INNOVATIONS IN APPLE HANDLING METHODS AND EQUIPMENT

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It is planned that data submitted by the Washington State Apple Commission, in fulfillment of its contract with the U. S. Department of Agriculture, will be published by the Agricultural Marketing Service in five reports. Marketing Research Report No. 49, *Apple Handling Methods and Equipment in Pacific Northwest Packing and Storage Houses,* published in June 1953, and Marketing Research Report No. 71, *Handling Empty Apple Boxes in Pacific Northwest Packing and Storage Houses,* published in June 1954, are the first two of these reports. This publication covering *Innovations in Apple Handling Methods and Equipment* is the third report. Other reports are expected to cover: (1) The effect of apple handling methods on storage space utilization; and (2) plant-wide materials-handling costs. After the five reports are issued, a summary report 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 available now in summary form, through the Department of Agriculture film entitled *Apple Handling Methods.* A print of this film may be obtained on a loan basis from:

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

For sale by the Superintendent of Documents, U. S. Government Printing Office
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SUMMARY

Two objectives of the materials-handling research undertaken in apple houses in the Pacific Northwest were: (1) To develop and test improved methods for using present equipment; and (2) to introduce some of the newer types of materials-handling equipment, develop methods for the use of this equipment, and test the methods under actual operating conditions. Eight innovations in apple handling methods were tested. These innovations and the major findings in the tests were:

1. Gravity-type roller conveyors were installed at a belt-conveyor plant on warehouse platforms and road-truck beds for receiving 36-box unit loads on pallets. Unloading by this new method cost about the same as unloading boxes one at a time, but added costs incurred at the orchard, inherent in the new method, made the innovation more expensive. The elapsed time for unloading 1,000 boxes, however, was reduced from 1.5 man-hours to 0.27 man-hour, and this saving in time for the road truck and its driver would have resulted in a reduction in total costs.

2. Forklift truck-trailer trains were used for transporting apples from storage to the packing line. An industrial forklift truck was used to pull a train of 3 trailers carrying six 48-box pallets of apples for 300 feet to the dumping area in a new one-story plant. The forklift truck was used to load the pallets onto the trailers; when 1 train was used, it also unloaded them on roller conveyors at the dumping station, and when 3 trains were used, the trailers were released at the dumping station, and boxes were unloaded as needed. There was no saving in handling costs when 1 train was used, but when 3 trains were used the labor and equipment cost of handling 1,000 boxes was reduced from $5.66, when the forklift truck alone was used, to $3.74 by the new method.

3. Tractor-trailer trains were used for transporting apples between storage and the packing line. Three trains of three trailers each, towed by a tractor (mule) instead of an industrial forklift truck, moved unpacked fruit from storage to the packing line and moved packed fruit from the packing line to storage. One industrial forklift truck was used at the packing line and another in the storage room to load and unload boxes of apples. This method proved to be much more expensive than the usual method of using two forklift trucks, one at each end of the packing line, to perform the whole operation.

4. Twenty-four-box industrial clamp-type lift trucks were used for handling apples in plants of more than one story and equipped with belt-conveyors, and customarily using hand trucks. Conveyors were continued in use for interfloor movement of apples. When the 24-box clamp truck was substituted for the usual hand truck and manual high-piling methods, costs per 1,000 boxes for receiving fruit into the plant were reduced from $12.60 to $9.38. Substantial savings were realized when a mechanical high-piler or an industrial clamp truck was used only for high-piling boxes of apples and breaking them out of high piles. When the 24-box clamp truck, instead of the usual hand-truck and manual methods, was used to move the fruit from the packing line back to storage, costs were reduced from $20.79 per 1,000 boxes to $12.78.

5. Twelve-box industrial clamp-type trucks were used for moving apples from storage to the packing line and for loading refrigerator cars. This method showed little or no saving compared with the usual methods.

6. Broad-blade industrial forklift trucks were used for handling unpalletized unit loads. The saving from elimination of pallets by this method was more than offset by costs arising from the necessity for top tie frames and dunnage strips and a reduction in maneuverability of the equipment, so that the innovation resulted in higher costs than those of the usual methods.

7. Industrial forklift trucks and elevators were used for moving pallet loads between floors in multistory buildings. By using a forklift truck on each floor to move boxes of apples between floors, the cost of handling the apples was $1 per 1,000 boxes less than when using the trucks and an elevator. Also, it cost $1.36 less to move the fruit from storage to the packing line with the trucks alone, as compared with costs for the trucks plus an elevator.

8. Thirty-six-box pallet loads of apples were loaded into a refrigerator car at a packinghouse and unloaded as units at destination. Use of this pallet system proved to be more than twice as expensive as the commonly used methods. Most of the cost of the pallet system lay in the cost of expendable pallets and strapping material.

INNOVATIONS IN APPLE HANDLING METHODS AND EQUIPMENT

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INTRODUCTION

One of the objectives of materials-handling research conducted in Washington State apple houses was to develop and test improved methods for using present equipment and to introduce and test, under actual operating conditions, some of the newer types of equipment not now being used. The program included testing 8 innovations, 5 of which applied to the receiving of apples; 1 to shipping; 1 to the possibility of reducing costs of pallets; and 1 to moving fruit between floor levels. The 8 innovations are reported in the sections that follow.

Emphasis was given to costs of receiving fruit because of their importance in warehousing. During the receiving period of 6 to 8 weeks, labor is scarce and it is difficult to regulate smoothly large crews of new help. Also, it is necessary to move fruit promptly and handle it gently to preserve quality. Although these factors cannot be measured in monetary terms, plant managers should consider them in selecting equipment.

Types of Packages Handled

The standard Northwest apple box is the principal type of container used in Washington State for handling both packed and unpacked fruit. Its inside dimensions are 10½ by 11½ by 18 inches. This box is used both as a field box and as a shipping container. The boxes are taken to the orchard and the picked apples are placed in them, no fruit extending higher than the top level of the box. The loose-filled boxes are then moved to the packing house and either stored or sent direct to the packing line. After unpacked boxes of fruit have been dumped at the packing line, the empty boxes are sent forward on conveyors, and the packers wrap and pack apples into them. Packed boxes are then lidded before leaving the packing line and either moved to storage or directly to a refrigerator car for shipment.

Because some fruit is now packed in cartons, a special field box is now being used commonly. These field boxes usually have the same dimensions as standard apple boxes, but are more substantial with the bottom and ends of thicker material.

The weight of an unpacked standard box of apples is roughly 35 pounds. Boxes of unpacked fruit are not lidded and must be handled accordingly. The weight of a packed standard box is 50 pounds. Packed boxes are handled and stacked on their sides.

