plan used for the clamp-type 2-wheel hand truck and belt conveyor method of operation. Aisles in this layout were assumed to be 4 feet wide. Width of aisles for efficient operation of 24-box industrial clamp lift trucks was assumed to be 9 feet (fig. 11). In receiving to the second floor, boxes were manually placed on the conveyor and elevated to the upper floor through a port in the wall (fig. 12) and a hatch in the second floor. On the second floor, the boxes were manually removed from the belt conveyor, stacked in 6-high stacks, and moved to the storage area by either clamp-type 2-wheel hand trucks or 24-box clamp-type lift trucks. When hand trucks were used, high-piling above the original 6-high stacks was done manually. High-piling was done by the lift truck when one was used: Boxes of loose fruit stored on the second floor were moved from storage area to temporary supply bank in the packing room by the same handling equipment and another belt conveyor. Packed boxes were moved from the segregation area in the packing room to second-floor storage by a third belt conveyor. The actual segregation was done on the second floor for fruit stored there. A fourth belt conveyor was used, in conjunction with hand trucks or an industrial clamp lift truck, to move packed fruit from second-floor storage to the shipping area.

Fruit stored on the first floor was moved from stabilized truckbeds to storage and stacked 12 high, or to a temporary supply bank, by industrial lift trucks. By the clamp-type 2-wheel hand truck method, 6-high stacks of boxes were moved from truckbeds to storage and high-piled manually to 12 high, or the 6-high stacks were moved directly to the temporary storage bank in the packing room. For fruit stored on the first floor, the methods used with both types of equipment for blocking out fruit to be shipped, moving it to shipping area and to rail cars or trucks, and loading it, were the same as those used for the 36-box industrial clamp lift trucks and 2-wheel hand trucks for the 1-floor, 100,000-box plant.



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Figure 10.--Assumed plant layout for a 2-floor, 100,000-box apple packing and storage plant when clamp-type 2-wheel hand trucks and belt conveyors are used, unpacked boxes stacked 12 high in storage.



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Figure 11.--Assumed plant layout for a 2-floor, 100,000-box apple packing and storage plant when 24-box industrial clamp lift trucks and belt conveyors are used, unpacked boxes stacked 12 high in storage.

Clamp-Type 2-Wheel Hand Trucks  
and Belt Conveyors



NEG. BN-5123

Figure 12.--Boxes being received by belt conveyor through port in wall.

Labor requirements and costs.--Crew size varied from 2 to 14 workers for the method using the clamp-type 2-wheel hand truck and belt conveyor in the 2-floor, 100,000-box plant (table 7). Total labor inputs required by this method for the season were 619 man-days. Four men were used the first 3 days to receive into storage 2,500 boxes per day. The crew consisted of 13 men for 17 days of the remaining 24-day receiving period (9 days before and 8 days after the peak operating period). During that time, 42,500 boxes were

received and placed into storage and 8,500 boxes were received and moved to the temporary supply bank in the packing room, 29,500 boxes were moved from storage to the temporary supply bank, 38,000 boxes were moved from temporary supply bank to packing line, 26,600 packed boxes were segregated and moved from packing room to storage, 13,500 boxes were blocked out in storage and moved to shipping area and to railroad cars or trucks, and were loaded. During the peak operating period, 14 men were used to receive 35,000 boxes into storage and 7,000 directly to temporary supply bank, move 9,000 boxes from storage to supply bank and 16,000 boxes from supply bank to packing line, segregate 11,200 packed boxes and transfer them to storage, and block out 5,500 boxes in storage and ship them. For the 20 days needed to pack out the remainder of the fruit, 10 men were used to move 46,000 boxes from storage to supply bank to packing line, segregate 32,200 packed boxes and return them to storage, and block out 16,000 boxes in storage and ship them. Two men were assumed for the remaining 44 days to block out and ship 35,000 boxes.

Table 7.--Estimated number of workers and man-days of labor required to perform handling operations for a 91-day season by use of clamp-type 2-wheel hand trucks and belt conveyors in a 2-floor, 100,000-box apple packing and storage plant

Period	Days of operation 1/	Workers per day 2/	Total labor required
	Number	Number	Man-days
1st to 3rd day . . . . .	3	4	12
4th to 12th day. . . . .	9	13	117
13th to 19th day . . . . .	7	14	98
20th to 27th day . . . . .	8	13	104
28th to 47th day . . . . .	20	10	200
48th to 91st day . . . . .	44	2	88
<b>Total . . . . .</b>	<b>91</b>	<b>-</b>	<b>619</b>

1/ Eight hours per day.

2/ Unskilled workers.

Total labor cost for the 2-wheel hand truck and belt conveyor method at the "current" wage rate of \$1.15 per hour was \$5,695 for the season.

Equipment requirements and costs.--As shown in table 8, the daily workload for the 7-day peak operating period in the 2-floor, 100,000-box plant, using the 2-wheel hand truck and belt conveyor method, required 15 clamp-type 2-wheel hand trucks, 450 feet of belt conveyor, and ten 10-foot sections of roller conveyor.

Total annual equipment cost of this method in the 2-floor plant was \$695.33. Of this, \$645.06, or 93 percent, was for the fixed-cost items of depreciation, interest, insurance, and taxes. A substantial part of the operating cost of \$50.27 was for maintenance of the 4 conveyors.

Labor and equipment costs.--Labor and equipment costs for the clamp-type 2-wheel hand truck and belt conveyor method in the 2-floor, 100,000-box plant amounted to \$6,390 per year. Of this total, 89 percent, or \$5,695, was for labor and the rest for equipment.

#### 24-Box Industrial Clamp Lift Trucks and Belt Conveyors

Labor requirements and costs.--When 24-box industrial clamp lift trucks and belt conveyors were used, 412 man-days of labor were required to perform handling operations over the 91-day period in the 2-floor, 100,000-box plant (table 9). This total consisted of 142 man-days of labor for lift-truck operators, at a cost of \$1,477, and 270 man-days for conveyormen, car loaders, and a worker to segregate packed boxes, at a cost of \$2,484.

Crew size for this plant using 24-box industrial clamp lift trucks and belt conveyors, varied from 2 to 8 workers. For the first 3 days of the period, 1 truck operator and 2 conveyormen were required to receive and place in storage 2,500 boxes of apples per day. A 7-man crew--2 truck operators, 2 conveyormen, 2 car loaders, and 1 man to segregate packed boxes--was used for 9 days before and 8 days after the peak receiving period to: (1) Receive 42,500 boxes into storage and 8,500 boxes directly to the temporary supply bank; (2) transfer 29,500 boxes from storage to temporary supply bank; (3) transfer 38,000 boxes from temporary supply bank to packing line; (4) segregate 27,000 packed boxes and move them to storage; and (5) block out 13,500 boxes in storage, transfer them to shipping area and to railroad cars or trucks, and load them. An 8-man crew (1 additional truck operator) was required for the 7-day peak operating period to: (1) Receive 35,000 boxes into storage and 7,000 boxes directly to the temporary supply bank; (2) transfer 9,000 boxes from storage to temporary supply bank; (3) transfer 16,000 boxes from temporary supply bank to packing line; (4) segregate 11,000 boxes and move them to storage; and (5) block out 5,500 boxes in storage, transfer them to shipping area and to railroad cars or trucks, and load them. A 7-man crew was required for 20 days after the receiving period to transfer 45,000 boxes from storage to temporary supply bank to packing line; segregate 32,000 boxes and move them to storage; and block out 16,000 boxes in storage, transfer them to shipping area and to railroad cars or trucks, and load them.

Table 8.--Ownership and operating costs for specified types of materials-handling equipment required by clamp-type 2-wheel hand truck and belt conveyor method in a 2-floor, 100,000-box apple packing and storage plant

Equipment type	Amount of equipment		Ownership cost per year		Insurance and taxes		Interest and depreciation		Electricity and maintenance		Total ownership and operating costs per year	
	Number	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Clamp-type 2-wheel hand truck . . . . .	15	1,111.50	20	55.58	27.78	22.23	105.59	8.25	8.25			113.84
Belt conveyor												
Belting @ \$2.30 per foot . . . . .	450 ft.	1,035.00	15	69.00								
Dip and load section . . . . .	4	399.00	25	15.96								
Curved end section . . . . .	2	99.50	25	3.98								
Motor . . . . .	4	888.00	25	35.52								
Drive . . . . .	4	570.00	25	22.80								
Idle ends . . . . .	8	332.00	25	13.28								
Floor supports . . . . .	36	216.00	25	8.64								
Roller sections . . . . .	40	1,580.00	25	63.20								
Installation (5 percent) . . . . .		256.00		10.24								
Total . . . . .		5,375.50		242.62	134.38	107.51	484.51	8.32	31.20	39.52		524.03
Roller conveyor, 11 floor supports, 1 curve section . . . . .	100 ft.	492.25	15	32.82	12.30	9.84	54.96	2.50	2.50			57.46
Grand total . . . . .		6,979.25		331.02	174.46	139.58	645.06	8.32	41.95	50.27		695.33

1/ Based on delivered cost in Washington State.  
 2/ Electricity at \$0.01 per kilowatt hour.

Table 9.--Estimated number of workers and man-days of labor required to perform handling operations for a 91-day season by use of 24-box industrial clamp lift trucks and belt conveyors in a 2-floor, 100,000-box apple packing and storage plant

Period	Days of operation 1/	Workers per day		Total labor required
		Semi-skilled 2/	Unskilled 3/	
	Number	Number	Number	Man-days
1st to 3rd day . . .	3	1	2	9
4th to 12th day . . .	9	2	5	63
13th to 19th day . . .	7	3	55	56
20th to 27th day . . .	8	2	5	56
28th to 47th day . . .	20	2	5	140
48th to 91st day . . .	44	1	1	88
<b>Total . . . .</b>	<b>91</b>	<b>-</b>	<b>-</b>	<b>412</b>

1/ Eight hours per day.

2/ Industrial truck operators.

3/ Conveyormen, car loaders, and segregators of packed boxes.

The remaining 35,000 packed boxes were shipped out over the last 44 days of the period by 1 car loader and 1 truck operator who assisted the car loader in moving boxes by conveyor from the second floor to the shipping area and in stowing boxes in cars.

Equipment requirements and costs.--Table 10 shows the annual ownership and operating costs of the equipment required by this method in the 2-floor, 100,000-box plant. The daily workload for the 7-day peak operating period required: (1) Three 24-box industrial clamp lift trucks (2 on first floor and 1 on second floor); (2) 4,160 board feet of 1- by 4-inch lumber for dunnage strips; (3) 4 belt conveyors; (4) 3 truckbed stabilizers; (5) ten 10-foot sections of roller conveyor; and (6) 6 clamp-type 2-wheel hand trucks for emergency use.

Total costs for the equipment were \$2,299.90 per year. Ownership and operating costs of the 3 lift trucks amounted to 71 percent of the total, or \$1,605.51. Of this, \$134.50 was operating costs.

Labor and equipment costs.--Labor and equipment costs for the method using the 24-box industrial clamp lift truck and belt conveyor in the 2-floor, 100,000-box plant amounted to \$6,261 per year, of which 63 percent, or \$3,961, was for labor and 37 percent, or \$2,300, for equipment.

Table 10.--Ownership and operating costs for specified types of materials-handling equipment required by 24-box industrial clamp lift truck and belt conveyor method in a 2-floor, 100,000-box apple packing and storage plant

Equipment type	Amount of equipment		Replacement cost		Assumed life		Ownership cost per year		Operation cost per year		Total		
	Dollars	Years	Dollars	Percent	Dollars	Percent	Dollars	Percent	Dollars	Dollars	Dollars		
24-box industrial clamp lift truck (1,000-lb. capacity, electric) Machine	3	20	7,416.00		370.80								
Clamp attachment	3	20	1,881.00		94.05								
Battery	3	7½	2,286.00		304.80								
Charger	3	20	1,350.00		67.50								
Freight			546.00		27.30								
Total			13,479.00		864.45		269.59		1,471.01	67.25	134.50	1,605.51	
Belt conveyor													
Beltting @ \$2.30 per foot	450		1,035.00	15	69.00								
Dip and load section	4	25	399.00		15.96								
Curved end section	2	25	99.50		3.98								
Motion	4	25	888.00		35.52								
Drive	4	25	570.00		22.80								
Idle ends	8	25	332.00		13.28								
Floor supports	36	25	216.00		8.64								
Roller sections	40	25	1,580.00		63.20								
Installation (5 per cent)			256.00		10.24								
Total			5,375.50		242.62		134.38		107.51	8.32	31.20	39.52	524.03
Dunnage strips	4,160												
Truckbed stabilizer	3	5	208.00		41.60		5.20		4.16			50.96	50.96
Roller conveyor, including 11 floor supports, 1 curve section and freight	100	15	150.00		10.00		3.75		3.00			16.75	16.75
Clamp-type 2-wheel hand truck	6	20	444.60		22.23		11.12		8.89		3.00	3.00	45.24
Grand total			20,149.35		1,213.72		503.72		402.99	75.57	103.95	179.52	2,299.90

1/ Based on delivered cost in Washington State.  
 2/ Electricity at \$0.01 per kilowatt hour.  
 3/ For standby use in event of breakdown of industrial lift trucks.



Comparative Costs of Five Methods

Table 11 shows the comparative labor and equipment costs of handling operations in moving apples into, within, and out of 1- and 2-floor, 100,000-box apple packing and storage plants by methods utilizing 5 types of equipment.

Table 11.--Comparative labor and equipment costs per year by use of specified types of materials-handling equipment in 1- and 2-floor, 100,000-box apple packing and storage plants 1/

Equipment	Labor and equipment costs per year				
	Labor required	Labor	Equipment	Current wages	Assumed wages
	Man-days	Dollars	Dollars	Dollars	Dollars
<u>1-floor plant</u>					
Clamp-type 2-wheel hand trucks . . . . .	568	5,225	166	5,391	6,528
36-box industrial clamp lift trucks . . . . .	<u>4/</u> 311	3,023	1,605	4,628	5,250
48-box industrial forklift trucks . . . . .	<u>5/</u> 267	2,566	1,573	4,139	4,672
<u>2-floor plant</u>					
Clamp-type 2-wheel hand trucks and belt conveyors . . . . .	619	5,695	695	6,390	7,628
24-box industrial clamp lift trucks and belt conveyors . . . . .	<u>6/</u> 412	3,961	2,300	6,261	7,085

1/ Handling operations performed are: (1) Receive 84,500 boxes to storage and 15,500 boxes to temporary supply bank in packing room; (2) transfer 84,500 boxes from storage to temporary supply bank; (3) transfer 100,000 boxes from supply bank to packing line; (4) segregate 70,000 packed boxes and transfer to storage; and (5) block out 70,000 boxes in storage, transfer to shipping area, to railroad cars or trucks, and load.

2/ Based on a wage rate of \$1.15 for unskilled labor and \$1.30 for semiskilled labor (truck operators).

3/ Based on a wage rate of \$1.40 for unskilled labor and \$1.55 for semiskilled labor (truck operators).

4/ Unskilled labor, 176 man-days; truck operators, 135 man-days.

5/ Unskilled labor, 176 man-days; truck operators, 91 man-days.

6/ Unskilled labor, 270 man-days; truck operators, 142 man-days.

The 48-box industrial forklift truck method required the least labor (267 man-days). The system using 36-box industrial clamp lift trucks had the next lowest labor input (311 man-days). Those methods using clamp-type 2-wheel hand trucks in the 1- and 2-floor plants required the highest labor inputs; the hand truck method in the 1-floor plant required 568 man-days and in the 2-floor plant, when used in combination with belt conveyors, 619 man-days.

The lowest cost method for both 1- and 2-floor plants was by use of the 48-box industrial forklift truck. Total costs for this method were \$4,139 per year, \$2,566 of which was for labor and \$1,573 for equipment. The cost difference between this method and the next lowest cost method was relatively small.

The next lowest cost method was by use of 36-box industrial clamp lift trucks. Of the total cost of \$4,628 per year for this method, \$3,023 was for labor and \$1,605 for equipment. The computation for this method provided for 2 industrial clamp lift trucks.

The system using clamp-type 2-wheel hand trucks and belt conveyors in the 2-floor plant was the highest cost method. By this method, labor and equipment costs amounted to \$6,390 per year, of which 89 percent was for labor (\$5,695) and 11 percent for equipment (\$695).

The method using 24-box industrial clamp lift trucks and belt conveyors had the highest equipment cost because 3 industrial lift trucks were assumed to be needed to perform all handling operations--2 on the first floor and 1 on the second--during each day of the peak operating period.

#### LABOR REQUIREMENTS AND TOTAL COSTS FOR 200,000-BOX PLANTS

The seasonal operating period assumed for the 1-floor and the 2-floor, 200,000-box plants was 91 days--the same as for the 100,000-box plants. The durations of the packing and shipping periods, at 44 and 88 days, respectively, also were the same as for the smaller plants. Fruit was assumed to be received from growers over a 33-day period, compared with 27 days for the 100,000-box plants.