Another type of container used for shipping apples is the regular slotted design cardboard carton. The greatest use of this carton is for fruit tray-packed in molded pulpboard trays. This carton usually has about the same outside dimensions as the standard wooden box.

Time studies show that labor for handling cartons does not differ greatly from labor for handling boxes. Also, there is little difference in labor in handling packed and unpacked boxes, but there is the difference that unpacked boxes are usually handled in multiples of 6, and packed fruit, in multiples of 5 boxes.

The appendix includes tabulations of standard data on the man-hours and equipment-hours required for the individual operations involved in comparing the eight innovations reported in this publication.

Several of the tables list costs of handling 1,000 boxes both at current wages and at *assumed* wages. The *current* wage computations are at the going rate for the 1952 season ($1.15 an hour for unskilled labor and $1.30 an hour for semiskilled). The *assumed* wages are $0.25 an hour higher for each group, and the results reveal a shifting of advantage in certain methods as wage rates change. Using the data in the appendix, any manager can compute corresponding cost figures for his own wage rates.

The appendix also explains the way in which the hourly cost for equipment was computed. The combined man-hour and equipment-hour costs provide a basis for comparing the relative efficiencies of the innovations. But the cost data shown do not reflect total costs to the plant and should not be used by plant managers for budgetary purposes. In plants that allocate labor and equipment costs to various operations, these costs might serve as desirable goals for cost reduction efforts.

GRAVITY-TYPE ROLLER CONVEYORS INSTALLED ON WAREHOUSE PLATFORMS AND ROAD TRUCK BEDS FOR RECEIVING 36-BOX PALLET LOADS

For receiving fruit at the warehouse, Innovation 1 was the installation of 14-inch-wide gravity-type roller conveyors on the warehouse platform and the road truck bed, so as to permit the transfer of 36-box unit loads directly from the road truck to the platform without the use of a forklift truck. This method was tested in an attempt to: (1) Reduce the time for growers' trucks and drivers at warehouses; and (2) reduce the size of the receiving crews and minimize their wait time between truckloads. This method tested use of roller conveyors for quickly transferring lots of fruit from the road truck to the platform to form a temporary bank from which boxes could be placed by hand on belt conveyors or hand-trucked to storage.

This method was tested in a plant that used belt conveyors for receiving fruit. Three 15-foot roller conveyor sections were laid lengthwise of and fastened to the bed of a road truck and three 15-foot sections of conveyor were fastened to the receiving dock adjacent to a belt conveyor. On the truck bed the conveyor sections were laid parallel to each other with one section in the center and the other two sections spaced to provide *tracks* near the outer edges. On the platform the sections were laid from the edge of the platform toward the inside of the building and spaced to correspond to the sections on

the road truck. A road truck bed stabilizer of the type shown in figure 1 was installed immediately in front of the roller conveyors fastened to the receiving dock. A stabilizer unit of this type, or one of those shown in figures 2 and 3, was necessary to hold the truck bed securely in place while unit loads were being rolled off to the receiving platform. The stabilizer also was necessary to elevate the road truck bed to the height of the receiving platform so that unit loads could be moved off smoothly. Sheets of 1/2-inch plywood, 36 by 40 inches, were used as pallets for a 36-box load. Figure 4 shows a hole drilled into one edge of each sheet and used for hooking and pulling the load over the roller conveyor.

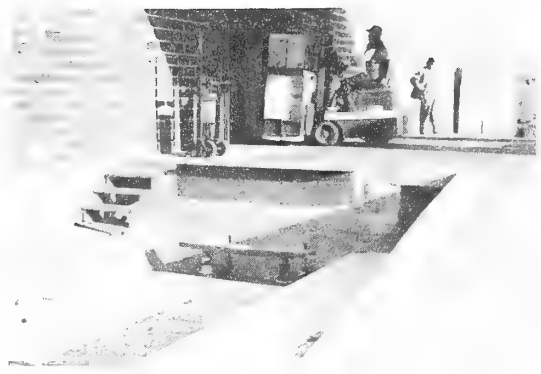

Figure 1.--A hydraulic stabilizer unit used to hold truck bed firmly in place during unloading operations.

Figure 2.--A modified wedge-shaped truck bed stabilizing unit made from angle iron.

Figure 3.--A wedge-shaped truck bed stabilizing unit made from 4 x 4's.

Loading Road Trucks in Orchard

In the orchard a 2-man crew loaded the road truck. One worker on the truck placed a plywood pallet in the corner of the truck and built on it a 36-box unit load. Another worker placed boxes on the roller conveyor and gave them a push to the piler (fig. 5). As each unit load was completed, another pallet was placed until 8 pallets, carrying 288 boxes, were filled. The four pairs of pallet loads were placed close together in the middle of the road truck bed so that the edges of both pallets rested on the center roller conveyor section. This left some space beteeen the load and the side gates of the truck. This unoccupied space made difficult the job of tying the load for transit. Block wedges were placed between the rollers back of the last pallets at the tailgate to stabilize the boxes on the roller conveyors. Wooden blocks also were placed between the side gates and

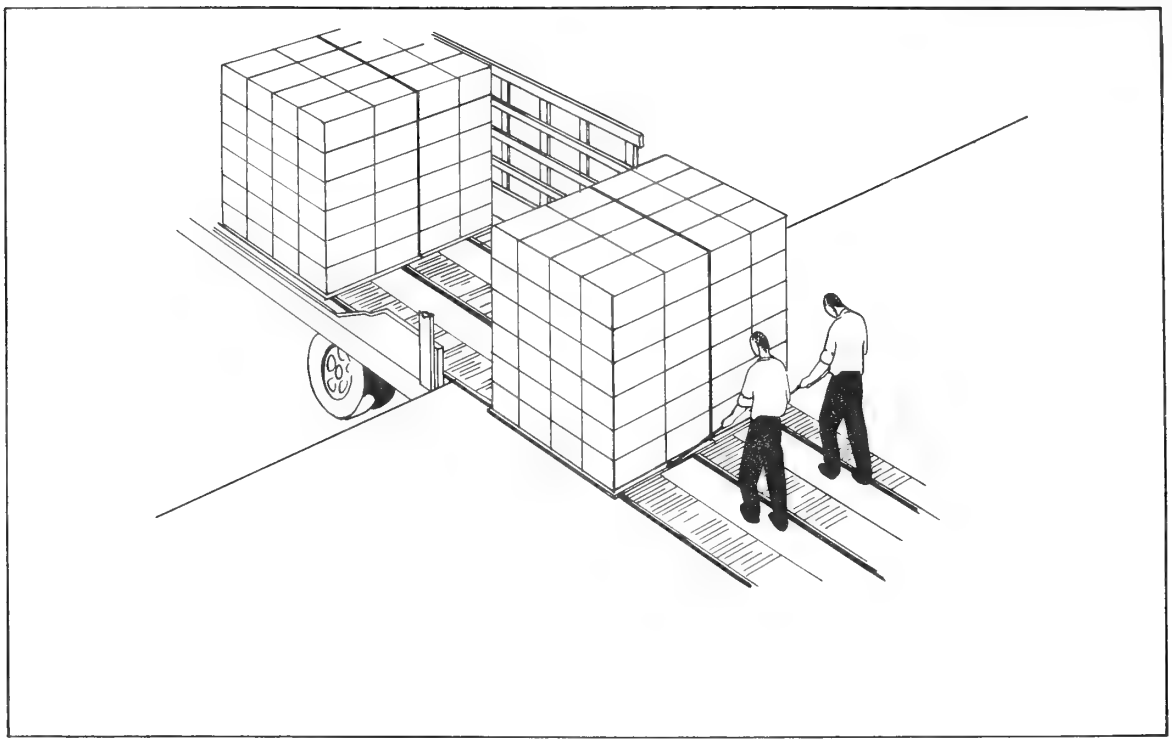

Figure 4.--A box hook is inserted into hole in the edge of a plywood pallet which is resting on roller conveyors attached to the receiving platform.

Figure 5.--One worker standing on orchard trailer bed pushes boxes on fixed roller conveyor sections to man stacking the boxes on the plywood pallets.

and the stacked boxes to prevent shifting. With rope pulleys, the load then was pulled together and tied for transit to the warehouse.

As shown in table 1, this method required 4.29 man-hours of labor to load 1,000 unpacked boxes of apples from orchard trailers to road trucks. The elapsed time required was 2.14 hours. The usual method of loading a truck with roller conveyors is to use a section of portable roller conveyor placed on the truck bed so that the individual boxes can be rolled from the tailgate to the piler. The roller conveyor section is withdrawn as the load is completed. By this method 4 man-hours of labor and 2 hours of elapsed time were required (table 2). The difference in labor requirements between these two methods was 0.29 man-hour per 1,000 boxes.

Table 1.--Labor required for a 2-man crew to load 1,000 unpacked boxes of apples from orchard trailers onto road trucks by use of 3-roller conveyor sections fixed to the road truck bed when boxes are palletized in 36-box unit loads

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Setup and cleanup	2	0.37	0.0	0.37
Position pallets on roller conveyors	2	.10	.10	.20
Transfer boxes from trailer to truck using fixed roller conveyors on the road truck bed	2	3.72	.0	3.72
Total man-hours	-	4.19	.10	4.29
Elapsed time--hours				2.14

Table 2.--Labor required for a 2-man crew to load 1,000 unpacked boxes of apples from orchard trailers onto road trucks by use of a portable roller conveyor section when boxes are not palletized 1/

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Setup and cleanup	2	0.28	0.0	0.28
Transfer boxes from trailer to truck using a roller conveyor on the road truck bed	2	3.72	.0	3.72
Total man-hours	-	4.00	.0	4.00
Elapsed time--hours				2.00

1/ Unpublished data, on orchard-handling methods, supplied by the Washington State Apple Commission.

The innovation using fixed roller conveyors on the bed of the truck and plywood pallets resulted in an orchard loading cost of $5.20 per 1,000 unpacked boxes of fruit which is $0.52 per 1,000 boxes more than the cost by the common method (table 3). Nearly one-half of the increase was attributable to the use of additional equipment.

Table 3.--Comparative labor and equipment costs for loading 1,000 unpacked boxes of apples from orchard trailers onto road trucks by 2 specified methods

Method	Workers	Elapsed time	Labor and equipment required		Labor and equipment costs			
			Equipment time	Total labor	Equipment	Labor	Total cost	
							Current wages	Assumed wages
	Number	Hours	Machine-hours	Man-hours	Dollars	Dollars	Dollars	Dollars
Portable roller conveyor: 2 men load boxes onto the bed of the road truck	2	2.00	1/ 1.86	4.00	0.08	4.60	4.68	5.68
Plywood pallet and 3 fixed roller conveyors: 2 men load boxes onto pallets resting on roller conveyors fixed to the bed of the road truck	2	2.14	2/ 2.14	4.29	.27	4.93	5.20	6.27

1/ One 15-foot section of portable roller conveyor. Equipment is used 0.14 hour less than total elapsed time of 2 hours because stacks at tailgate of road truck were loaded manually.
2/ Three 15-foot sections of roller conveyor or total of 45 feet. Pallet cost not included.

Unloading from Road Trucks and Moving Apples into Storage

When the loaded truck used in testing the new method arrived at the warehouse it was backed in against the receiving platform so that the sections of roller conveyor on the truck bed matched the sections on the platform (fig. 6). No great difficulty was encountered in matching the ends of each section as the 14-inch conveyors used permitted the truck to be an inch or so off center without causing any difficulty in unloading. After the road truck was backed into place, a hydraulic stabilizer unit was placed under the truck to raise and stabilize the truck bed at a height matching the height of the rollers on the receiving dock. After the truck bed was stabilized, 2 workers untied the load and, with box hooks inserted in the holes in the plywood pallets, they simultaneously pulled 2 unit loads off the truck bed onto the platform (fig. 7). In approximately 5 minutes, the 2 workers unloaded all 8 pallet loads. After all pallet loads had been removed from the truck bed, the road truck driver released the hydraulic stabilizer unit, loaded 8 empty plywood pallets and was ready for the return trip.

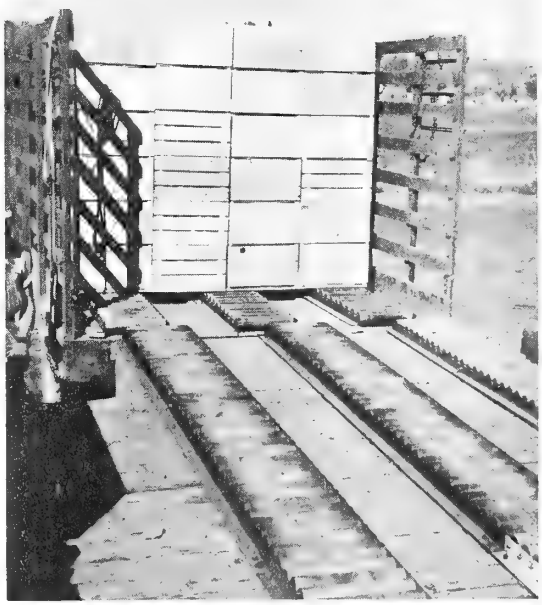

Figure 6.--Road truck backed into place against receiving dock so that the roller conveyors on the road truck bed match the roller conveyors on the platform.