Figure 13 shows the elapsed time of 7 handling operations over the 91-day operating period. Receiving fruit into storage was the only operation performed the first 3 days of the period. Fruit moved to the 2 packing lines at a rate of 600 boxes per hour, or 4,500 boxes per day, for the 44-day period. With 1,596 packed boxes (2 railroad-car equivalents) shipped daily, operations connected with shipment of fruit covered 88 days.

Fruit received the first 3 days, at the rate of 3,400 boxes per day, was moved directly into storage. The receiving rate for the next 12 days was 5,000 boxes per day, 1,600 boxes going to the temporary supply bank in the packing room. For the 8-day peak operating period, 8,000 boxes per day were

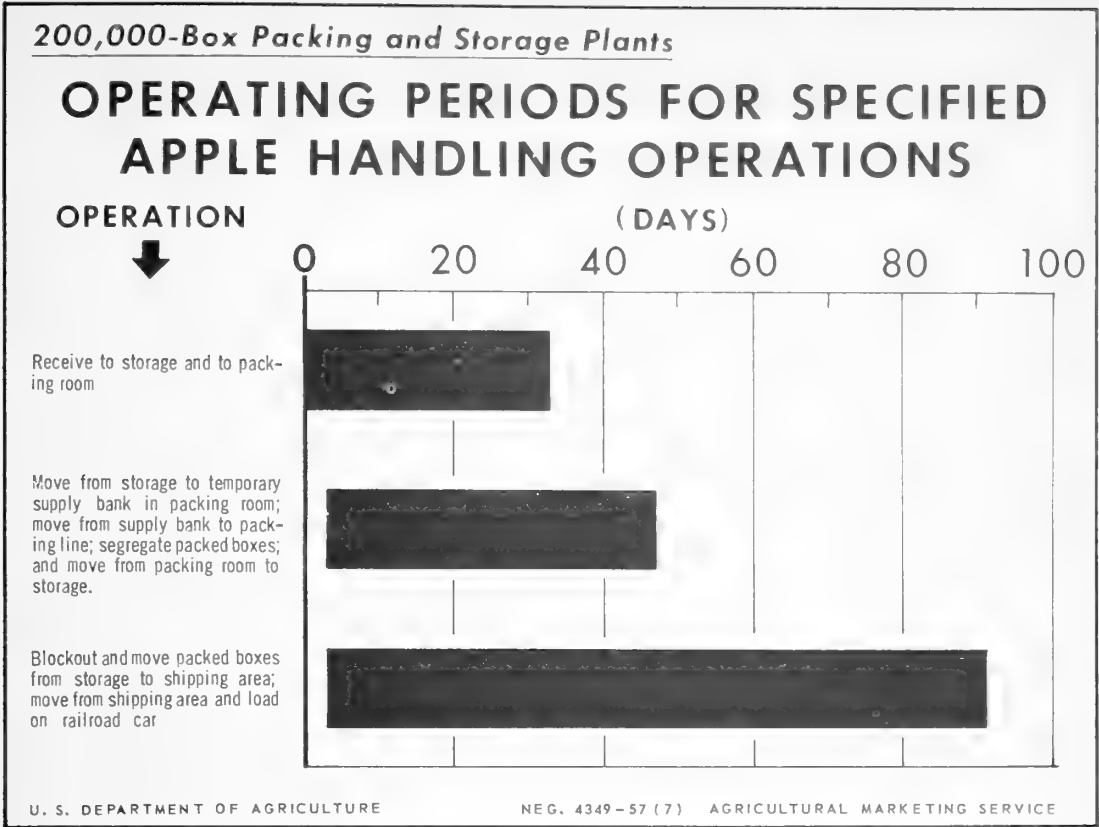


Figure 13

transferred to storage and 2,000 boxes to the temporary supply bank. The volume received daily for the last 10 days of the receiving period was the same as that for the 12 days preceding the peak period.

The packing rate was assumed to be 4,500 boxes of loose fruit per day. For the first 12 days of the 44-day period, and from the 20th to the 30th day, 1,600 boxes per day were received from growers and transferred to the temporary supply bank, and 2,900 boxes were transferred from storage. For the peak period, 2,000 of the 10,000 boxes received per day from growers were moved to the supply bank and 2,500 boxes transferred from storage. For the other 14 days of the packing period, 4,500 boxes were transferred daily from storage to the supply bank. Throughout the 44-day period, 4,500 boxes per day were moved from temporary supply bank to packing line. With a packout of 70 percent, 3,150 packed boxes per day were segregated by grade, variety, and size and moved to storage. Shipment of fruit, at 2 railroad carload equivalents a day, began on the 4th day and ended on the 91st day. Hence, 1,596 boxes per day were blocked out in storage, moved to shipping area, moved to railroad cars or trucks, and loaded.

Single-Floor Plant

Figure 14 shows the layout of a 1-floor, 200,000-box plant used to compute labor and equipment requirements for the clamp-type 2-wheel hand truck handling method. It included four 88- by 100-foot storage units. For fast receiving of fruit from growers, 8 openings (4 in the front and 4 in the rear of the building) were provided. Width and layout of aisles for each unit were assumed to be the same as for the 1-floor, 100,000-box plant. The need for 2 packing lines is based on the assumption that 1 packing line is required for each 150,000 boxes of loose fruit packed.

The layout for the 1-floor, 200,000-box plant used for the industrial lift truck methods of operation is shown in figure 15. Aisle width and layout are the same as for the 100,000-box plant layout.

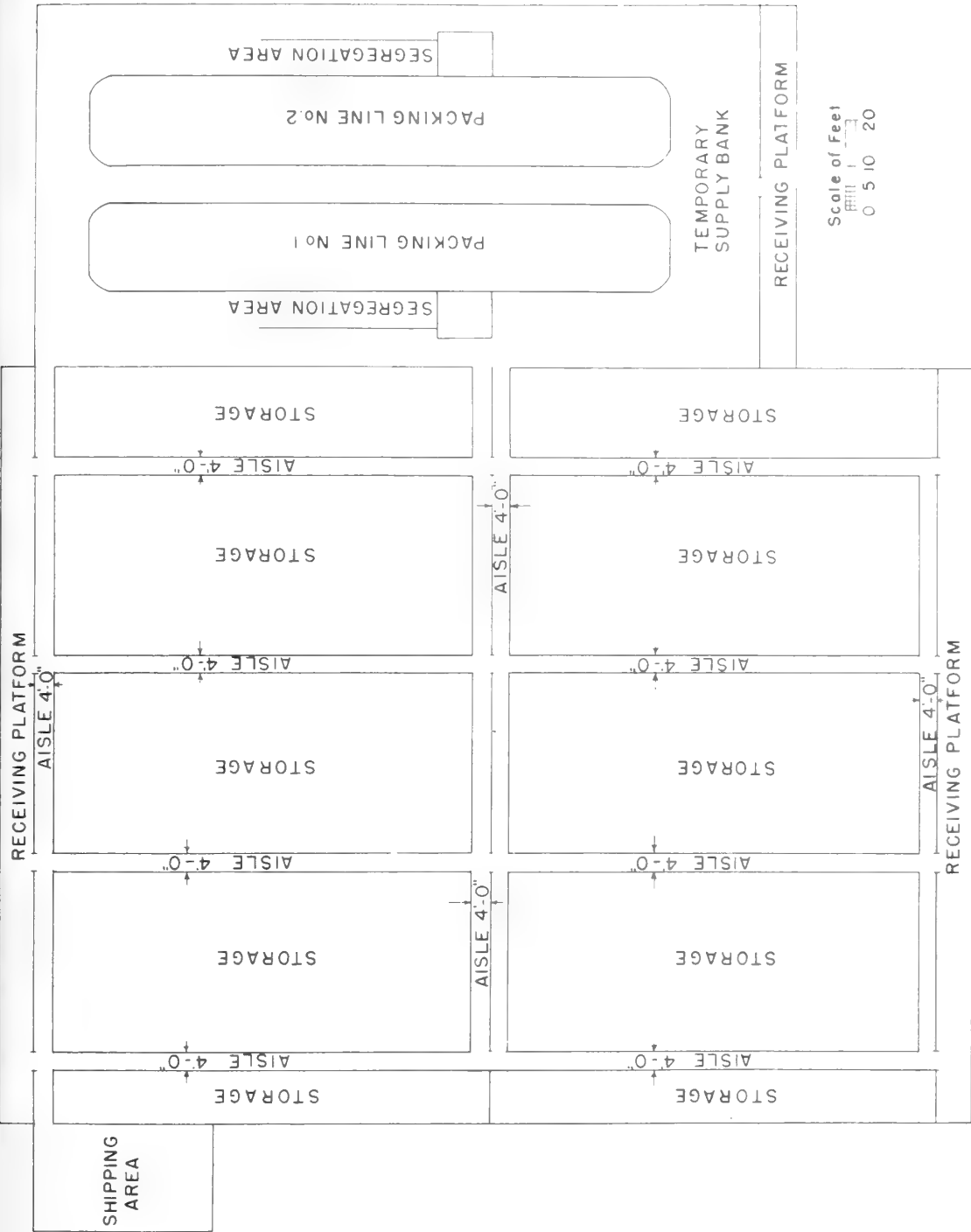
Clamp-Type 2-Wheel Hand Trucks

Labor requirements and costs.--Table 12 shows the number of workers and man-days of labor used daily for specified periods throughout the 91-day season for the 2-wheel hand truck method in the 1-floor, 200,000-box plant. Crew size ranged from 4 workers for the first 3 days and last 44 days, to 22 workers for the peak operating period.

Table 12.--Estimated number of workers and man-days of labor required to perform handling operations for a 91-day season by use of clamp-type 2-wheel hand trucks in a 1-floor, 200,000-box apple packing and storage plant

Period	: Days of : operation 1/ : <u>Number</u>	: Workers : per day 2/ : <u>Number</u>	: Total labor : required : <u>Man-days</u>
1st to 3rd day . . . . .	3	4	12
4th to 15th day. . . . .	12	20	240
16th to 23rd day . . . . .	8	22	176
24th to 33rd day . . . . .	10	20	200
34th to 47th day . . . . .	14	17	238
48th to 91st day . . . . .	44	4	176
Total . . . . .	91	-	1,042

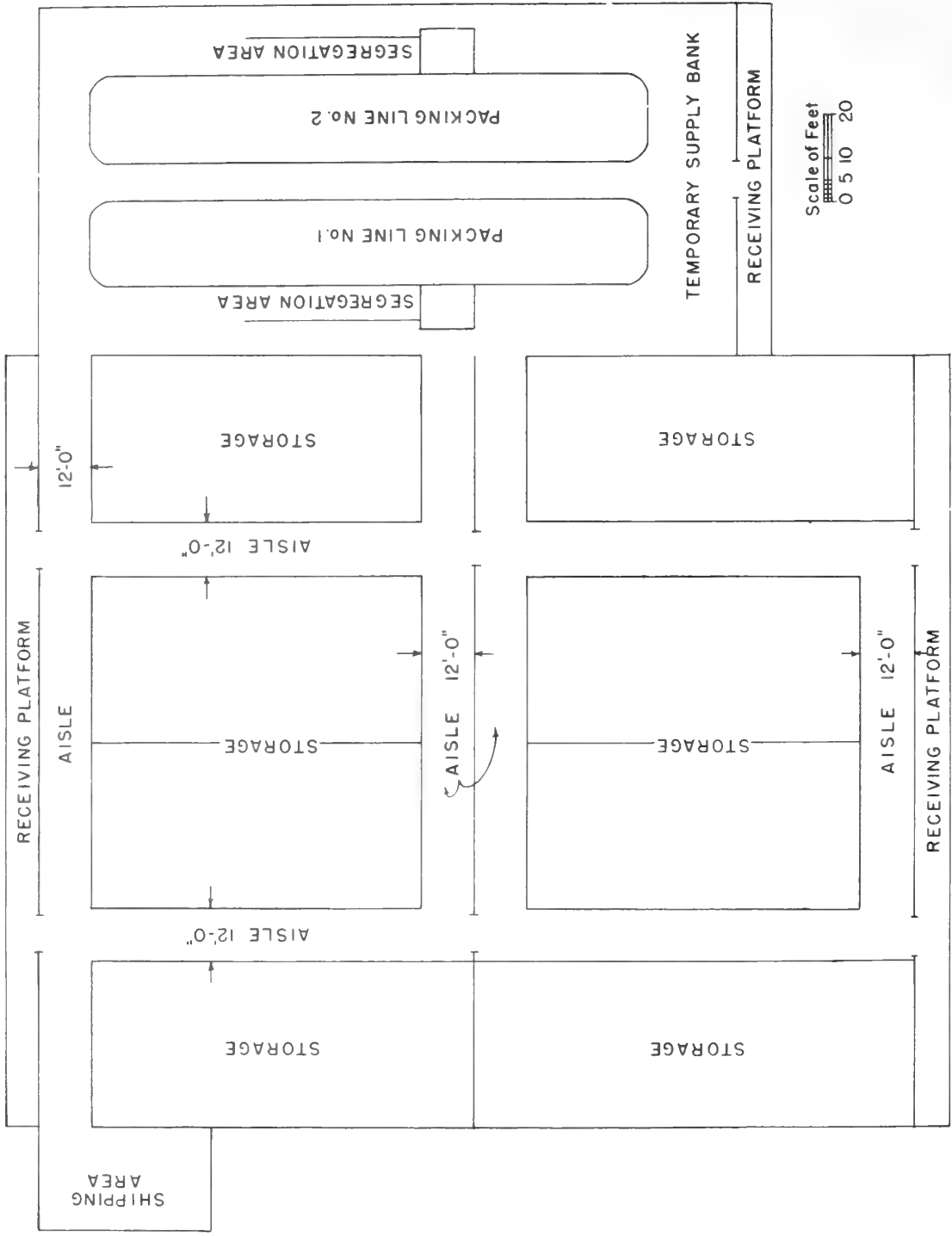
1/ Eight hours per day.  
2/ Unskilled workers.



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Figure 14.--Assumed plant layout for a 1-floor, 200,000-box apple packing and storage plant when clamp-type 2-wheel hand trucks are used, unpacked boxes stacked 12 high in storage.



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Figure 15.--Assumed plant layout for a 1-floor, 200,000-box apple packing and storage plant when industrial lift trucks are used, unpacked boxes are used, 12 high in storage.

Total labor required to perform handling operations throughout the season was 1,042 man-days. Since no other operations were performed, only 4 workers--2 hand truckers and 2 high-pilers--were needed for the first 3 days to receive and place into storage 3,400 boxes of loose fruit per day. For 22 of the remaining 30 days of the receiving period--12 days before and 10 days after the 8-day peak operating period--440 man-days of labor (20 men per day) were used to: (1) Receive 74,000 boxes into storage and 36,000 directly to the temporary supply bank in the packing room; (2) transfer 64,000 boxes from storage to temporary supply bank; (3) transfer 100,000 boxes from temporary supply bank to packing line; (4) segregate 70,000 packed boxes and transfer them to storage; and (5) block out 35,000 boxes in storage, transfer them to shipping area and to railroad cars or trucks, and load them. For the 8-day peak receiving period, a daily work crew of 22 men (176 man-days of labor) was used to: (1) Receive 64,000 boxes into storage and 16,000 to the temporary supply bank; (2) transfer 20,000 boxes from storage to temporary supply bank; (3) transfer 36,000 boxes from temporary supply bank to packing line; (4) segregate 25,200 packed boxes and transfer them to storage; and (5) block out 13,000 boxes in storage, move them to shipping area and to railroad cars or trucks, and load them. After all fruit was received, 238 man-days of labor were required for the next 14 days to transfer 64,000 boxes from storage to temporary supply bank to packing line, segregate 44,800 packed boxes and transfer them to storage, and block out 22,000 boxes in storage and load them out. A 4-man crew shipped out the remaining 70,000 boxes of packed fruit, in the last 44 days of the season.

In the 1-floor, 200,000-box plant, unskilled labor was used to perform all handling operations using the 2-wheel hand truck method. Total labor cost for the season (1,042 man-days), using the "current" wage rate, was \$9,586.

Equipment requirements and costs.--The amount and kinds of equipment used to compute costs for the 2-wheel hand truck handling method in the 1-floor, 200,000-box plant are shown in table 13. Including reserve equipment for emergencies, 20 clamp-type 2-wheel hand trucks were needed to perform handling operations occurring daily for the 8-day peak operating period. For accumulation of unpacked boxes at packing lines and segregating packed boxes, twenty 10-foot sections of roller conveyor were used. No other equipment was needed.

Ownership and operating costs for the equipment amounted to \$276.73 per year. About 81 percent of the \$26 per year operating cost was for maintenance of the 20 hand trucks.