Figure 7.--Two workers pull unit loads off road truck bed onto receiving platform.

After the road truck pulled away the 2 workers on the receiving platform transferred the boxes from the plywood pallets to a belt conveyor (fig. 8). As each group of 2 pallets was unloaded, the workers removed the empty pallets and pulled 2 more loads forward to the conveyor.

The necessity for moving the unit loads forward on the roller conveyors might have been eliminated if rows containing 3 pallets each had been moved to both sides of the belt conveyor instead of both rows of pallets being on one side of the conveyor. Boxes would have been transferred from the previously positioned pallets onto the belt. The warehouse workers would have moved down the belt conveyor, transferring the boxes to the belt from pallets previously positioned on each side of the belt, and removing the pallets after all the boxes had been unloaded. Thus, an entire truckload might have been placed on the belt with no interruptions.

By use of plywood pallets and fixed roller conveyors the total labor required to unload and move to storage 1,000 unpacked boxes of apples was 11.79 man-hours which was not significantly different from the labor required by the method usually employed at

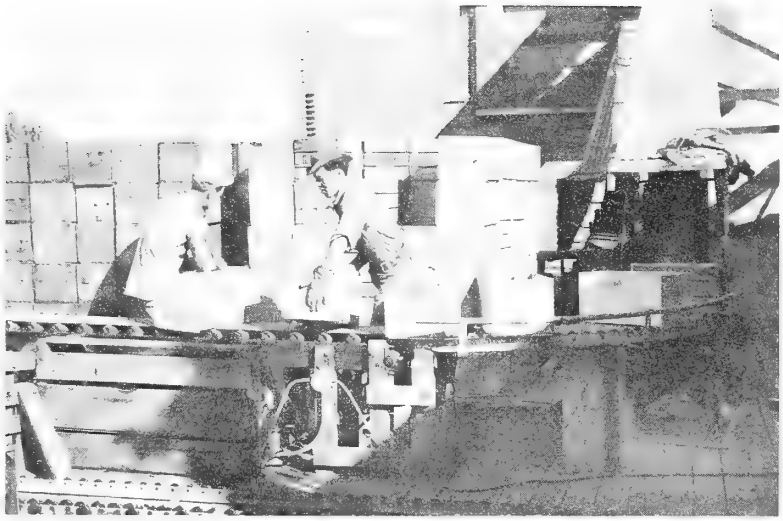

Figure 8.--Two warehouse workers transfer boxes from the plywood pallets to the moving belt conveyor.

belt-conveyor-plants (tables 4 and 5). However, the important consideration is that the elapsed truck-unloading time was reduced from 1.50 hours by the conventional method to 0.27 hour through the use of the innovation.

Table 4.--Labor required for a 10-man crew to unload from road trucks in 36-box unit loads and move into storage 1,000 unpacked boxes of apples by use of gravity-type roller conveyors, belt conveyors, and clamp-type 2-wheel hand trucks and manually high-pile boxes 12 high as fruit is received

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Setup and cleanup	2	0.17	0.0	0.17
Pull 36-box unit loads off road truck bed to platform	2	.36	.0	.36
Transfer boxes from pallets to belt conveyor (conveyor moves boxes 50 feet)	2	1.57	.99	2.56
Move empty pallets to stacking point	2	.23	.0	.23
Transfer boxes from the belt conveyor to 6-high stacks	2	1.57	1.25	2.82
Pick up stacks by 2-wheel hand trucks	2	.32	.0	.32
Transport 6-high stacks 50 feet by 2-wheel hand truck to storage point	2	1.07	1/ .08	1.15
Release 6-high stacks in storage area	2	.39	.96	1.35
Manually high-pile boxes 12 high (500 boxes)	2	2.83	.0	2.83
Total man-hours	-	8.51	3.28	11.79
Elapsed time--hours				2/ .27

1/ Wait time caused by crew interference.
2/ Truck unloading only.

Table 5.--Labor required for an 8-man crew to unload from road trucks 1 box at a time and move into storage 1,000 unpacked boxes of apples by use of belt conveyors and clamp-type 2-wheel hand truck, and manually high-pile boxes 12 high as fruit is received 1/

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Setup and cleanup	2/ 8	0.16	0.52	0.68
Place boxes on belt conveyor (conveyor moves boxes 50 feet)	2	1.53	1.29	2.82
Transfer boxes from the belt conveyor to 6-high stacks	2	1.57	1.25	2.82
Pick up stacks by 2-wheel hand trucks	2	.32	.0	.32
Transport 6-high stacks 50 feet by 2-wheel hand trucks to storage point	2	1.07	3/ .08	1.15
Release 6-high stacks in storage area	2	.39	.96	1.35
Manually high-pile boxes 12 high (500 boxes)	2	2.83	.0	2.83
Total man-hours	-	7.87	4.10	11.97
Elapsed time--hours				1.50

1/ Data from table 41 of Marketing Research Report No. 49--"Apple Handling Methods and Equipment in Pacific Northwest Packing and Storage Houses."

2/ Two of the 8 workers do the setup work at the road truck while the other 6 workers spend most of their time waiting.

3/ Wait time caused by crew interference.

Based solely on plant handling costs, the new method did not materially reduce the cost of receiving fruit from road trucks. As shown in table 6, labor and equipment costs per 1,000 boxes are almost identical with the costs of receiving unpalletized boxes by the conveyor-hand truck method, there being only $0.01 difference which was computed on the basis of current wage rates. Equipment costs with the new method are slightly greater than by the usual method offsetting a small saving in labor. The elapsed time to unload the road truck was reduced 82 percent. If this reduction in the time the road truck and driver remain at the plant for unloading were taken into account, a substantial saving should result from the new method. At an assumed cost of $3 per hour for road truck time, the 1.23 hours saved per 1,000 boxes would have a value of $3.69. The saving in the driver's time would amount to $1.41 (at $1.15 per hour wage rate), bringing the total saving to $5.10 per 1,000 boxes.

Combined Loading and Receiving Costs

When the costs of orchard and warehouse handling are combined, costs by use of the new method are slightly greater than costs using the common method (table 7). Elapsed time was reduced 31 percent. All this reduction results from the saving of time at the warehouse.

Conclusions and Recommendations

One of the reasons the new method fails to reduce the handling costs incurred in belt conveyor-hand truck plants by use of present methods is that the unit loads built on the road truck in the orchard are not maintained intact throughout the receiving cycle. Additional costs, principally for equipment, are incurred by use of the innovation solely for the purpose of transferring the unit load from the road truck to the receiving platform.

Table 6.--Comparative labor and equipment costs for unloading 1,000 unpacked boxes of apples from road trucks, moving into storage, and high-piling in 12-box high stacks, by use of belt conveyors and clamp-type 2-wheel hand trucks when fruit is palletized and unpalletized on road trucks by use of 2 specified methods

Method	Workers	Elapsed time	Labor and equipment required		Labor and equipment costs			
			Equipment time	Total labor	Equipment	Labor	Total cost: Current wages	Total cost: Assumed wages
	Number	Hours	Machine-hours	Man-hours	Dollars	Dollars	Dollars	Dollars
Present:								
Unload road truck directly to belt conveyor 1 box at a time	8	1.50	1/ 6.00	11.97	1.38	13.77	15.15	18.14
Innovation:								
Roll 36-box unit load off road truck bed to platform by use of fixed roller conveyors and transfer boxes to belt conveyor later	10	2/ .27	3/ 5.91	11.79	4/ 1.59	13.55	15.14	18.10

1/ Clamp-type 2-wheel hand trucks 3 machine-hours, 100-foot belt conveyor 1.5 machine-hours, 15-foot gravity-type roller conveyor 1.5 machine-hours, total 6 machine-hours.

2/ Truck unloading only.

3/ Clamp-type 2-wheel hand trucks 3 machine-hours, 100-foot belt conveyor 1.5 machine-hours, 45 feet of gravity-type roller conveyor 1.41, total 5.91 machine-hours.

4/ Includes cost of 16 40- by 36- by 5/8-inch plywood pallets at $0.135 per warehouse handling (based on an initial equipment cost of $53.00 for 16 pallets or 1 truckload and 1 exchange), 5-year depreciation, interest, and investment 5 percent, 2 percent allowance for insurance and taxes, and 96 handlings per year. In the test conducted, hydraulic jacks were used to stabilize the truck bed and their cost was insignificant. However, any plant operator wishing to adopt this method should not overlook the cost of a permanently installed truck-bed stabilizer.

Table 7.--Comparative labor and equipment costs for loading road trucks in the orchard and receiving at the plant per 1,000 boxes of unpacked apples by use of 2 specified methods

Method	Workers	Elapsed time	Labor and equipment required		Labor and equipment costs			
			Equipment time	Total labor	Equipment	Labor	Total cost: Current wages	Total cost: Assumed wages
	Number	Hours	Machine-hours	Man-hours	Dollars	Dollars	Dollars	Dollars
Present:								
Portable roller conveyor in the orchard, roller conveyor extension and belt conveyor in the warehouse	10	3.50	1/ 7.86	15.97	1.46	18.37	19.83	23.82
Innovation:								
Fixed roller conveyors on bed of road truck and receiving platform and handling in unit loads of 36 boxes to belt conveyor	12	2.41	1/ 8.05	16.08	1.86	18.48	20.34	24.33

1/ See tables 3 and 6 for types of equipment used and machine-hours of use of each type.

On the platform the 36-box unit loads are broken down and each box is individually handled as it is placed on the belt conveyor on which the boxes are moved to the storage room. However, the innovation has possible advantages that are not shown by comparative costs or elapsed times. The use of roller conveyors on the receiving platform should permit the unloading of 1 or 2 road truckloads thus providing a temporary bank of supply which would tend to decrease the time the receiving crews spends awaiting the arrival of trucks. Added to this potential advantage is the elimination of wait time of road trucks and their drivers during the receiving season when, at some warehouses, several trucks may stand by awaiting their turn to unload.

The new method appears to have greatest possibilities for effecting handling cost reductions in apple packinghouses that receive most of their fruit directly at the packing line. In these plants the unit loads could be maintained intact from the orchard to the dumper at the beginning of the packing line. For this it obviously would be necessary to connect the edge of the receiving platform and the washer or dumper with three rows of gravity-type roller conveyors. 1/

A possible disadvantage of the new method in plants that receive most of their fruit at storage points and that have relatively small receiving platforms is the possibility of congestion on the platform during peak receiving periods. When receiving crews have no standby time, the innovation actually would delay unloading operations and should not be used during extreme peak periods of receiving.

FORKLIFT TRUCK-TRAILER TRAINS FOR TRANSPORTING APPLES FROM STORAGE TO THE PACKING LINE

Apple packing and storage houses designed for the use of the industrial forklift truck and pallets usually are constructed with all packing and storage rooms on one level. Single-story plants must be wider and deeper than multistory structures to obtain equivalent floor space so, within-plant transportation distances are greater than in multistory buildings. In a number of the newer Washington State plants, the distance from storage to the dumper, at the packing line, and from the segregating area to storage averages considerably in excess of 300 feet. These distances materially affect labor and equipment costs.

Engineers suggested that efficiencies in within-plant transportation could be gained by substituting trailer trains for forklift trucks when transportation distances exceed 300 feet. The use of trailer trains, towed by the forklift truck used to remove pallet loads from storage stacks and load the trailers, was tested in one plant for moving unpacked boxes of fruit from storage to the packing line to measure its efficiency and compare it with that of the forklift truck alone.

The trailers were 36 inches wide and 72 inches long, holding two 48-box pallets. The trailers were equipped with snap-latch type couplings and had 2 swivel and 2 fixed solid

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1/ For a discussion of another method of using gravity-type roller conveyors for receiving fruit at the packing line, see page 146 of the report *Apple Handling Methods and Equipment in Pacific Northwest Packing and Storage Houses*, MRR 49.

rubber wheels. Because of limited space for turnarounds, the tests were planned so that the lift truck would tow 3 trailers at a time containing a total of six 48-box pallet loads of fruit. A 4,000-pound capacity electric forklift truck was used in the tests.

In this plant, transportation distances from storage to the packing line were between 200 and 400 feet. As the aisles in the storage rooms were not wide enough so that the trailer train could be turned around in the room, the forklift truck pulled the trailer train in through one doorway and out through another. Thus, there was a difference in transportation distances when the trailers were loaded and when they were empty, the shorter distance being when they were loaded. When fruit was being broken out of stacks at the end of one of the rows (away from the main aisle) in the storage room, it was necessary to transport the pallet loads a distance of from 50 feet to 75 feet with the lift truck as the trailer train could not be moved into the lateral aisles.

After the trailer train had been positioned in the main aisle, the forklift truck traveled empty to the storage stack where it picked up unit loads from the third, second, or first tiers, traveled 50 feet to the trailer, and released the pallet load on the trailer bed (fig. 9). This cycle was repeated until the 3 trailers were loaded. After the trailer train was coupled to the forklift truck, it was pulled 300 feet to the packing room (fig. 10). In the dumper area the forklift truck lifted the loaded pallets from the trailers and deposited them on the floor. The total distance traveled by the trailer train in 1 cycle was 700 feet. However, the forklift truck transported each pallet load 50 feet in the storage room and 25 feet at the dumper which means that it traveled 150 feet for each pallet load handled, or 900 feet for 6 pallets, bringing the total distance traveled to 1,600 feet.