Labor and equipment costs.--Total annual labor and equipment costs in the 1-floor, 200,000-box plant by use of 2-wheel hand trucks was \$9,863. Of this, almost 97 percent, or \$9,586, was for labor and the rest for equipment.

### 36-Box Industrial Clamp Lift Trucks

As in the case of the 100,000-box plant, all operations were performed by industrial clamp lift trucks, except segregating packed boxes and loading boxes into railroad cars or trucks.

Table 13.--Ownership and operating costs for specified types of materials-handling equipment required by clamp-type 2-wheel hand truck method in a 1-floor, 200,000-box apple packing and storage plant

Type and amount of equipment	Ownership cost per year						Oper- ating cost per year 2/	Total ownership and oper- ating cost per year
	Replace- ment cost 1/	Assumed life	Depre- ciation	Inter- est at 5 per- cent	Insur- ance and taxes at 2 per- cent	Total		
	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
20 clamp-type 2-wheel hand trucks . . . . .	1,482.00	20	74.10	37.05	29.64	140.79	21.00	161.79
200 feet of roller conveyor . . . . .	650.00							
22 floor supports . . . . .	110.00							
90° curved sections . . . . .	71.50							
Freight . . . . .	153.00							
Total . . . . .	984.50	15	65.63	24.62	19.69	109.94	5.00	114.94
Grand total . . . . .	2,466.50		139.73	61.67	49.33	250.73	26.00	276.73

1/ Total replacement cost f.o.b. Washington State points.

2/ Consists only of maintenance.

Labor requirements and costs.--Total labor required for the 91-day operating period in the 1-floor, 200,000-box plant using 36-box industrial clamp lift trucks was 399 man-days (table 14). Based on daily workloads, crew sizes using this system ranged from 1 to 7 workers. Only 1 truck operator was needed to receive 3,400 boxes per day into storage the first 3 days of the period. A 7-man crew, consisting of 3 truck operators, 2 segregators, and 2 car loaders, was used for the remaining 30 days of the receiving period to: (1) Receive 138,000 boxes into storage and 52,000 boxes directly to temporary supply bank in packing room; (2) transfer 148,000 boxes from storage to temporary supply bank; (3) transfer 200,000 boxes from temporary supply bank to packing lines; (4) segregate 140,000 packed boxes and transfer them to storage; and (5) block out 70,000 boxes in storage, transfer them to shipping area and to railroad cars or trucks, and load them. A lift-truck operator and one carloader were used for the remaining 44 days to block out and ship 70,000 boxes.

Total labor cost of this method for the season was \$3,886. Truck operators were paid \$1,862 for 179 man-days of work and segregators and car loaders \$2,024 for 220 man-days.

Equipment requirements and costs.--Handling operations performed daily for the 8-day peak operating period required three 36-box industrial clamp lift trucks, 8,320 board feet of 1- by 4-inch lumber for dunnage strips, 5 truckbed stabilizers, twenty 10-foot sections of roller conveyor, and 8 clamp-type 2-wheel hand trucks, the hand trucks for emergency use (table 15).



Table 14.--Estimated number of workers and man-days of labor required to perform handling operations for a 91-day season by use of 36-box industrial clamp lift trucks in a 1-floor, 200,000-box apple packing and storage plant

Period	Days of operation 1/ Number	Workers per day		Total labor required Man-days
		Semi-skilled 2/ Number	Unskilled 3/ Number	
1st to 3rd day . . .	3	1	-	3
4th to 47th day. . .	44	3	4	308
48th to 91st day . . .	44	1	1	88
Total. . . . .	91	-	-	399

- 1/ Eight hours per day.
- 2/ Clamp lift truck operators.
- 3/ Car loaders and segregators.

Total costs for the equipment were \$2,507.40 per year. Of this, \$2,298.40 (92 percent) was ownership costs and \$209 (8 percent) was operating costs. Of the total, \$2,202.30 was for ownership and operation of the 3 industrial lift trucks.

Labor and equipment costs.--The annual labor and equipment costs in a 1-floor plant for receiving, in-plant handling, and shipping out 200,000 boxes of unpacked fruit, using 36-box industrial clamp lift trucks, totalled \$6,393. Of this, \$3,886 was for labor and \$2,507 for equipment.

#### 48-Box Industrial Forklift Trucks

Labor requirements and costs.--Use of the 48-box industrial forklift truck method in the 1-floor, 200,000-box plant required 355 man-days of labor for the 91-day season (table 16). About 38 percent of this labor, or 135 man-days, was for truck operators and 62 percent, or 220 man-days, for segregators of packed boxes and car loaders.

Based on the daily workload, the size of crew for this method varied from 1 to 6 workers. For the first 3 days, only a truck operator was needed to receive 3,400 boxes per day into storage. From the 4th to the 47th day (44 days), 264 man-days of labor were required of a 6-man crew (2 truck operators, 2 segregators, and 2 car loaders) to: (1) Receive 138,000 boxes into storage and 52,000 boxes directly to temporary supply bank in packing room; (2) transfer 148,000 boxes from storage to temporary supply bank; (3) transfer 200,000 boxes from temporary supply bank to packing line; (4) segregate

Table 15.--Ownership and operating costs for specified types of materials-handling equipment required by 36-box industrial clamp lift truck method in a 1-floor, 200,000-box apple packing and storage plant

Equipment type	Number	Dollars	Years	Ownership cost per year		Operating cost per year		Total
				Dollars	Dollars	Dollars	Dollars	
	Amount	Replacement	Assumed	Interest	and taxes	Total	Electricity	and operating costs
	of equipment	cost	life	at 5 percent	at 2 percent	Maintenance	Total	per year
	1/2			Dollars	Dollars	Dollars	Dollars	Dollars
				Dollars	Dollars	Dollars	Dollars	Dollars
36-box industrial clamp lift truck (2,000-lb. capacity, electric)	3	10,701.00	20	535.05				
Clamp attachment	3	1,881.00	20	94.05				
Battery	3	3,276.00	7½	437.86				
Charger	3	1,350.00	20	67.50				
Freight		984.00		49.20				
Total		18,192.00		1,183.66	454.80	363.84	2,002.30	100.00
Dunnage strips	8,320							
Truckbed stabilizer	5	416.00	5	83.20	10.40	8.32	101.92	101.92
Roller conveyor (200 feet)		250.00	15	16.67	6.25	5.00	27.92	27.92
Sections	20	650.00						
Floor supports	22	110.00						
90° curve	2	71.50						
Freight		153.00						
Total		984.50	15	65.63	24.62	19.69	109.94	5.00
Clamp-type 2-wheel hand trucks 3/4	8	592.80	20	29.64	14.82	11.86	56.32	4.00
Grand total		20,435.30		1,378.80	510.89	408.71	2,298.40	109.00

1/ Based on delivered cost in Washington State.

2/ Electricity at \$0.01 per kilowatt hour.

3/ For standby use in event of breakdown of industrial lift trucks.

140,000 packed boxes and transfer them to storage; and (5) block out 70,000 boxes in storage, transfer them to shipping area and to railroad cars or trucks, and load them. A lift-truck operator and a car loader were used the last 44 days of the season to block out and ship 70,000 boxes.

Total labor cost for the season by this method was \$3,428. About \$1,404 (41 percent) was paid to truck operators and \$2,024 to segregators of packed boxes and car loaders.

Table 16.--Estimated number of workers and man-days of labor required to perform handling operations for a 91-day season by use of 48-box industrial forklift trucks in a 1-floor, 200,000-box apple packing and storage plant

Period	Days of operation 1/	Workers per day			Total labor required
		Semi-skilled 2/	Unskilled 3/		
	Number	Number	Number	Man-days	
1st to 3rd day . . . .	3	1	-	3	
4th to 47th day . . . .	44	2	4	264	
48th to 91st day . . . .	44	1	1	88	
Total . . . .	91	-	-	355	

- 1/ Eight hours per day.
- 2/ Forklift truck operators.
- 3/ Car loaders and segregators.

Equipment requirements and costs.--Based on the daily workload for the peak operating period, 2 industrial forklift trucks, 2,775 pallets, 5 truck-bed stabilizers, twenty 10-foot sections of roller conveyor, 4 pallet dollies (for car loading), and 8 clamp-type 2-wheel hand trucks (for emergency use) were required to perform all handling operations in the 1-floor, 200,000-box plant (table 17).

Total annual costs for the equipment amounted to \$3,016.60. About 92 percent of this total was for ownership and operation of the 2 industrial trucks and 2,775 pallets. Of the total, \$2,780.11 represented depreciation, interest, insurance, and taxes on all equipment.

Labor and equipment costs.--Labor and equipment costs for handling operations performed by the 48-box industrial forklift truck system in the 1-floor, 200,000-box plant totalled \$6,445. Labor cost of \$3,428 per year exceeded equipment cost by \$411.

Table 17.--Ownership and operating costs for specified types of materials-handling equipment required by 48-box industrial forklift truck method in a 1-floor, 200,000-box apple packing and storage plant

Equipment type	Amount:		Replacement:		Ownership cost per year		Operating cost per year		Total	
	of	equipment:	of	equipment:	of	equipment:	of	equipment:	of	equipment:
	Assumed:	life	Depreci-	ation:	Interest:	Insurance:	Total	Electricity:	Maintenance:	ownership and oper-
	life	at 5	ation:	at 2	at 5	at 2	Total	Electricity:	Maintenance:	ating costs
	percent	percent	percent	percent	percent	percent	2/	2/	2/	per year
	Number:	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
48-box industrial forklift truck (4,000-lb. capacity, electric)	2	9,458.00	20	472.90						
Battery	2	2,794.00	7½	372.53						
Charger	2	1,380.00	20	69.00						
Freight		910.00		45.50						
Total		14,542.00		959.93	363.55	290.84	1,614.32	81.68	95.12	1,791.12
Pallets, 48-box (40 by 48 inches)	2,775	8,325.00	15	555.00	208.12	166.50	929.62		46.69	976.31
Roller conveyor (200 feet)										
Sections	20	650.00								
Floor supports	22	110.00								
90° curve	2	71.50								
Freight		153.00								
Total		984.50		65.63	24.62	19.69	109.94		5.00	114.94
Truckbed stabilizer	5	250.00	15	16.67	6.25	5.00	27.92			27.92
Pallet dolly for loading out.	4	171.40	5	34.28	4.28	3.43	41.99		4.00	45.99
Clamp-type 2-wheel hand truck 4/.	8	592.80	20	29.64	14.82	11.86	56.32		4.00	60.32
Grand total		24,865.70		1,661.15	621.64	497.32	2,780.11	81.68	154.81	3,016.60

1/ Based on delivered cost in Washington State.  
 2/ Electricity at \$0.01 per kilowatt hour.  
 3/ Maintenance at \$0.25 per pallet life.  
 4/ For standby use in event of breakdown of industrial lift trucks.

### Two-Floor Plant

Layouts for the 2-floor, 200,000-box plants used to compute labor and equipment requirements and costs for clamp-type 2-wheel hand trucks and 24-box industrial clamp lift trucks, in combination with belt conveyors, are shown in figures 16 and 17. Four-foot aisles were provided for the 2-wheel hand truck method, and 9-foot aisles for the industrial lift truck method. Five belt conveyors were used to move fruit to and from second-floor storage. Fruit was taken to the second floor by 2 conveyors. Boxes off-loaded from these conveyors were stacked in unit loads of 6 and 24 boxes each for movement to stacking areas by hand trucks or industrial lift trucks. Boxes were moved by conveyor from the second floor to the temporary supply bank in the packing room. Packed boxes were moved to the second floor by a conveyor in the rear of the packing room. The fifth conveyor extended from the second floor to the shipping area. Since boxes were transferred directly from road trucks to storage areas by hand truck or industrial lift truck, no belt conveyors were provided for movement of fruit stored on the first floor.

#### Clamp-Type 2-Wheel Hand Trucks and Belt Conveyors

Labor requirements and costs.--In the 2-floor, 200,000-box plant, this method required 1,108 man-days of labor for all handling operations over the 91-day season (table 18). Size of crew ranged from 4 to 23 workers, based on daily workloads for specified periods. To receive 3,400 boxes per day for the first 3 days, a 4-man crew (12 man-days) was required. For the next 12 days and from the 23rd to the 33rd day, 22 men (484 man-days) were needed to: (1) Receive 74,000 boxes into storage and 36,000 boxes directly to temporary supply bank in packing room; (2) transfer 64,000 boxes from storage to temporary supply bank; (3) transfer 100,000 boxes from supply bank to packing lines; (4) segregate 70,000 packed boxes and transfer them to storage; and (5) block out 35,000 boxes in storage, transfer them to shipping area and to railroad cars or trucks, and load them. A 23-man crew was required during the 8-day peak operating period to: (1) Receive 64,000 boxes into storage and 16,000 to temporary supply bank; (2) transfer 20,000 boxes from storage to supply bank; (3) transfer 36,000 boxes from supply bank to packing lines; (4) segregate 25,200 packed boxes and transfer them to storage; and (5) block out 13,000 boxes in storage and ship them. With the packing rate set at 4,500 boxes of loose fruit per day, 18 men were used for 14 days following the receiving period to: (1) Transfer 64,000 boxes from storage to temporary supply bank to packing line; (2) segregate 44,800 packed boxes and transfer them to storage; and (3) block out 22,000 boxes in storage and ship them. A 4-man crew was required for the remaining 44 days of the 91-day period to block out 70,000 boxes in storage and ship them.

Total labor cost for the season, when the clamp-type 2-wheel hand truck and belt conveyor method was used in the 2-floor plant, was \$10,194.

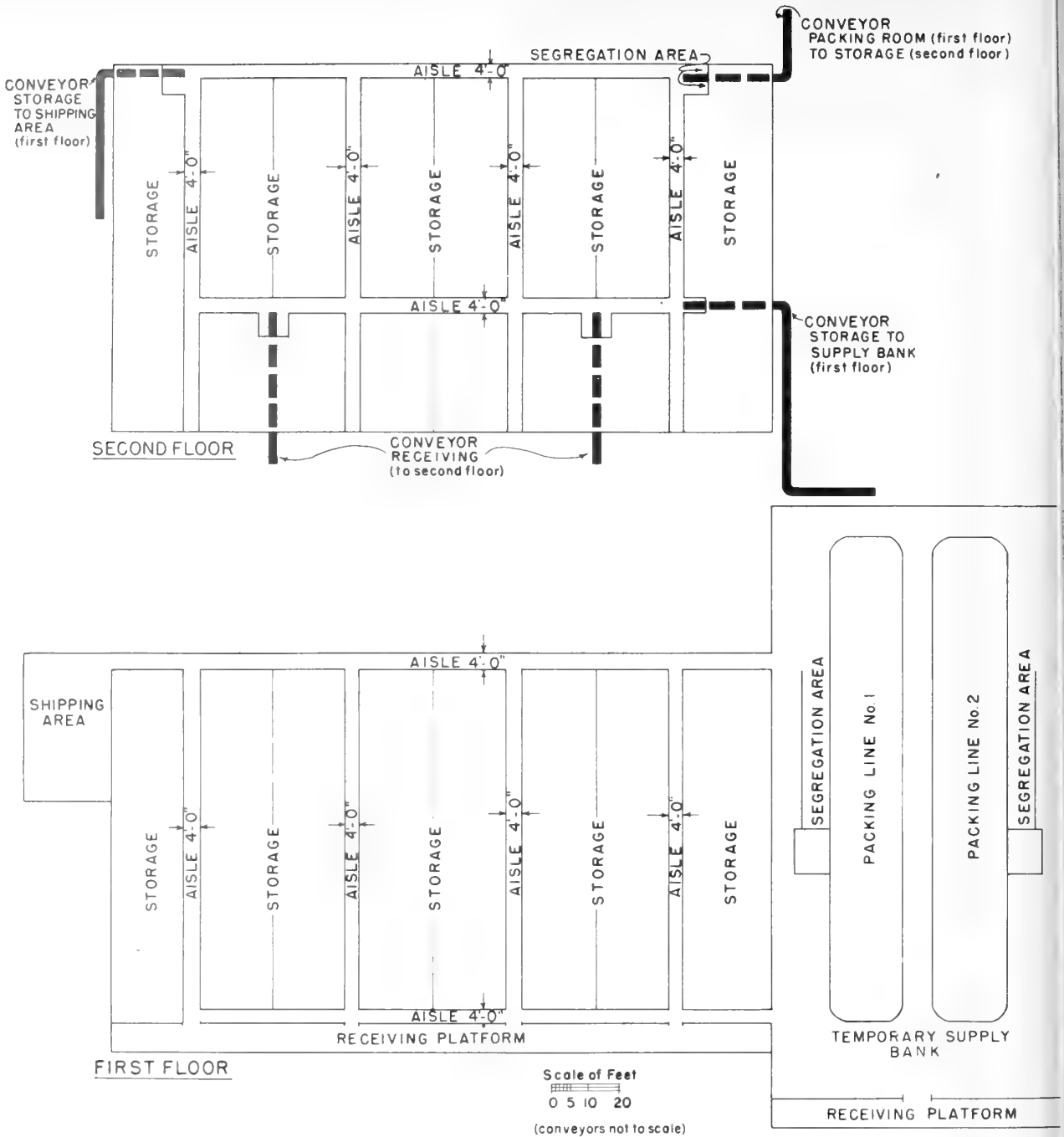
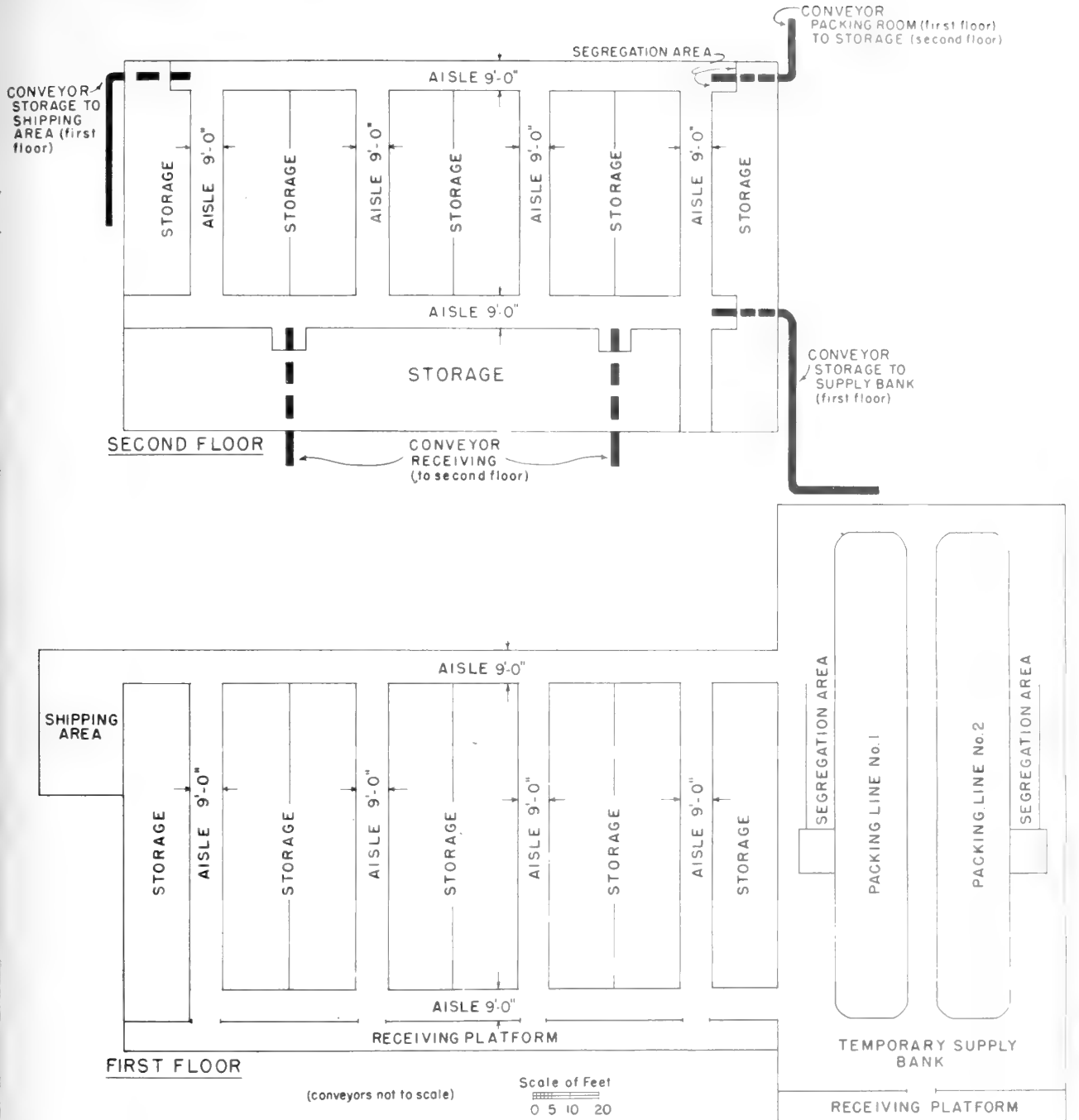


Figure 16.--Assumed plant layout for a 2-floor, 200,000-box apple packing and storage plant when clamp-type 2-wheel hand trucks and belt conveyors are used, unpacked boxes stacked 12 high in storage.



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Figure 17.--Assumed plant layout for a 2-floor, 200,000-box apple packing and storage plant when 24-box industrial clamp lift trucks and belt conveyors are used, unpacked boxes stacked 12 high in storage.

Table 18.--Estimated number of workers and man-days of labor required to perform handling operations for a 91-day season by use of clamp-type 2-wheel hand trucks and belt conveyors in a 2-floor, 200,000-box apple packing and storage plant

Period	Days of operation 1/ Number	Workers per day 2/ Number	Total labor required Man-days
1st to 3rd day . . . . .	3	4	12
4th to 15th day . . . . .	12	22	264
16th to 23rd day . . . . .	8	23	184
24th to 33rd day . . . . .	10	22	220
34th to 47th day . . . . .	14	18	252
48th to 91st day . . . . .	44	4	176
Total . . . . .	91	-	1,108

1/ Eight hours per day.  
2/ Unskilled workers.

Equipment requirements and costs.--To perform daily handling operations during the peak operating period, 25 hand trucks, 5 belt conveyors, and 200 feet of roller conveyor were needed (table 19).

Total annual equipment costs of this method in the 2-floor plant were \$1,001.53. About 69 percent of this total, or \$694.41, was for ownership and operating costs of the 5 belt conveyors. Costs for the 25 hand trucks were \$192.23 per year, or about 19 percent of the total.

Labor and equipment costs.--Total labor and equipment costs of the clamp-type 2-wheel hand truck and belt conveyor method in the 2-floor plant were \$11,196 per year. Of this, 91 percent, or \$10,194, was for labor and 9 percent, or \$1,002, for equipment.

#### 24-Box Industrial Clamp Lift Truck and Belt Conveyor

Labor requirements and costs.--The number of workers used per day for specified periods throughout the 91-day season, using 24-box industrial clamp lift trucks and belt conveyors, and total man-days of labor required to perform all handling operations in the 2-floor, 200,000-box plant are shown in table 20. This method required 619 man-days of labor.



Table 19.--Ownership and operating costs for specified types of materials-handling equipment required by clamp-type 2-wheel hand truck belt conveyor method in a 2-floor, 200,000-box apple packing and storage plant

Equipment type	Amount: Replacement		Ownership cost per year		Operating cost per year		Total				
	of equipment	ment	Assumed: Depreciation	Interest and taxes	Electricity	Maintenance					
	cost	cost	at 5%	at 2%	2/		ownership and operating costs per year				
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars				
	Number	Years	Dollars	Dollars	Dollars	Dollars	Dollars				
Clamp-type 2-wheel hand truck . . . . .	25	1,852.50	20	92.62	46.31	37.05	175.98	16.25	192.23		
Belt conveyor											
Belting @ \$2.30 per foot . . . . .	570 ft.	1,311.00	15	87.40							
Dip and load section . . . . .	5	498.75	25	19.95							
Curved end section . . . . .	3	149.25	25	5.97							
Motor . . . . .	5	1,110.00	25	44.40							
Drive . . . . .	5	712.50	25	28.50							
Idle ends . . . . .	10	415.00	25	16.60							
Floor supports . . . . .	45	270.00	25	10.80							
Roller sections . . . . .	50	1,975.00	25	79.00							
Installation (5 percent) . . . . .		322.00		12.88							
Total . . . . .		6,763.50		305.50	169.09	135.27	609.86	17.80	66.75	84.55	694.41
Roller conveyor (200 feet)											
Sections . . . . .	20	650.00									
Floor supports . . . . .	22	110.00									
90° curve . . . . .	2	71.50									
Freight . . . . .		153.00									
Total . . . . .		984.50	15	65.63	24.62	19.69	109.94		5.00	5.00	114.94
Grand total . . . . .		9,600.50		463.75	240.02	192.01	895.78	17.80	88.00	105.80	1,001.58

1/ Based on delivered cost in Washington State.  
 2/ Electricity at \$0.01 per kilowatt hour.

Table 20.--Estimated number of workers and man-days of labor required to perform handling operations for a 91-day season by use of 24-box industrial clamp lift trucks and belt conveyors in a 2-floor, 200,000-box apple packing and storage plant

Period	Days of operation 1/	Workers per day		Total labor required
		Semi-skilled 2/	Unskilled 3/	
	Number	Number	Number	Man-days
1st to 3rd day . . . .	3	1	2	9
4th to 15th day. . . .	12	4	7	132
16th to 23rd day . . . .	8	5	7	96
24th to 33rd day . . . .	10	4	7	110
34th to 47th day . . . .	14	3	7	140
48th to 91st day . . . .	44	1	2	132
Total . . . .	91	-	-	619

- 1/ Eight hours per day.
- 2/ Clamp lift truck operators.
- 3/ Car loaders and segregators.

On the basis of the assumed daily workloads for the various levels of operation throughout the season, crews ranged from 3 workers for the first 3 days of operation to 12 for the 8-day peak period. Three workers (1 truck operator and 2 conveyormen) were required for the first 3 days to receive 3,400 boxes per day into storage. For 22 of the remaining 30 days of the receiving period (12 days before and 10 days after the peak operating period), 4 truck operators, 4 conveyormen, 1 segregator, and 2 car loaders were used to: (1) Receive 74,000 boxes into storage and 36,000 directly to the temporary supply bank in the packing room; (2) transfer 64,000 boxes from storage to temporary supply bank; (3) transfer 100,000 boxes from supply bank to packing line; (4) segregate 70,000 packed boxes and transfer them to storage; and (5) block out 35,000 boxes in storage, transfer them to shipping area and to railroad cars or trucks, and load them. A crew of 12 men--1 more truck operator to handle additional receipts--was needed during the 8-day peak operating period. A crew of 3 truck operators, 4 conveyormen, 1 segregator, and 2 car loaders was used for 14 days following the receiving period to: (1) Transfer 64,000 boxes from storage to supply bank to packing line; (2) segregate 44,800 packed boxes and transfer them to storage; and (3) block out 22,000 boxes in storage and ship them. Shipment of 70,000 boxes over the remaining 44 days

of the season required 1 truck operator and 2 men to load packed boxes of fruit into railroad cars and to man the belt conveyor.

Total labor cost for this method in the 2-floor plant was \$5,955 for the 91-day season. Of this, \$2,257 was paid to truck operators and \$3,698 to conveyormen, segregator, and car loaders. (Packed boxes moved to second-floor storage are segregated at the terminal end of the conveyor.)

Equipment requirements and costs.--To perform daily handling operations during the 8-day peak operating period, the following amounts and types of equipment were required: (1) Five 24-box industrial clamp lift trucks; (2) 5 belt conveyors; (3) 8,320 board feet of 1- by 4- by 24-inch strips of lumber for dunnage; (4) 5 truckbed stabilizers; (5) 200 feet of roller conveyor; and (6) 8 clamp-type 2-wheel hand trucks for emergency use (table 21).

Total costs for the equipment amounted to \$3,717.19 per year. Of this, about 90 percent was for ownership costs and 10 percent for operation. Seventy-three percent of the \$3,357.64 ownership costs was for depreciation, interest, insurance, and taxes for the 5 industrial lift trucks.

Labor and equipment costs.--Total labor and equipment costs of the method using the 24-box industrial clamp lift truck and belt conveyor for the 2-floor plant were \$9,672 for the 91-day period. These costs were divided into \$5,955 for labor and \$3,717 for equipment.

#### Comparative Costs of Five Methods

Table 22 shows the comparative labor inputs and labor and equipment costs for performing operations associated with handling 200,000 boxes of unpacked fruit into, within, and out of 1- and 2-floor plants by specified systems of handling. The method requiring the lowest amount of labor was that using 48-box industrial forklift trucks. However, the lowest cost method (by a small amount) was that using 36-box industrial clamp lift trucks. As in the 100,000-box plants, the highest cost system was that using 2-wheel hand trucks in the 2-floor plant.

Labor input for the 48-box industrial forklift truck method for the 91-day period was 355 man-days. The next lowest was for the 36-box industrial clamp lift truck system, which required 399 man-days of labor. Labor input required by the 2-wheel hand truck method in the 1-floor plant was 1,042 man-days, almost 3 times as much as that for the industrial forklift truck method. In the 2-floor plant, the hand truck method required 1,108 man-days, more than 3 times as much as the forklift truck method.

Total labor and equipment costs for the 36-box industrial clamp lift truck system (the lowest cost method) were \$6,393 for the year. Of this, \$3,886 was for labor and \$2,507 for equipment.

Table 21.--Ownership and operating costs for specified types of materials-handling equipment required by 24-box industrial clamp lift truck and belt conveyor method in a 2-floor, 200,000-box apple packing and storage plant

Equipment type	Amount of equipment	Replacement cost	Years of life	Ownership cost per year		Operating cost per year		Total ownership and operating costs per year			
				Dollars	Percent	Dollars	Percent				
24-box industrial clamp lift truck (1,000-lb. capacity, electric)	5	12,360.00	20	618.00							
Machine	5	3,135.00	20	156.75							
Clamp attachment	5	3,810.00	7½	508.00							
Battery	5	2,250.00	20	112.50							
Charger		910.00		45.50							
Freight											
Total		22,465.00		1,440.75	561.63	449.30	2,451.68	133.00	266.00	2,717.68	
Belt conveyor											
Belting @ \$2.30 per foot	570	1,311.00	15	87.40							
Dip and load section	5	498.75	25	19.95							
Curved end section	3	149.25	25	5.97							
Motor	5	1,110.00	25	44.40							
Drive	5	712.50	25	28.50							
Idle ends	10	415.00	25	16.60							
Floor supports	45	270.00	25	10.90							
Roller sections	50	1,975.00	25	79.00							
Installation (5 percent)		322.00		12.08							
Total		6,763.50		305.50	169.09	135.27	609.86	17.80	66.75	84.55	694.41
Dunnage strips	8,320 bd.ft.	416.00	5	83.20	10.40	8.32	101.92				101.92
Truckbed stabilizer	5	250.00	15	16.67	6.25	5.00	27.92				27.92
Roller conveyor (200 feet)											
Sections	20	650.00									
Floor supports	22	110.00									
90° curve	2	71.50									
Freight		153.00									
Total		984.50		65.63	24.62	19.69	109.94	5.00			114.94
Clamp-type 2-wheel hand truck 3/	8	592.80	20	29.64	14.82	11.86	56.32	4.00			60.32
Grand total		31,471.80		1,941.39	786.31	629.44	3,357.64	150.80	208.75	359.55	3,717.19

1/ Based on delivered cost in Washington State.  
 2/ Electricity at \$0.01 per kilowatt hour.  
 3/ For standby use in event of breakdown of industrial lift trucks.

Table 22.--Comparative labor and equipment costs per year by use of specified types of materials-handling equipment in 1- and 2-floor, 200,000-box apple packing and storage plants 1/

Equipment	Labor and equipment costs per year				
	Labor required	Labor 2/	Equipment	Total cost	
				Current wages 2/	Assumed wages 3/
	Man-days	Dollars	Dollars	Dollars	Dollars
<u>One-floor plant</u>					
Clamp-type 2-wheel hand trucks . . . . .	1,042	9,586	277	9,863	11,947
36-box industrial clamp lift trucks. . . . .	<u>4/</u> 399	3,886	2,507	6,393	7,191
48-box industrial forklift trucks . . . . .	<u>5/</u> 355	3,428	3,017	6,445	7,155
<u>Two-floor plant</u>					
Clamp-type 2-wheel hand trucks and belt conveyors . . . . .	1,108	10,194	1,002	11,196	13,412
24-box industrial clamp lift trucks and belt conveyors . . . . .	<u>6/</u> 619	5,955	3,717	9,672	10,910

1/ Handling operations performed are: (1) Receive 149,000 boxes to storage and 51,000 boxes to temporary supply bank in packing room; (2) transfer 149,000 boxes from storage to temporary supply bank; (3) transfer 200,000 boxes from supply bank to packing line; (4) segregate 140,000 packed boxes and transfer them to storage; and (5) block out 140,000 boxes in storage, transfer them to shipping area and to railroad cars or trucks, and load them.

2/ Based on a wage rate of \$1.15 for unskilled labor and \$1.30 for semi-skilled labor (truck operators).

3/ Based on a wage rate of \$1.40 for unskilled labor and \$1.55 for semi-skilled labor (truck operators).