Figure 9.--Releasing a pallet load on a trailer.

To transport single pallet loads, the forklift truck travels 375 feet each trip and makes 6 round trips from the cold-storage room to the dumper for every trip of the trailer train. The total travel distance by this method is 4,500 feet.

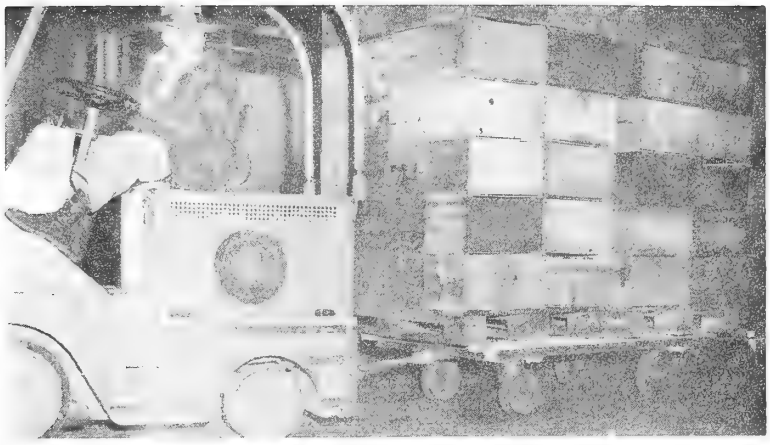

Figure 10.--A forklift truck towing a loaded trailer train.

As shown in table 8, 0.92 man-hour of labor is required to move 1,000 boxes of fruit from storage to the packing line by using the forklift truck and trailer train. The fork-lift truck requires 0.96 man-hour to do the same work without the use of the trailers (table 9). Thus, from a standpoint of labor saved, it appears that there would be little advantage in using trailers over transportation distances no greater than those in the plant in which the study was made unless the number of trailers per train could be increased or some of the operations at the dumper eliminated.

Table 8.--Labor required for 1 worker to move 1,000 unpacked boxes of apples from storage to the packing line by pallets, fork-lift truck, and trailer train and roller conveyors, when trailers are unloaded at washer

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Pick up 48-box pallet loads from stacks 3-tiers high by fork-lift truck	1	0.09	0.0	0.09
Transport 50 feet to trailer train	1	.23	.0	.23
Release pallet load on trailer bed	1	.11	.0	.11
Transport empty trailers 400 feet by fork-lift truck	1	.06	.0	.06
Transport loaded trailers 300 feet by fork-lift truck	1	.08	.0	.08
Pick up 48-box pallet loads off trailer bed by fork-lift truck	1	.06	.0	.06
Transport 25 feet to washer area	1	.15	.0	.15
Release pallet loads on roller conveyors at washer	1	.11	.0	.11
Hook on	1	.02	.0	.02
Hook off	1	.01	.0	.01
Total man-hours	-	.92	.0	.92
Elapsed time--hours				.92

Table 9.--Labor required for 1 worker to move 1,000 unpacked boxes of apples from storage to the packing line by pallets, fork-lift truck, and roller conveyors

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Pick up 48-box pallet loads from stacks 3-tiers high by fork-lift truck	1	0.09	0.0	0.09
Transport 375 feet to washer area	1	.76	.0	.76
Release pallet loads on roller conveyors at washer	1	.11	.0	.11
Total man-hours	-	.96	.0	.96
Elapsed time--hours				.96

A modification in the trailer train method could be made by using additional trailers so that loaded trailers could be left at the dumper, thus relieving the forklift truck operator from the necessity of having to remove the pallets from the trailer in the dumping area. Loaded trailers could be pushed into place by the worker doing the dumping in the same manner that pallet loads are handled on pallet dollies. As shown in table 10, this would result in a saving of labor.

Table 10.--Labor required for 1 worker to move 1,000 unpacked boxes of apples from storage room to the packing line by pallets, fork-lift truck, and trailer train when loaded trailers are released at washer

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Pick up 48-box pallet loads from stacks 3-tiers high by fork-lift truck	1	0.09	0.0	0.09
Transport 50 feet to trailer train	1	.23	.0	.23
Release pallet load on trailer bed	1	.11	.0	.11
Transport empty trailers 400 feet	1	.06	.0	.06
Transport loaded trailers 300 feet	1	.08	.0	.08
Release loaded trailers at washer (hook off)	1	.01	.0	.01
Pick up empty trailers at washer (hook on)	1	.02	.0	.02
Total man-hours	-	.60	.0	.60
Elapsed time--hours				.60

Labor and equipment costs for moving 1,000 unpacked boxes of apples from storage to the packing line by a forklift truck handling 1 pallet load of fruit at a time are $5.66 (table 11). If the forklift truck towed a 3-trailer train and unloaded the 6 pallets at the washer, the cost would be slightly less at $5.63 per 1,000 boxes. By using 3 trains of 3 trailers each, so that the forklift truck would not have to remove pallets from the trailers at the dumping area, the cost of moving 1,000 boxes to the packing line would be $3.74--a saving of about 34 percent. This saving results from a reduction in both labor and machine costs.

Table 11.--Comparative labor and equipment costs for moving 1,000 unpacked boxes of apples from storage to the packing line by use of 3 specified methods

Method	Workers	Labor and equipment required		Labor and equipment costs			
		Equipment time	Total labor	Equipment	Labor	Total cost Current wages	Total cost Assumed wages
	Number	Machine-hours	Man-hours	Dollars	Dollars	Dollars	Dollars
Fork-lift truck industrial unit loads	1	1/ 5.25	0.96	4.41	1.25	5.66	5.90
Fork-lift truck and 3 industrial trailers--2 pallets per trailer (remove pallet in the washer area)	1	2/ 6.09	.92	4.43	1.20	5.63	5.86
Fork-lift truck and 9 industrial trailers--2 pallets per trailer (leave pallets on trailer in washer area)	1	3/ 1.80	.60	2.96	.78	3.74	3.89

1/ 4,000-pound capacity electric fork-lift truck 0.96 machine hour, 20.8 pallets (48-box) 0.96 machine-hour, 30 feet of gravity roller conveyor 3.33 machine-hours, total 5.25 machine-hours.

2/ 4,000-pound capacity electric fork-lift truck 0.92 machine-hour, 20.8 pallets (48-box) 0.92 machine-hour, 30 feet of gravity roller conveyor 3.33 machine-hours, 3 36- by 72-inch industrial trailers, 0.92 machine-hour, total 6.09 machine-hours.

3/ 4,000-pound capacity electric fork-lift truck 20.8 pallets (48-box), and 9 36- by 72-inch industrial trailers 0.60 machine-hour each, total 1.80 machine-hours.