4/ Unskilled labor, 220 man-days; semiskilled labor, 179 man-days.

5/ Unskilled labor, 220 man-days; semiskilled labor, 135 man-days.

6/ Unskilled labor, 402 man-days; semiskilled labor, 217 man-days.

The next lowest cost method was by use of 48-box industrial forklift trucks. Total costs for this system were \$6,445 per year. This is only 1 percent more than the lowest cost method. Forty-nine percent of this, or \$3,428, was for labor and 51 percent, or \$3,017, for equipment.

In the 2-floor plant, labor and equipment costs for the system using 24-box industrial clamp lift trucks totaled \$9,672, which was \$1,524, or 14 percent, less than for the hand truck and belt conveyor method.

Calculated at "assumed" wage rates, the cost of the highest cost method, that using hand trucks and belt conveyors, was \$13,412, which was 87 percent greater than that of the lowest cost method (\$7,191), that using 36-box industrial clamp lift trucks.

### LABOR REQUIREMENTS AND TOTAL COSTS FOR 400,000-BOX PLANTS

The seasonal operating period for the 1- and 2-floor, 400,000-box plants was established at 152 days (fig. 18). Duration of the receiving period was 35 days--2 days longer than for the 200,000-box plant and 8 days longer than for the 100,000-box plant. Receiving was the only operation performed the first 3 days. The operations associated with fruit packing cover 59 days. These operations were: (1) Transfer boxes of apples from storage to temporary supply bank in packing room; (2) transfer from temporary supply bank to packing line; (3) segregate packed boxes; and (4) transfer packed boxes from packing room to storage. The shipping period was determined to be 149 days; this compared with 88 days for both the 100,000- and 200,000-box plants.

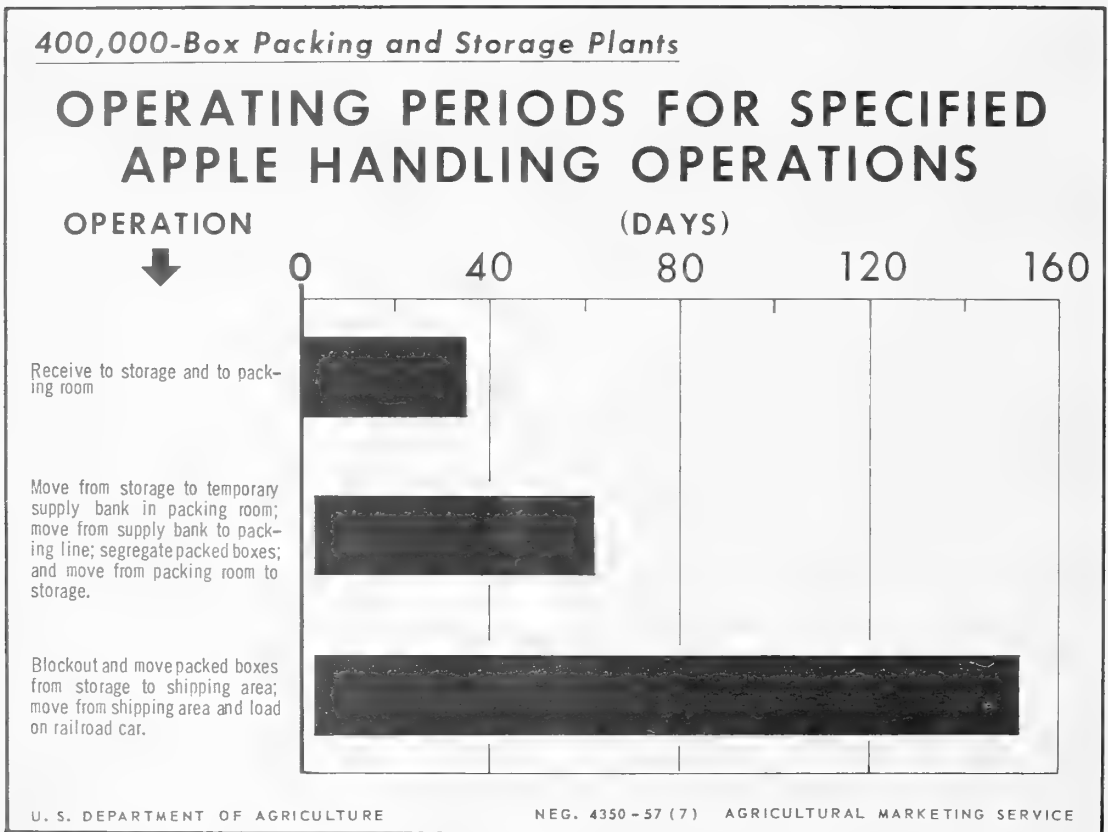


Figure 18

For the first 3 days of the receiving period, 7,000 boxes per day were received and placed in storage. The receiving rate for the next 12 days, and from the 26th to the 35th day, was 9,000 boxes per day; of these, 2,000 boxes were moved directly to the temporary supply bank in the packing room. During the 10-day peak operating period, 18,000 boxes per day were received, 3,000 boxes going directly to the temporary supply bank. Of the 400,000 boxes received, about 325,000 were moved to storage and 75,000 directly to the temporary supply bank.

To pack out 400,000 boxes of apples, 3 packing lines were in continuous operation for 59 days. Packing operations started on the 4th day and ended on the 62nd day. For the first 12 days of the packing period, and from the 22nd day to the 32nd day, of the 6,750 boxes packed per day, 4,750 were moved out of storage to the temporary supply bank in the packing room. During the peak receiving period, 3,750 boxes were transferred from storage to the temporary supply bank and 3,000 boxes were moved directly from growers' trucks to the temporary supply bank. For the remaining 27 days of the packing period, the entire 6,750 boxes per day were taken from storage and moved to the temporary supply bank. Throughout the packing period, 6,750 boxes per day were transferred from the temporary supply bank to the 3 packing lines. With a pack-out of 70 percent, 4,725 packed boxes per day were segregated as to size, grade, and variety, and placed in storage.

The shipping period began on the 4th day and ended on the last day of the period. For 75 days of this period, 2,394 boxes (3 railroad carload equivalents) were blocked out in storage, transported to shipping area and to railroad cars or trucks, and loaded. For a 50-day period, shipments were reduced to 2 carloads a day, or 1,596 boxes, and for the remaining 24 days of the period, to 1 carload.

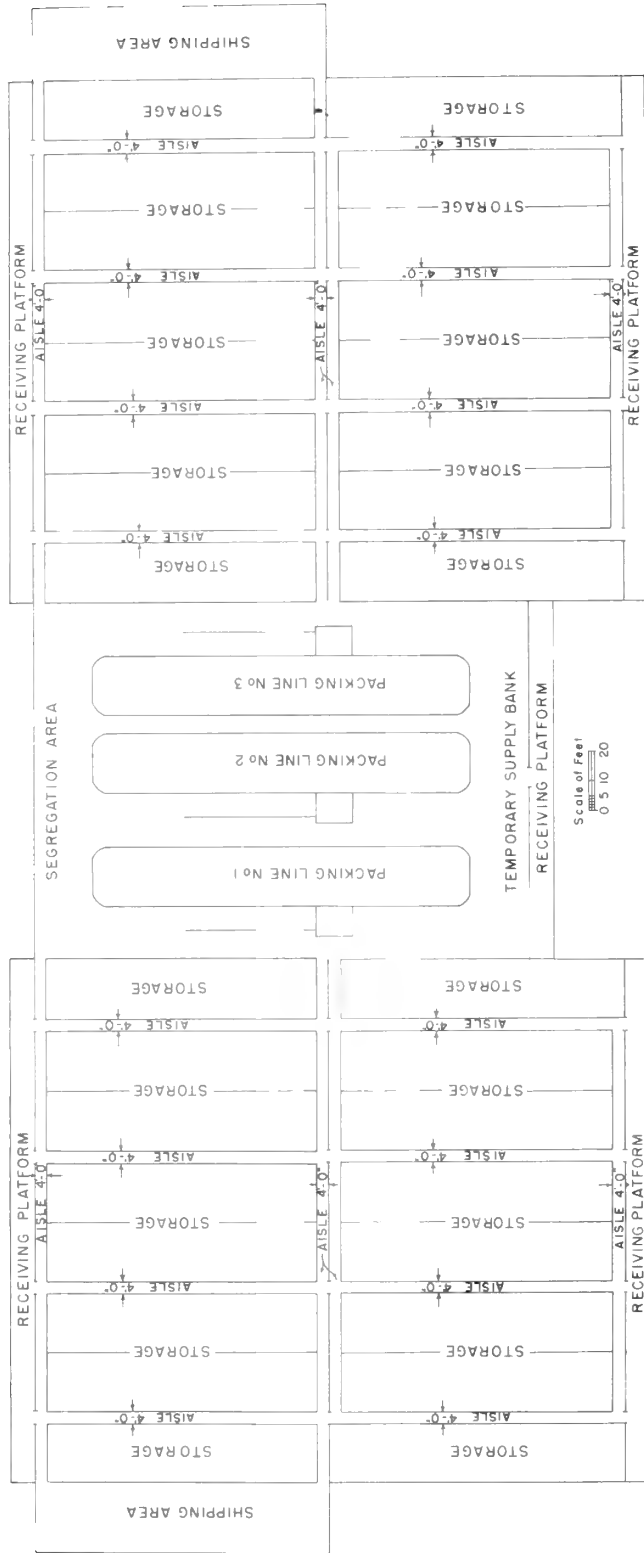
### Single-Floor Plant

The 1-floor, 400,000-box plant layout used to compute labor and equipment requirements when clamp-type 2-wheel hand trucks alone were used is shown in figure 19. Eight 88- by 100-foot storage units were used, 4 of them located on each side of the 3-line packing room. Sixteen entrances gave access to storage areas from the receiving platforms. Eight were at the front and eight at the rear. Their locations minimized travel distances in receiving fruit and moving it to storage.

Figure 20 shows the 400,000-box plant layout for industrial lift truck methods of operation. Since stacking depth was greater when industrial lift trucks were used, only 8 entrances for receiving fruit were provided, 4 at the front and 4 at the rear of the building. Both layouts provided an enclosed shipping area at each end of the building.

### Clamp-Type 2-Wheel Hand Trucks

Labor requirements and costs.--Labor requirements when clamp-type 2-wheel hand trucks were used in the 1-floor, 400,000-box plant amounted to 2,114 man-days for the 152-day period (table 23). Crew sizes ranged from 2 to 34 workers.

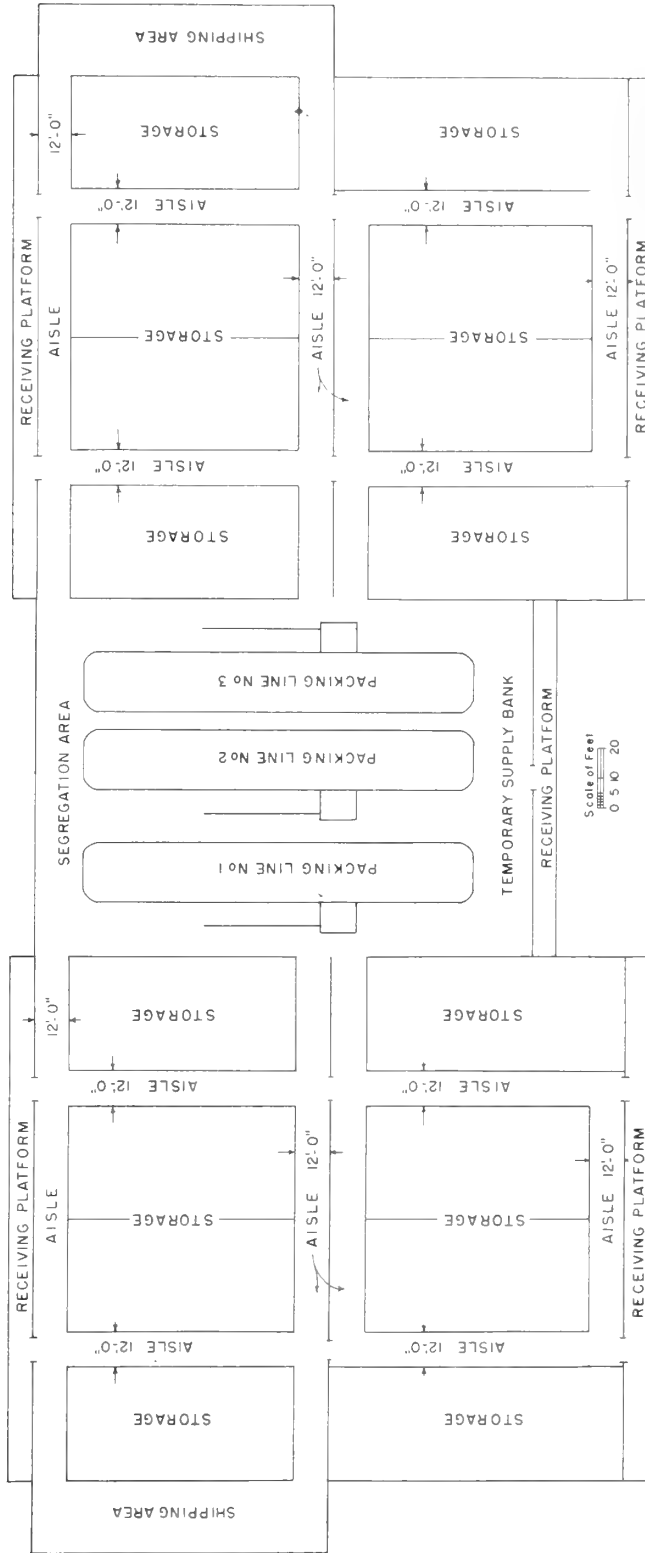


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Figure 19. --Assumed plant layout for a 1-floor, 400,000-box apple packing and storage plant when clamp-type 2-wheel hand trucks are used, unpacked boxes stacked 12 high in storage.





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Figure 20.--Assumed plant layout for a 1-floor, 400,000-box apple packing and storage plant when industrial lift trucks are used, unpacked boxes stacked 12 high in storage.

Table 23.--Estimated number of workers and man-days of labor required to perform handling operations for a 152-day season by use of clamp-type 2-wheel hand trucks in a 1-floor, 400,000-box apple packing and storage plant

Period	Days of operation 1/ Number	Workers per day 2/ Number	Total labor required Man-days
1st to 3rd day . . . . .	3	6	18
4th to 15th day . . . . .	12	30	360
16th to 25th day . . . . .	10	34	340
26th to 35th day . . . . .	10	30	300
36th to 62nd day . . . . .	27	26	702
63rd to 78th day . . . . .	16	6	96
79th to 128th day . . . . .	50	5	250
129th to 152nd day . . . . .	24	2	48
Total . . . . .	152	-	2,114

1/ Eight hours per day.

2/ Unskilled workers.

Eighteen man-days were required of a 6-man crew for the first 3 days of operation to receive into storage and high-pile 7,000 boxes per day. A crew of 30 men was used for 22 days (12 days before and 10 days after the peak receiving period) to: (1) Receive 154,500 loose boxes into storage and 44,000 to the temporary supply bank in the packing room; (2) transfer 105,000 boxes from storage to temporary supply bank; (3) transfer 149,000 boxes from temporary supply bank to packing lines; (4) segregate 104,300 packed boxes and transfer them to storage; and (5) block out 53,000 boxes in storage, transfer them to shipping area and to railroad cars or trucks, and load them. A 34-man crew was required during the 10-day peak period to: (1) Receive 150,500 boxes into storage and 30,000 directly to the temporary supply bank; (2) transfer 38,000 boxes from storage to temporary supply bank; (3) transfer 68,000 boxes from temporary supply bank to packing lines; (4) segregate 47,600 packed boxes and transfer them to storage; and (5) block out 24,000 boxes in storage and ship them. For 27 days following the receiving period, 26 men were used to: (1) Move 183,000 boxes from storage to temporary supply bank, and from there to packing lines; (2) segregate 128,100 packed boxes and transfer them to storage; and (3) block out and ship 65,000 boxes. Shipment of 3 carloads per

day continued for the next 16 days; a 6-man crew was used for this period to block out and ship 39,000 boxes. Shipments of 2 carloads per day were made by a 5-man crew from the 73th to the 128th day (50 days) of the operating period, or a total of 80,000 boxes. For the last 24 days of the period, a 2-man crew blocked out and shipped 1 carload equivalent per day, totaling 19,000 boxes.

Total labor cost of this system for moving 400,000 boxes of loose fruit into, within, and out of apple plants over a 152-day period in a 1-floor plant was \$19,449.

Equipment requirements and costs.--Table 24 shows the amount and costs of equipment required to perform handling operations daily during the 10-day peak receiving period. The daily workload of this period required 25 clamp-type 2-wheel hand trucks and 300 feet of roller conveyor.

Compared with other handling methods, the total equipment cost of \$397.89 for the 2-wheel hand truck method was relatively low. Of the total annual equipment cost, 86 percent, or \$340.89, was for ownership, and 14 percent, or \$57, for maintenance. Costs for the 300 feet of roller conveyor, at \$164.91, were about \$11 lower than those for the 25 hand trucks.

Table 24.--Ownership and operating costs for specified types of materials-handling equipment required by clamp-type 2-wheel hand truck method in a 1-floor, 400,000-box apple packing and storage plant

Type and amount of equipment	Ownership cost per year						Operating cost per year	Total ownership and operating cost per year
	Replace- ment cost <sup>1/</sup>	Assumed: life	Depre- ciation:	Inter- est at 5 per- cent	and taxes at 2 per- cent	Total		
	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
25 clamp-type 2-wheel hand trucks . . . . .	1,852.50	20	92.62	46.31	37.05	175.98	47.00	222.98
300 feet of roller conveyor . . . . .	975.00							
33 floor supports . . . . .	165.00							
3 90° curved sections . . . . .	107.25							
Freight . . . . .	229.50							
Total . . . . .	1,476.75	15	98.45	36.92	29.54	164.91	10.00	174.91
Grand total . . . . .	3,328.25		191.07	83.23	66.59	340.89	57.00	397.89

<sup>1/</sup> Total replacement cost f.o.b. Washington State points.

<sup>2/</sup> Consists only of maintenance.

Labor and equipment costs.--Total labor and equipment costs to perform handling operations in the 1-floor, 400,000-box plant using the clamp-type 2-wheel hand truck method were \$19,847. Of this, \$19,449, or 98 percent, was for labor and \$398 for equipment.

36-Box Industrial Clamp Lift Trucks

Labor requirements and costs.--The number of workers used daily for specified periods throughout the 152-day season and the man-days of labor required to perform handling operations by the 36-box industrial clamp lift truck method in the 1-floor, 400,000-box plant are shown in table 25. Of the 729 man-days of labor required, 387 man-days were for truck operators and 342 man-days for car loaders and segregators of packed boxes.

Table 25.--Estimated number of workers and man-days of labor required to perform handling operations for a 152-day season by use of 36-box industrial clamp lift trucks in a 1-floor, 400,000-box apple packing and storage plant

Period	Days of operation 1/	Workers per day		Total labor required
		Semi-skilled 2/	Unskilled 3/	
	Number	Number	Number	Man-days
1st to 3rd day . . . . .	3	1	-	3
4th to 15th day . . . . .	12	5	4	108
16th to 25th day . . . . .	10	6	4	100
26th to 35th day . . . . .	10	5	4	90
36th to 62nd day . . . . .	27	4	4	216
63rd to 78th day . . . . .	16	2	2	64
79th to 128th day . . . . .	50	1	1	100
129th to 152nd day . . . . .	24	1	1	48
<b>Total . . . . .</b>	<b>152</b>	<b>-</b>	<b>-</b>	<b>729</b>

1/ Eight hours per day.  
 2/ Clamp lift truck operators.  
 3/ Car loaders and segregators.

The number of workers used daily by this method throughout the season was substantially less than in the 2-wheel hand truck method. By the industrial clamp lift truck method, only 1 lift truck was needed for the first 3 days of the season to receive into storage 7,000 boxes per day. For 22 days of the receiving period (12 days before and 10 days after the peak receiving period), 5 truck operators, 2 car loaders and 2 segregators were used to: (1) Receive 154,500 boxes into storage and 44,000 boxes to the temporary supply bank in the packing room; (2) transfer 105,000 boxes from storage to temporary supply bank; (3) transfer 149,000 boxes from temporary supply bank to packing lines; (4) segregate 104,300 packed boxes and transfer them to storage; and (5) block out 53,000 boxes in storage, move them to shipping area and to railroad cars or trucks, and load them. The crew was increased by 1 truck operator (6 truck operators, 2 car loaders, and 2 segregators) for the 10-day peak receiving period when daily receipts were assumed to be twice those of the 22-day period. For the 27 days needed to pack out the remainder of the fruit, 4 truck operators, 2 car loaders, and 2 segregators were used to: (1) Move 183,000 boxes from storage to temporary supply bank and then to packing lines; (2) segregate 128,100 packed boxes and transfer them to storage; and (3) block out and ship 65,000 packed boxes. To block out and ship 3 carload equivalents per day for the next 16 days required 2 truck operators and 2 car loaders. For the remaining 74 days of the period, 1 car loader and 1 truck operator, who assisted the car loader in stowing boxes in railroad cars or trucks, blocked out and shipped 2 carloads a day for 50 days and 1 carload for the last 24 days.

Total labor cost of the 36-box industrial clamp lift truck method in the 1-floor, 400,000-box plant was \$7,171 for the season. Of this, \$4,025 was paid to truck operators and \$3,146 to segregators and car loaders.

Equipment requirements and costs.--The amount of equipment, based on the daily workload for the 10-day peak receiving period, and annual ownership and operating costs for this method are shown in table 26. The daily workload during the period required the use of 6 industrial clamp lift trucks, 16,640 board feet of 1- by 4-inch lumber for dunnage strips, 9 truckbed stabilizers, thirty 10-foot sections of roller conveyor, and twelve 2-wheel hand trucks for emergency use in the event of equipment breakdown.

Total annual costs for the equipment required were \$5,036.17. Of this, \$4,532.41 was for ownership cost and \$453.76 for operating cost. About 88 percent of the total cost was for ownership and operation of the 6 industrial lift trucks.

Labor and equipment costs.--Total labor and equipment costs for the method using 36-box industrial clamp lift trucks in the 1-floor plant were \$12,207. Labor costs of \$7,171 were about \$2,135 greater than equipment costs.

Table 26.--Ownership and operating costs for specified types of materials-handling equipment required by 36-box industrial clamp lift truck method in a 1-floor, 400,000-box apple packing and storage plant

Equipment type	Amount of equipment	Replacement cost	Assumed life	Ownership cost per year		Operating cost per year		Total ownership and operating costs per year
				Dollars	Years	Dollars	Dollars	
36-box industrial clamp lift truck (2,000-lb. capacity, electric).	6	21,402.00	20	1,070.10				
Machine	6	3,762.00	20	188.10				
Clamping arms	6	6,552.00	7½	873.60				
Battery	6	2,700.00	20	135.00				
Charger	6	1,968.00		98.40				
Freight		36,384.00		2,365.20	909.60	727.68	4,002.48	218.88
Total		16,640						437.76
Dunnage strips	bd. ft.	832.00	5	166.40	20.80	16.64	203.84	203.84
Trucked stabilizer	9	450.00	15	30.00	11.25	9.00	50.25	50.25
Roller conveyor (300 feet)								
Sections	30	975.00						
Floor supports	33	165.00						
90° curve	3	107.25						
Freight		229.50						
Total		1,476.75	15	174.91	36.92	29.54	241.37	10.00
Clamp-type 2-wheel hand truck 3/	12	889.20	20	44.46	22.23	17.78	84.47	6.00
Grand total		40,031.95		2,780.97	1,000.80	800.64	4,582.41	453.76

1/ Based on delivered cost in Washington State.

2/ Electricity at \$0.01 per kilowatt hour.

3/ For standby use in event of breakdown of industrial lift trucks.

### 48-Box Industrial Forklift Trucks

Labor requirements and costs.--Table 27 shows the number of workers used daily for specified periods over a 152-day season and total man-days of labor required to perform all handling operations using 48-box industrial forklift trucks in a 1-floor, 400,000-box plant. Of the total of 644 man-days of labor required, 342 were for car loaders and segregators of packed boxes and 302 man-days for truck operators.

Table 27.--Estimated number of workers and man-days of labor required to perform handling operations for a 152-day season by use of 48-box industrial forklift trucks in a 1-floor, 400,000-box apple packing and storage plant

Period	Days of operation 1/ Number	Workers per day		Total labor required Man-days
		Semi- skilled 2/ Number	Un- skilled 3/ Number	
1st to 3rd day . . . .	3	1	-	3
4th to 15th day . . . .	12	4	4	96
16th to 25th day . . . .	10	4	4	80
26th to 35th day . . . .	10	4	4	80
36th to 62nd day . . . .	27	3	4	189
63rd to 78th day . . . .	16	1	2	48
79th to 128th day . . . .	50	1	1	100
129th to 152nd day . . . .	24	1	1	48
<b>Total . . . .</b>	<b>152</b>	<b>-</b>	<b>-</b>	<b>644</b>

- 1/ Eight hours per day.
- 2/ Forklift truck operators.
- 3/ Car loaders and segregators.

Crew size for this method ranged from 1 to 8 workers. One truck operator was used the first 3 days of the period to receive into storage 7,000 boxes per day. For 22 days of the receiving period (12 days before and 10 days after the peak receiving period), 4 truck operators, 2 car loaders, and 2 segregators of packed boxes were used to: (1) Receive 154,500 boxes into storage and 44,000 boxes to temporary supply bank in packing room; (2) transfer 105,000 boxes

from storage to temporary supply bank; (3) transfer 149,000 boxes from temporary supply bank to packing lines; (4) segregate 104,300 packed boxes and transfer them to storage; and (5) block out 53,000 boxes in storage, transfer them to shipping area and to railroad cars or trucks, and load them. The same crew was used for the 10-day peak receiving period, when daily receipts were twice those of the 22-day period. A 7-man crew (3 truck operators, 2 segregators, and 2 car loaders) was required for the succeeding 27 days to pack out the remainder of the fruit and also block out and ship 3 carloads per day. For the 16-day period when 3 carloads per day were blocked out and shipped (no other operations performed), 1 truck operator and 2 car loaders were used. The crew was reduced to 1 car loader and 1 truck operator for the remaining 74 days; 2 carloads per day were shipped for 50 days and 1 carload for the last 24 days.

Equipment requirements and costs.--Table 28 shows the amount of equipment needed to perform the handling operations daily during the 10-day peak receiving period for the 48-box industrial forklift truck method, and the annual ownership and operating costs for this equipment. To perform these operations the following equipment was used: (1) Four industrial lift trucks; (2) 6,250 pallets; (3) thirty 10-foot sections of roller conveyor; (4) 9 truck-bed stabilizers; (5) 6 pallet dollies; and (6) 12 clamp-type 2-wheel hand trucks (for emergency use).

Equipment costs for this method were \$6,124.19 per year. Of this, \$5,685.02 was for ownership and \$439.17 for operating costs. Total costs for the 4 industrial lift trucks and 6,250 pallets amounted to \$5,739.57 per year, or almost 94 percent of total equipment costs.

Labor and equipment costs.--Labor and equipment costs for the 48-box industrial forklift truck method in the 1-floor, 400,000-box plant for the 152-day period totaled \$12,411. Equipment cost for this method was \$6,124 which was \$163 less than labor cost.

### Two-Floor Plants

Figures 21 and 22 show the layouts for the 2-floor, 400,000-box apple packing and storage plants used to compute labor and equipment costs for 2 methods of operation. One layout is for clamp-type 2-wheel hand trucks and belt conveyors, and the other for 24-box industrial clamp lift trucks and belt conveyors. In both layouts, 2 conveyors, at the front of the building, were used to receive fruit. Boxes moved to the second floor were off-loaded from conveyors, stacked in unit loads of 6 and 24 boxes, and moved to and placed in storage areas by 2-wheel hand trucks or industrial lift trucks. A conveyor was provided to carry unpacked boxes from the second floor to the temporary supply bank in the packing room. Another conveyor carried packed boxes from the packing room to the second floor, where they were off-loaded, segregated, and stacked in unit loads. A fifth belt conveyor was used to transfer packed boxes from the second floor to the shipping area.



Table 28.--Ownership and operating costs for specified types of materials-handling equipment required by 48-box industrial forklift truck method in a 1-floor, 400,000-box apple packing and storage plant

Equipment type	Amount		Replace-		Ownership cost per year		Operating cost per year		Total			
	of	equipment	ment	cost	Assumed	Depreci-	Interest	and taxes		Total	Electricity	Maintenance
	Number	Dollars	Years	Dollars	life	ation	at 5	at 2	tricity	Dollars	Dollars	Dollars
48-box industrial forklift truck (4,000-lb. capacity, electric)												
Machine . . . . .	4	18,916.00	20	945.80								
Battery . . . . .	4	5,588.00	7½	745.07								
Charger . . . . .	4	2,760.00	20	138.00								
Freight . . . . .		1,820.00		91.00								
Total . . . . .		29,084.00		1,919.87		727.10	581.68	3,228.65	144.16	167.84	312.00	3,540.65
Pallets, 48 boxes (40 by 48 inches)	6,250	18,750.00	15	1,250.00		468.75	375.00	2,093.75		105.17	3/105.17	2,198.92
Roller conveyor (300 feet)												
Sections . . . . .	30	975.00										
Floor supports . . . . .	33	165.00										
90° curve . . . . .	3	107.25										
Freight . . . . .		229.50										
Total . . . . .		1,476.75	15	98.45	36.92	29.54	164.91		10.00	10.00		174.91
Truckbed stabilizer	9	450.00	15	30.00	11.25	9.00	50.25					50.25
Pallet dolly for loading . . . . .	6	257.10	5	51.42	6.43	5.14	62.99		6.00	6.00		68.99
Clamp-type 2-wheel hand truck 4/ . . . . .	12	889.20	20	44.46	22.23	17.78	84.47		6.00	6.00		90.47
Grand total . . . . .		50,907.05		3,394.20	1,272.68	1,018.14	5,685.02	144.16	295.01	439.17		6,124.19

1/ Based on delivered cost in Washington State.  
 2/ Electricity at \$0.01 per kilowatt hour.  
 3/ Maintenance at \$0.25 per pallet life.  
 4/ For standby use in event of breakdown of industrial lift trucks.

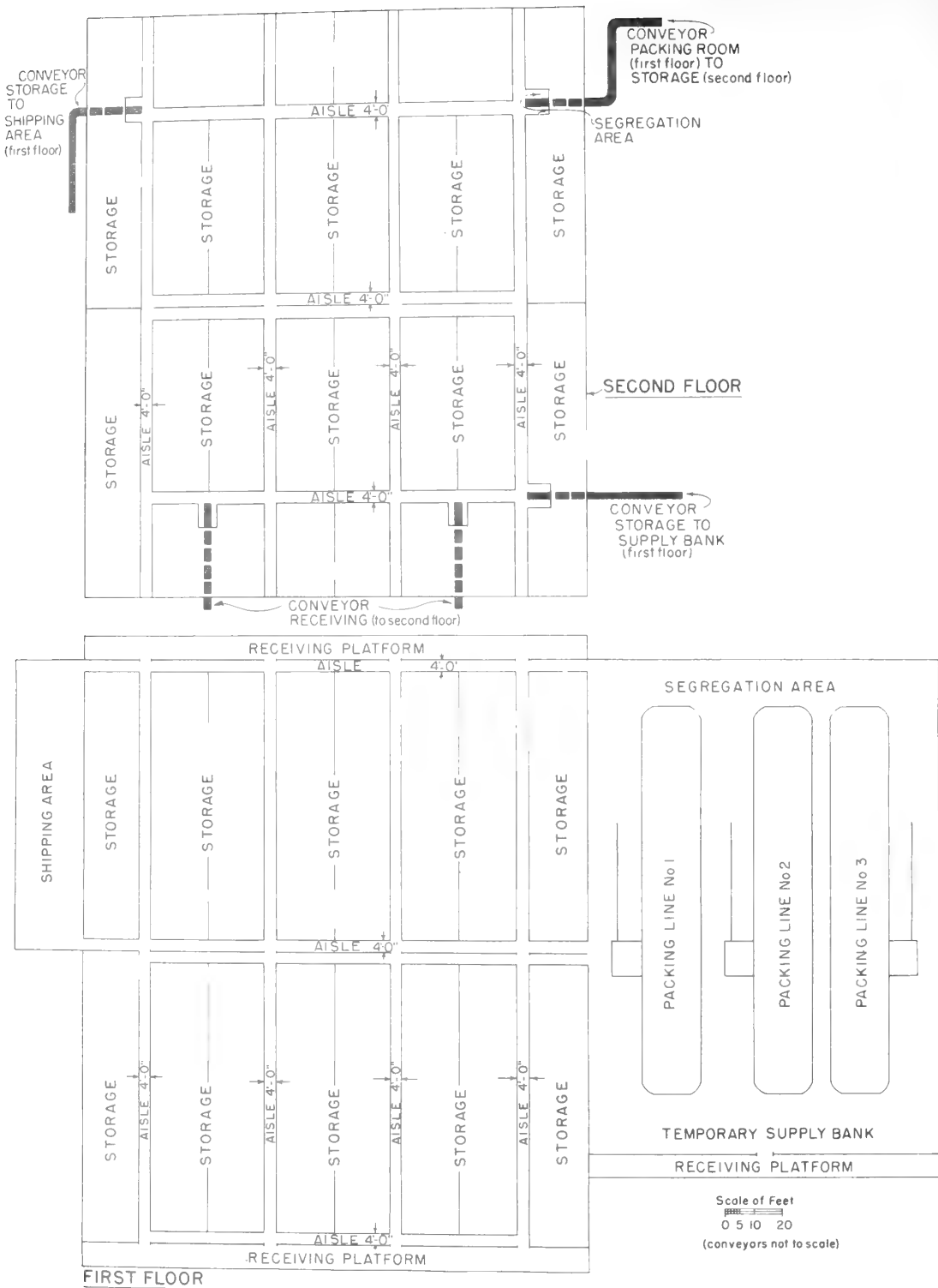


Figure 21.--Assumed plant layout for a 2-floor, 400,000-box apple packing and storage plant when clamp-type 2-wheel hand trucks and belt conveyors are used, unpacked boxes stacked 12 high in storage.