It is possible that some plants having layouts which require the transportation of fruit for more than 350 feet could make efficient use of trailer trains towed by the lift trucks that are used to load and unload the trailers. The advantages, however, would be small unless arrangements were made for sufficient trailers so that the worker supplying the dumper could unload the trailers, thereby eliminating the unloading of trailers by the forklift trucks. Under some circumstances it might be possible that use of trailer trains would relieve a plant from the necessity of having to buy an additional forklift truck by releasing the trucks already owned to help with the receiving cycle of apple warehousing.

TRACTOR-TRAILER TRAINS FOR TRANSPORTING APPLES BETWEEN STORAGE POINTS AND THE PACKING LINE

The use of a tractor for towing trailer trainloads of fruit between storage and the packing line was studied in the same plant in which studies were made of the forklift truck for towing trailer trains. One industrial forklift truck normally is used in this plant to move 48-box pallet loads of unpacked fruit from storage to the dumpers at 2 packing lines (fig. 11). A second forklift truck is used to move 40-box pallet loads of packed fruit from the segregation area to storage. In these jobs each truck travels 375 feet with 1 pallet load and returns empty. Tests with tractor-trailer trains were made to determine the possibilities of reducing this travel time.

The equipment used in the tractor-trailer-train tests were: (1) The two 4,000-pound capacity electric forklift trucks normally used for moving fruit to and from the packing line; (2) one 2,500-pound drawbar-pull gasoline-powered tractor (mule) of the type shown in figure 12; and (3) three trailer trains, each of which consisted of three industrial-type,

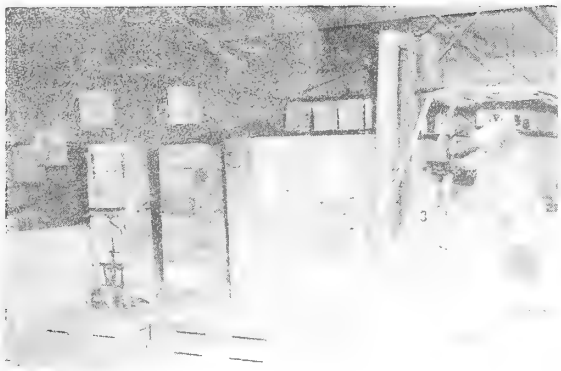

Figure 11.--Forklift truck releases individual unit load at the washer.

Figure 12.--Tractor pulling empty trailers back to storage.

36- by 72-inch trailers. Base transportation times for the trucks and tractor are shown in figure 13.

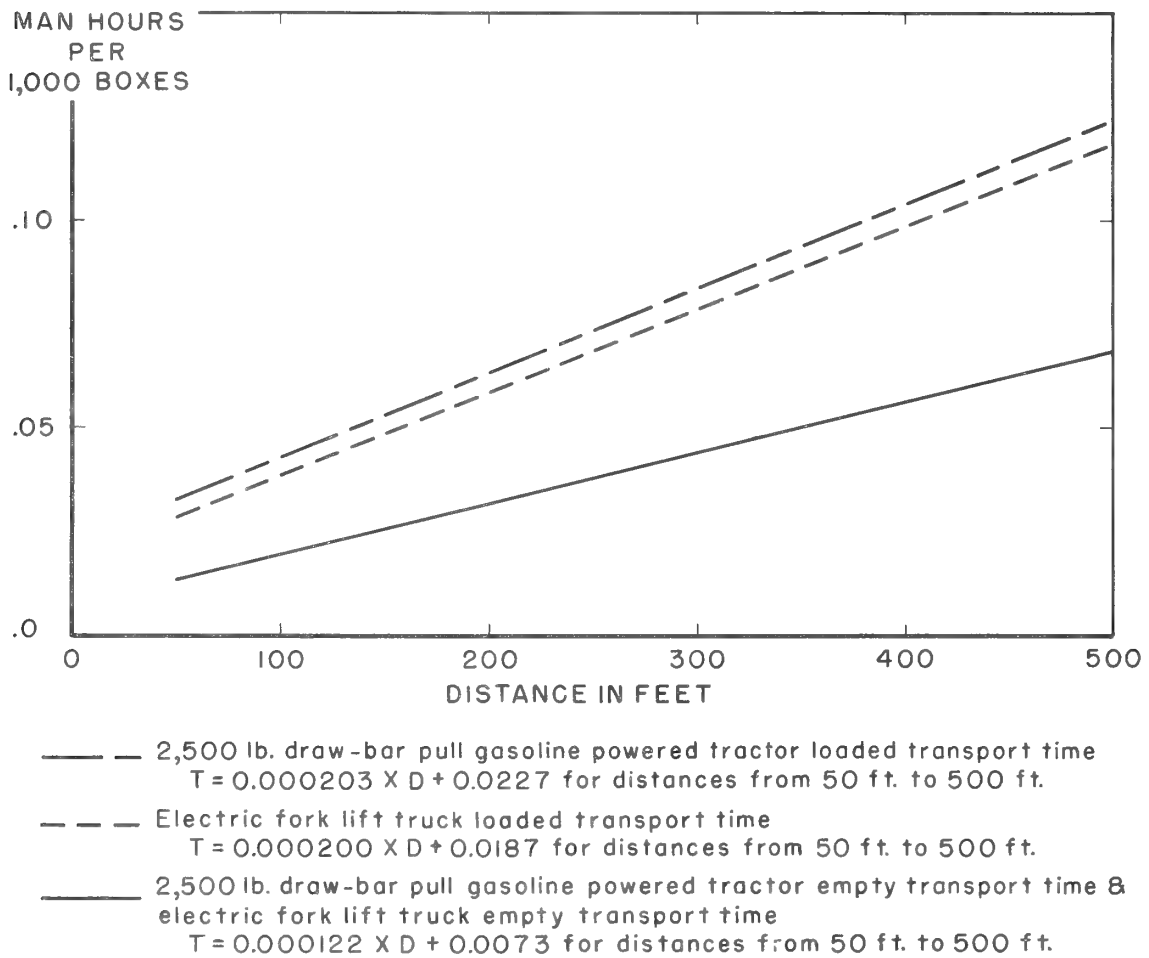

Figure 13.--Base transportation times for 4,000-pound electric forklift truck and 2,500-pound drawbar-pull gasoline-powered tractor under specified conditions and for various distances.