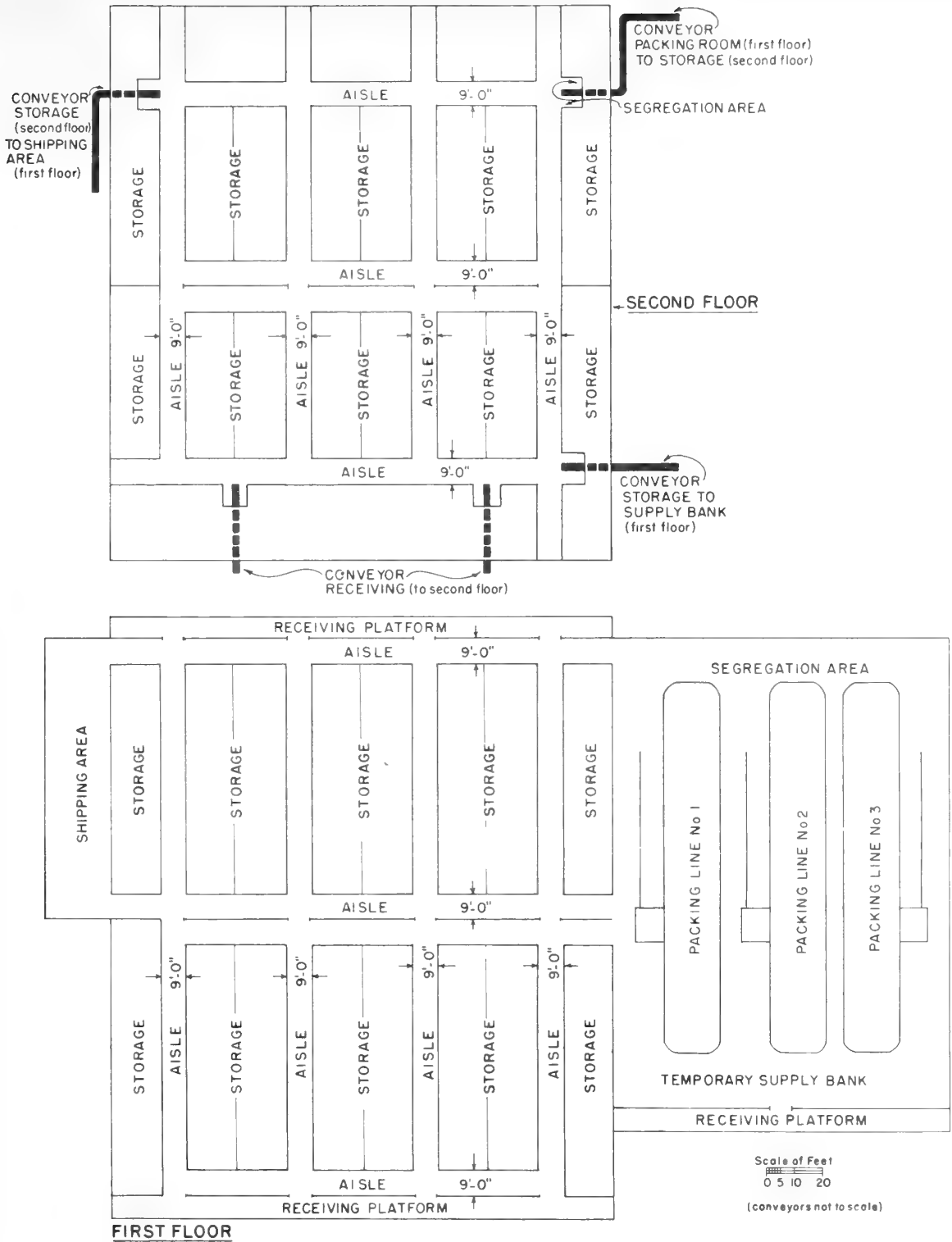


Figure 22.--Assumed plant layout for a 2-floor, 400,000-box apple packing and storage plant when 24-box industrial clamp lift trucks and belt conveyors are used, unpacked boxes stacked 12 high in storage.

Clamp-Type 2-Wheel Hand Trucks and Belt Conveyors

Labor requirements and costs.--The number of workers used daily for specified periods throughout the 152-day season and the man-days of labor required to perform handling operations with 2-wheel hand trucks and belt conveyors in the 2-floor, 400,000-box plant are shown in table 29. Only unskilled labor was used by this method.

Table 29.--Estimated number of workers and man-days of labor required to perform handling operations for a 152-day season by use of clamp-type 2-wheel hand trucks and belt conveyors in a 2-floor, 400,000-box apple packing and storage plant

Period	: Days of : operation 1/ : <u>Number</u>	: Workers : per day 2/ : <u>Number</u>	: Total labor : required : <u>Man-days</u>
1st to 3rd day . . . . .	3	8	24
4th to 15th day. . . . .	12	32	384
16th to 25th day . . . . .	10	38	380
26th to 35th day . . . . .	10	32	320
36th to 62nd day . . . . .	27	26	702
63rd to 78th day . . . . .	16	7	112
79th to 128th day. . . . .	50	5	250
129th to 152nd day . . . . .	24	3	72
Total. . . . .	152	-	2,244

1/ Eight hours per day.

2/ Unskilled workers.

Crew size, based on daily workload, ranged from 3 to 38 workers. For the first 3 days of the 152-day period, 8 men were used to receive into storage 7,000 boxes per day. For 22 days of the receiving period (12 days before and 10 days after the peak receiving period), 32 workers were used to: (1) Receive 154,500 boxes into storage and 44,000 boxes to the temporary supply bank in the packing room; (2) transfer 105,000 boxes from storage to temporary supply bank; (3) transfer 149,000 boxes from temporary supply bank to packing lines; (4) Segregate 104,300 packed boxes and transfer them to storage; and (5) block out 53,000 boxes in storage, transfer them to shipping area and to railroad cars or trucks, and load them. The crew was increased to 38 men for the

10-day peak receiving period; during this period, receipts were double those of the 22-day period, and all other operations were performed. For 27 days following the receiving period, the crew was reduced to 26 men. During this period: (1) 183,000 boxes were transferred from storage to temporary supply bank to packing lines; (2) 128,100 packed boxes were segregated and transferred to storage; and (3) 65,000 boxes were blocked out and shipped. After all fruit was packed out, a 7-man crew was used for 16 days to ship 3 railroad carload equivalents per day. Beginning on the 78th day of the period, and continuing for the next 50 days, 5 workers were used to block out and ship 2 carloads a day, or a total of 80,000 boxes. For the remaining 24 days of the period, a 3-man crew was used to block out and ship 1 carload a day, or 19,000 boxes.

Total labor cost to perform handling operations involved in receiving, packing, and shipping 400,000 boxes of unpacked apples in a 152-day period in a 2-floor plant by this method was \$20,645.

Equipment requirements and costs.--The amount of equipment required by this method for handling operations during the 10-day peak period and costs for this equipment are shown in table 30. This method required 28 clamp-type 2-wheel hand trucks, 5 belt conveyors, and 300 feet, or thirty 10-foot sections, of roller conveyor. Total ownership and operating costs for this equipment was \$1,201.46 per year. Ownership costs for the equipment amounted to \$963.88, or 86 percent of the total.

Labor and equipment costs.--Labor and equipment costs for the 2-wheel hand truck and belt conveyor method in the 2-floor, 400,000-box plant amounted to \$21,763. Of this, \$20,645, or over 95 percent, was for labor, and \$1,118 for equipment.

#### 24-Box Industrial Clamp Lift Trucks and Belt Conveyors

Labor requirements and costs.--Table 31 shows the number of workers and man-days of labor required when 24-box industrial clamp lift trucks and belt conveyors were used for specified periods throughout the 152-day season. Of the total labor required, 627 man-days were used by car loaders, conveyormen, and segregators, and 505 man-days by truck operators.

Crew size ranged from 2 to 18 workers, depending on the daily workload, throughout the 152-day period. One truck operator and 2 conveyormen were used the first 3 days of operation to receive 7,000 boxes per day. For the next 12 days, and from the 25th to the 35th day, 7 truck operators, 5 conveyormen, 2 car loaders, and 1 segregator (used on the first floor) were required to: (1) Receive 154,500 boxes into storage and 44,000 directly to temporary supply bank in packing room; (2) transfer 105,000 boxes from storage to temporary supply bank; (3) transfer 149,000 boxes from temporary supply bank to packing lines; (4) segregate 104,300 packed boxes and transfer them to storage; and (5) block out 53,000 boxes in storage, transfer them to shipping area and to railroad cars or trucks, and load them. The crew was increased by 1 truck operator and 2 conveyormen for the 10-day peak receiving period.

Table 30.--Ownership and operating costs for specified types of materials-handling equipment required by clamp-type 2-wheel hand truck and belt conveyor method in 2-floor, 400,000-box apple packing and storage plant

Equipment type	Amount of equipment	Replace-ment cost 1/	Years of life	Ownership cost per year		Operating cost per year		Total	
				Dollars	Percent	Dollars	Percent		Dollars
Clamp-type 2-wheel hand truck . . . . .	28	2,074.80	20	103.74	51.87	41.50	197.11	49.00	246.11
Belt conveyor:									
Belting @ \$2.30 per foot . . . . .	540	1,242.00	15	82.80					
Dip and load section . . . . .	5	498.75	25	19.95					
Curved end section . . . . .	3	149.25	25	5.97					
Motor . . . . .	5	1,110.00	25	44.40					
Drive . . . . .	5	712.50	25	28.50					
Idle ends . . . . .	10	415.00	25	16.60					
Floor supports . . . . .	45	270.00	25	10.80					
Roller sections . . . . .	50	1,975.00	25	79.00					
Installation (5 percent) . . . . .		318.00		12.74					
Total . . . . .		6,691.10		300.76	167.28	133.82	601.86	20.00	75.00
Total . . . . .									95.00
Roller conveyor (300 feet):									
Sections . . . . .	30	975.00							
Floor supports . . . . .	33	165.00							
90° curve . . . . .	3	107.25							
Freight . . . . .		229.50							
Total . . . . .		1,476.75	15	98.45	36.92	29.54	164.91	10.00	174.91
Grand total . . . . .		10,242.65		502.95	256.07	204.86	963.88	20.00	134.00
									154.00
									1,117.88

1/ Based on delivered cost in Washington State.

2/ Electricity at \$0.01 per kilowatt hour.

For the 27 days following the receiving period, 6 truck operators, 4 conveyormen, 2 car loaders, and 1 segregator were needed to transfer 183,000 boxes from storage to temporary supply bank to packing lines, segregate 128,100 packed boxes and transfer them to storage, and block out and ship 65,000 boxes. For 16 days after all fruit was packed out, 2 truck operators and 2 other workers--to man the conveyor and load cars--were used to block out and ship 3 carload equivalents per day. The truck operators were also available part of the time to assist with car loading. For the 50 days when 2 carloads per day were blocked out and shipped, services of 1 truck operator and 2 workers--to man the conveyor and load cars--were used. One truck operator and 1 car loader were used for the remaining 24 days to block out and ship 1 carload per day.

Labor cost to perform the handling operations connected with receiving, packing, and shipping 400,000 boxes of unpacked apples by the 24-box industrial clamp lift truck and belt conveyor method in the 2-floor plant was \$11,020 for the 152-day season. Of this, \$5,768 was paid to conveyormen, car loaders, and segregators, and \$5,252 to truck operators.

Table 31.--Estimated number of workers and man-days of labor required to perform handling operations for a 152-day season by use of 24-box industrial clamp lift trucks and belt conveyors in a 2-floor, 400,000-box apple packing and storage plant

Period	Days of operation 1/	Workers per day			Total labor required
		Semi-skilled 2/	Unskilled 3/	Man-days	
	Number	Number	Number		
1st to 3rd day . . . .	3	1	2	9	
4th to 15th day . . . .	12	7	8	180	
16th to 25th day . . . .	10	8	10	180	
26th to 35th day . . . .	10	7	8	150	
36th to 62nd day . . . .	27	6	7	351	
63rd to 78th day . . . .	16	2	2	64	
79th to 128th day . . . .	50	1	2	150	
129th to 152nd day . . . .	24	1	1	48	
<b>Total . . . . .</b>	<b>152</b>	<b>-</b>	<b>-</b>	<b>1,132</b>	

1/ Eight hours per day.

2/ Clamp lift truck operators.

3/ Conveyormen, car loaders, and segregators.

Equipment requirements and costs.--Amount of equipment and ownership and operating costs required to perform operations occurring daily during the 10-day peak receiving period for this method are shown in table 32. The daily workload for this period required 8 industrial lift trucks, 5 belt conveyors, 16,640 board feet of 1- by 4-inch lumber, 9 truckbed stabilizers, thirty 10-foot sections of roller conveyor, and twelve 2-wheel hand trucks for emergency use. To own and operate this equipment cost \$5,655.81 per year. Of this cost, 89 percent, or \$5,028.01, was for ownership and 11 percent, or \$627.80, for operation. About 78 percent of the total cost was for ownership and operation of the 8 industrial lift trucks.

Labor and equipment costs.--Labor and equipment costs of the 24-box industrial clamp lift truck and conveyor method in the 2-floor, 400,000-box plant was \$16,676. About two-thirds of this cost was for labor.

#### Comparative Costs of Five Methods

Table 33 shows the labor inputs and total costs of the 5 handling methods discussed for the 1- and 2-floor, 400,000-box plants. For plants of this size, the system using 36-box industrial clamp lift trucks reflected the lowest total cost. The next lowest cost method, only slightly higher, was that using 48-box industrial forklift trucks. Because of large amounts of labor required, the highest cost methods in both 1- and 2-floor plants were those employing clamp-type 2-wheel hand trucks.

As in the case of the 100,000- and 200,000-box plants, the industrial forklift truck method required the least man-days of labor. By this method, 644 man-days of labor were used to perform all handling operations. Labor used with the 36-box industrial clamp lift truck method was 729 man-days, about 13 percent greater. The 2 methods using 2-wheel hand trucks required over 2,100 man-days of labor during the 152-day period.

Total costs for the 36-box industrial clamp lift truck method, using "current" wage rates, were \$12,207 per year. Labor costs amounted to \$7,171, or 59 percent of the total. Annual ownership and operating costs for equipment were \$5,036.

Labor and equipment costs when 48-box industrial forklift trucks were used totaled \$12,411 per year. This is less than 2 percent greater than costs of the industrial clamp lift truck method. For the industrial forklift truck method, the labor cost of \$6,287 was \$162 more than equipment costs.

The highest cost method was that using the clamp-type 2-wheel hand truck and belt conveyors in the 2-floor plant. Many handlings of individual boxes, such as those in high-piling, breaking out of high piles, and placing on and off conveyors, resulted in the relatively large labor cost of \$20,645 for this method. Equipment costs were only 5 percent of total costs, and amounted to \$1,118.



Table 32.--Ownership and operating costs for specified types of materials-handling equipment required by 24-box industrial clamp lift truck and belt conveyor method in a 2-floor, 400,000-box apple packing and storage plant

Equipment type	Amount of equipment	Replacement cost	Assumed life	Ownership cost per year		Operation cost per year		Total ownership and operating costs per year			
				Dollars	Years	Dollars	Percent		Dollars	Dollars	
24-box industrial clamp lift truck (1,000-lb. capacity, electric)	8	19,776.00	20	983.80							
Machine	8	5,016.00	20	250.80							
Clamping arms	8	6,096.00	7½	812.80							
Battery	8	3,600.00	20	180.00							
Charger	8	1,456.00		72.80							
Freight											
Total		35,944.00		2,305.20	898.60	718.88	3,922.68	258.40	516.00	4,439.40	
Belt conveyor											
Belt conveyor	540										
foot	feet	1,242.00	15	82.80							
Dip and load section	5	498.75	25	19.95							
Curved end section	3	149.25	25	5.97							
Motor	5	1,110.00	25	44.40							
Drive	5	712.50	25	28.50							
Idle ends	10	415.00	25	16.60							
Floor supports	45	270.00	25	10.80							
Roller sections	50	1,975.00	25	79.00							
Installation (5 percent)		318.60		12.74							
Total		6,691.10		300.76	167.28	133.82	601.86	20.00	75.00	95.00	696.86
Dunnage strips	16,640										
Truckbed stabilizer	bd.ft.	832.00	5	166.40	20.80	16.64	203.84				203.84
Roller conveyor (300 feet)	9	450.00	15	30.00	11.25	9.00	50.25				50.25
Sections	30	975.00									
Floor supports	33	165.00									
90° curve	3	107.25									
Freight		229.50									
Total		1,476.75	15	98.45	36.92	29.54	164.91	10.00	10.00	10.00	174.91
Clamp-type 2-wheel hand truck	12	889.20	20	44.46	22.23	17.78	84.47	6.00	6.00	6.00	90.47
Grand total		46,283.05		2,945.27	1,157.08	925.66	5,028.01	278.40	349.40	627.80	5,655.81

1/ Based on delivered cost in Washington State.  
 2/ Electricity at \$0.01 per kilowatt hour.  
 3/ For standby use in event of breakdown of industrial lift trucks.

Table 33.--Comparative labor and equipment costs per year by use of specified types of materials-handling equipment in 1- and 2-floor, 400,000-box apple packing and storage plants 1/

Equipment	Labor and equipment costs per year				
	Labor required:	Labor 2/	Equipment Dollars	Total cost	
				Current wages 2/	Assumed wages 3/
	Man-days	Dollars	Dollars	Dollars	Dollars
<u>1-floor plant</u>	:	:	:	:	:
Clamp-type 2-wheel hand trucks . . . . .	2,114	19,449	398	19,847	24,075
36-box industrial clamp lift trucks. . . . .	<u>4/</u> 729	7,171	5,036	12,207	13,665
48-box industrial fork-lift trucks. . . . .	<u>5/</u> 644	6,287	6,124	12,411	13,699
<u>2-floor plant</u>	:	:	:	:	:
Clamp-type 2-wheel hand trucks and belt conveyors . . . . .	2,244	20,645	1,118	21,763	26,251
24-box industrial clamp lift trucks and belt conveyors. . . . .	<u>6/</u> 1,132	11,020	5,656	16,676	18,940

1/ Handling operations performed are: (1) Receive 326,000 boxes to storage and 74,000 boxes to temporary supply bank in packing room; (2) transfer 326,000 boxes from storage to temporary supply bank; (3) transfer 400,000 boxes from temporary supply bank to packing lines; (4) segregate 280,000 packed boxes and transfer them to storage; and (5) block out 280,000 boxes in storage, transfer them to shipping area and to railroad cars or trucks, and load them.

2/ Based on a wage rate of \$1.15 for unskilled labor and \$1.30 for semi-skilled labor (truck operators).

3/ Based on a wage rate of \$1.40 for unskilled labor and \$1.55 for semi-skilled labor (truck operators).

4/ Unskilled labor, 342 man-days; truck operators, 387 man-days.

5/ Unskilled labor, 342 man-days; truck operators, 302 man-days.

6/ Unskilled labor, 627 man-days; truck operators, 505 man-days.

COMPARISON OF COSTS FOR HANDLING DIFFERENT VOLUMES OF APPLES  
BY USE OF FIVE TYPES OF EQUIPMENT

Previous sections dealt with labor and equipment requirements and costs for performing handling operations in moving boxes of fruit into, within, and out of apple packing and storage houses by various types of equipment for given volumes. Equipment costs were based on equipment requirements for the peak harvesting period for an 8-hour work day. On the other hand, sizes of work crews for all plants were varied to meet labor needs throughout the packing season. In all cases, sufficient equipment was used in cost calculations to perform all handling operations occurring in an 8-hour work day, plus an allowance for changing from one job to another and performing miscellaneous jobs in the plant. Allowances for changing jobs and performing other work also were included in labor cost computations.

In this section, costs for the different types and combinations of types of equipment are compared for the 3 plant sizes on the basis of costs per 1,000 boxes (table 34). These costs are limited to handling operations; they do not include costs for fruit-packing operations, management, supervisory help, or permanent facilities.

Table 34.--Comparative labor and equipment costs for handling 1,000 boxes of apples by various types of equipment in 1- and 2-floor plants handling specified volumes

Equipment type	100,000-boxes			200,000 boxes			400,000 boxes		
	Labor	Equip- ment	Total	Labor	Equip- ment	Total	Labor	Equip- ment	Total
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
<u>1-floor plant</u>	:	:	:	:	:	:	:	:	:
Clamp-type 2-wheel hand trucks . . .	52.25	1.66	53.91	47.93	1.38	49.31	48.62	1.00	48.62
36-box industrial clamp lift trucks	30.23	16.05	46.28	19.43	12.54	31.97	17.93	12.59	30.52
48-box industrial forklift trucks .	25.66	15.73	41.39	17.14	15.08	32.22	15.72	15.31	31.03
<u>2-floor plant</u>	:	:	:	:	:	:	:	:	:
Clamp-type 2-wheel hand trucks and belt conveyors . .	56.95	6.95	63.90	50.97	5.01	55.98	51.61	2.80	54.41
24-box industrial clamp lift trucks and belt con- veyors . . . . .	39.61	23.00	62.61	29.78	18.58	48.36	27.55	14.14	41.69

As shown in figure 23, use of 36-box industrial clamp lift trucks was the most economical of the 3 methods considered in 1-floor plants for all volumes except the 100,000-box plant. Estimated labor and equipment cost of \$41.39 per thousand boxes for the industrial forklift truck method in the 100,000-box plant was almost \$5 less than for the 36-box industrial clamp lift truck method. This difference was relatively small. It is probable that in most cases final choice between these 2 types of handling equipment would rest on factors other than cost--factors beyond the scope of this report. Labor and equipment costs per 1,000 boxes for the industrial clamp lift truck method of handling volumes of less than 100,000 boxes (volumes requiring use of only one lift truck) would be lower than for the forklift truck method.

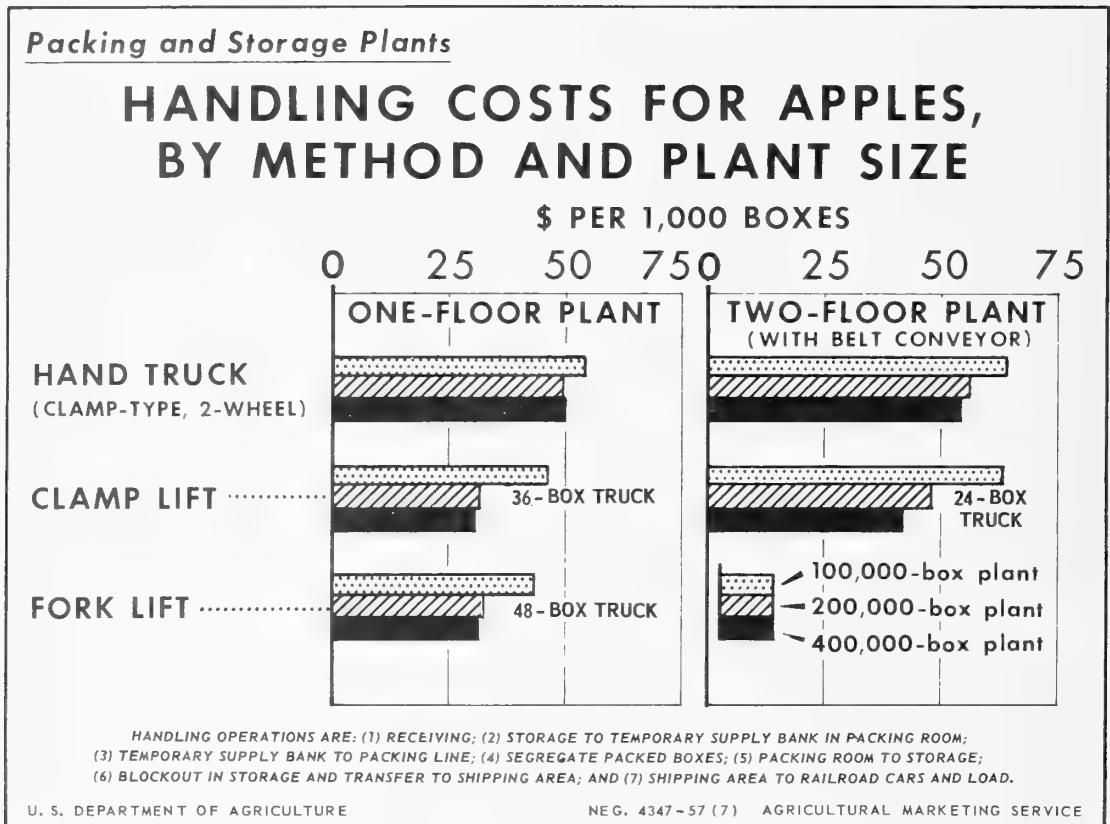


Figure 23.--Comparative labor and equipment costs per thousand boxes for all handling operations (except packing line) involved in receiving, packing, and shipping apples for plants handling given volumes by selected types of equipment.

The slight advantage accruing to the 36-box industrial clamp lift truck method in 1-floor plants was due mainly to equipment costs. A truck with a rated capacity of 2,000 pounds is required to handle the 36-box load. Initial cost of a 2,000-pound truck, including battery, charger, clamping arms, and freight, was less than the cost of a 4,000-pound lift truck required to handle a 48-box pallet load. Also, lumber cost for dunnage strips used to tier loads handled by a clamp lift truck was substantially less than pallet cost.

Estimated labor and equipment costs per 1,000 boxes handled by the clamp-type 2-wheel hand truck method were substantially higher than costs of industrial lift truck methods in 1-floor plants for volumes greater than 100,000 boxes. Some operations performed manually by the 2-wheel hand truck method are executed mechanically by lift truck methods--such operations as stacking boxes of apples in storage from 6 to 12 high, and breaking boxes out of stacks. Also, more labor is needed to move 1,000 boxes of apples into and out of storage because smaller unit loads are handled by the 2-wheel hand truck and the travel distances are long. These are the main reasons for the relatively high total handling costs for the clamp-type 2-wheel hand truck method.

In a 2-floor plant handling a volume of 100,000 boxes per season, labor and equipment cost differences for handling operations were small between the clamp-type 2-wheel hand truck and belt conveyor method and the 24-box industrial clamp lift truck and conveyor method. The estimated difference in handling costs of the 2 methods for moving 100,000 boxes of unpacked apples was \$1.29 per 1,000 boxes in favor of industrial lift trucks and conveyors. Because of smaller equipment costs, the hand truck and conveyor method would probably have an economic advantage at lower volume levels. However, at the 100,000-box level and above, the 24-box industrial lift truck and conveyor method is more economical because labor is used to better advantage in performing the important operations of receiving fruit, moving it from storage to packing room and return, and blocking out and shipping it; for the 2-floor, 400,000-box plant, the cost difference between these methods, in favor of lift trucks and conveyors, is about \$12.72 per 1,000 boxes.

#### CONCLUSIONS AND RECOMMENDATIONS

Determination of the most efficient type or combination of types of materials-handling equipment must be made on an individual plant basis. For instance, the 48-box industrial forklift truck method was found to be the most efficient for the 1-floor, 100,000-box plant; but in many of the older plants, low ceilings, posts or columns, cooling equipment suspended from ceilings, and other obstructions in the storage rooms restrict stacking heights to 9 or 10 boxes, and limit the stacking arrangement. Because of the restriction on stacking height in many existing plants, this equipment cannot be used to good advantage. Wise selection of equipment for any plant involves several considerations. Among these are: (1) Amount of travel distance required; (2) layout and design of plant; (3) necessary remodeling of plant; (4) expected volume of work; (5) capital outlay for equipment; (6) maintenance of quality of fruit; and (7) available labor supply.

One of the most important factors to consider when selecting equipment is the amount of travel distance involved in receiving fruit, in moving it from storage to packing room and return, and in shipping it out. Use of 2-wheel hand trucks alone may be satisfactory only if travel distances are relatively short. The 36- and 48-box industrial lift trucks have a distinct advantage when travel distances for the handling operations are relatively long. For example, estimated labor and equipment costs to break out unpacked

boxes in storage, move them 190 feet, and release them in the packing room are \$4.06 per 1,000 boxes for a 48-box industrial forklift truck, \$4.53 for a 36-box industrial clamp lift truck, and \$11.50 for clamp-type 2-wheel hand trucks. 3/

Building stacks of boxes and breaking them out of stacks in storage is another factor to consider when contemplating a change in type of handling equipment, particularly for plants experiencing labor recruitment problems during the peak operating period. High-piling is a manual operation in many plants using 2-wheel hand trucks above the 6-box-high level; usually 1 man is used to build stacks from 6 to 8 boxes high and 2 men to build above this level to 12 boxes high. Not only is manual high-piling of boxes heavy work, but, percentagewise, it accounts for a large part of handling costs when boxes are stacked 12 high. Managers of plants using 2-wheel hand trucks and high-piling 10 to 12 boxes high, by hand, should consider use of portable mechanical high-pilers capable of stacking 1 or 2 6-high stacks of boxes. 4/ The most efficient stacking equipment currently in use in Pacific Northwest apple packing-houses is the industrial forklift truck. This equipment can tier as high as 4 pallet loads, or 24 boxes. However, for most older plants, shifting from a conventional method, using 2-wheel hand trucks, to use of forklift trucks, in order to take advantage of this stacking feature, would present costly remodeling problems. For new construction, this equipment should be considered. The usual stacking height of the 24- and 36-box industrial clamp lift trucks is 2 unit loads, or 12 boxes high. However, the trucks can be used to stack to heights of 9, 11, 15, or 18 boxes. The 24-box industrial clamp lift truck, because of its light weight and maneuverability, can be used in some multi-story plants having a number of posts or columns, 12- to 15-foot ceilings, and floors of limited carrying capacity.

Of concern to plant operators desiring a change in handling equipment is the expected volume of work and length of operating period. The workloads in individual plants are closely related to equipment ownership costs. Industrial lift trucks, along with supplementary equipment, such as pallets, dunnage and truckbed stabilizers, require relatively large capital investments. For short seasons and low volume, ownership costs cannot be spread. Consequently, ownership costs per 1,000 boxes handled are relatively high for industrial lift trucks, as compared, for example, with costs of 2-wheel hand trucks. Since per unit handling cost for an industrial lift truck method decreases as volume increases, this factor is less important to large-volume plants.

Number and size of lots may be of concern to some plant operators. Operators who handle and custom-pack a relatively large number of small lots of fruit for growers are confronted with the problem of retaining the identity

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3/ From "Apple Handling Methods and Equipment in Pacific Northwest Packing and Storage Houses," Marketing Research Report No. 49, U. S. Dept. Agr.

4/ "A Portable Mechanical Lift for High-Piling and Breaking Out High-Piled Boxes of Apples," May 1952, U. S. Dept. Agr.

of each lot received. These operators, of necessity, must provide a larger number of cross aisles in order to maintain the identity of individual lots. In many cases, they would be compelled to use equipment which handles relatively small unit loads in order to reduce aisle width, or to sacrifice storage space for aisle space.

Maintenance of quality of fruit should be considered when selecting handling equipment. Some conventional types of equipment require 10 to 15 individual handlings of boxes in receiving, moving to and from packing room, and shipping out. These handlings cause some bruising or other damage to the fruit. Handling boxes in larger unit loads reduces the number of handlings.

Labor cost comparisons of handling methods by use of different types of equipment for plants handling specified volumes, presented earlier, show the influence of wage rates on total handling costs. Labor costs for conventional handling methods, which require many individual handlings, show greater total cost increases, as wage rates increase, than do methods using more modern equipment. For example, when wage rates are increased 25 cents an hour, labor cost for the 2-wheel hand truck method in the 200,000-box plant increase \$2,084 per year; this compares with increases of \$710 and \$798 per year, respectively, for the 48-box industrial forklift truck and 36-box industrial clamp lift truck methods.

The total of wages paid for handling operations is not the only problem confronting many plant operators. Handling operations must proceed with dispatch, particularly during the receiving period, because quality is adversely affected if the fruit is not placed in refrigerated storage promptly after it is picked. When using most conventional types of handling equipment, plant operators must add to their crews during this period to increase the rate of receiving. Packing plants are in competition with orchards for labor during the harvest period. Adoption of handling methods utilizing industrial lift trucks, which require smaller work crews, would help to solve this problem.

These are the more important factors that plant operators should consider when contemplating a change in handling equipment. Other considerations of less importance are number, location, and size of doors, local safety regulations, and the type and kind of refrigeration and air circulation used. Although several types of equipment may appear to work equally well in a given plant, there usually are controlling factors which determine the most economical and practical type to use.