In the method developed for testing the tractor-trailer train, one forklift truck was at the packing line The second was in the storage room. The tractor-trailer trains, operated by 1 driver, were used to transport unpacked boxes of fruit from storage to the 2 packing lines and, on the return trip, to transport packed boxes from the segregation area to storage. The pace was regulated by the combined rates of the 2 packing lines, 600 boxes of unpacked fruit per hour. Their combined output was 420 boxes of packed fruit per hour. To equalize the workload, thus eliminating the necessity for an occasional trailer train to return empty to the storage room for unpacked fruit to keep the 2 packing lines supplied, each trailer train brought out six 48-box pallet loads (288 boxes) and returned with five 40-box pallet loads (200 boxes).

In the storage room, 1 forklift truck loaded 48-box pallet loads of unpacked fruit on the outgoing trailers and unloaded 40-box pallet loads of packed fruit from the incoming trailers. Another lift truck unloaded the trailers in the dumping area and loaded the packed boxes (fig. 14). In so doing it was necessary for each forklift truck to travel empty for 100 feet and return. The tractor-trailer trains traveled approximately 300 feet loaded and 100 feet empty each way in making the round trip from the storage room to the packing lines (fig. 15).

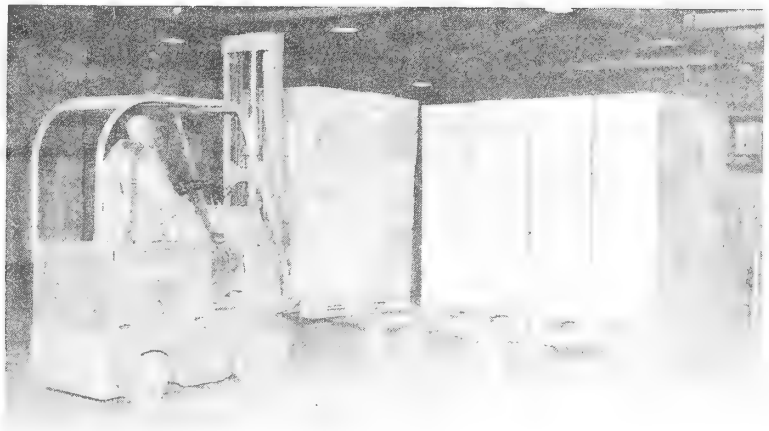

Figure 14.--Forklift truck unloading the trailers in the dumper area.

Beginning at the dumpers, the forklift truck operator picks up 48-box pallet loads of unpacked fruit from the trailers, transports the pallet loads 25 feet, and releases them on roller conveyors. Both the forklift truck and tractor-trailer train then travel empty for 100 feet from the dumpers to the packed fruit segregation area. As packed fruit becomes available, the forklift truck loads the trailer train with five 40-box pallet loads. After loading, the train is pulled 300 feet by the tractor to the storage area. The forklift truck returns empty to the dumpers. In the packed-fruit storage area, the tractor picks up an empty trailer train and tows it to the unpacked-fruit storage area. It then hauls a trailer train of unpacked apples 300 feet to the dumpers. While the tractor is placing a trailer train, the forklift truck in the storage room unloads pallet loads of packed

Figure 15.--Loaded tractor-trailer train in the dumper area.

fruit from the trailers, transports the pallet loads 25 feet, and stacks them. This truck then travels empty for 100 feet and loads unpacked fruit on the trailers in the unpacked-fruit storage area.

Table 12 shows this method used 5.01 man-hours of labor to bring 1,000 unpacked boxes of apples to the packing line and move 700 packed boxes of fruit back to storage. An important part of this time was wait time as the packing lines did not use fruit rapidly enough to keep these workers fully occupied. Wait time was 67 percent. The usual method in this plant for moving the fruit to and from the packing lines with forklift trucks requires 1.72 man-hours of labor to move 1,000 boxes to the packing line and to move 700 packed boxes of fruit back to the storage room (table 13). No wait or idle time is charged against these operations as both lift-truck operators did other work.

By the use of 2 forklift trucks fruit could be moved to and from the packing line at a cost of slightly less than $10 per 1,700 boxes compared with nearly $21 when tractors and trailers were used (table 14). The greater cost of using tractor-trailer trains is partly owing to increased labor costs and to increased equipment costs. The forklift truck method requires one fewer crew member than does the tractor-trailer method.

Thus it may be concluded that tractor-trailer trains would not be as efficient as forklift trucks operating independently for moving fruit to and from the packing line unless the volume of work were sufficient to keep the tractor drivers, forklift truck operators, and their equipment fully occupied. Where a relatively large part of the work to be done does not involve transportation, the tractor-trailer train method tends to lose most of its value. The use of the tractor-trailer trains in this operation did not eliminate a lift truck. As a matter of fact, an additional lift truck was required as compared with the method in which a forklift truck was used to tow the trailers.

Table 12.—Labor required for 3 workers to move 1,000 unpacked boxes of apples from storage to the packing line and 700 packed boxes of apples from the segregation area to the storage room by use of fork-lift trucks, pallets, tractor-trailer trains, and roller conveyors 1/

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
First fork-lift truck picks up 48-box pallet loads unpacked apples off trailers, transports 25 feet, releases at dumper on roller conveyors (1,000 boxes--6 pallet loads per train)	1	0.34	0.0	0.34
First fork-lift truck travels empty 100 feet from dumper to segregation area and waits	1	.02	.85	.87
Tractor pulls empty trailer train 100 feet from dumper to segregation area and waits	1	.02	1.12	1.14
First fork-lift truck picks up 40-box pallet loads packed apples in segregation area, transports 25 feet, releases on trailers (700 boxes--5 pallet loads per train)	1	.27	.0	.27
First fork-lift truck travels empty 100 feet from segregation area to dumper and waits	1	.02	.17	.19
Tractor pulls loaded trailer train 300 feet from segregation area to packed fruit storage area, and releases train (hooks off) (1,000-box basis)	1	.08	.0	.08
Tractor hooks on empty trailer train, pulls 100 feet from packed fruit storage area to unpacked fruit storage area, and releases train (hooks off)	1	.02	.01	.03
Second fork-lift truck picks up 48-box pallet loads of unpacked apples from 1st, 2d, and 3d tiers; transports 50 feet, and releases on trailers (1,000 boxes--6 pallets per train)	1	.44	.0	.44
Tractor hooks on loaded trailer train, pulls 300 feet from unpacked fruit storage area to dumper, and waits	1	.08	.34	.42
Second fork-lift truck travels empty 100 feet from unpacked fruit to packed fruit storage area	1	.02	.0	.02
Second fork-lift truck picks up 40-box pallet loads packed apples off trailers; transports 50 feet; releases in 1st, 2d, and 3d tiers, and waits (700 boxes)	1	.34	.85	1.19
Second fork-lift truck travels empty 100 feet from packed fruit storage area to unpacked fruit storage area	1	.02	.0	.02
Total man-hours	-	1.67	3.34	5.01

1/ This method was used to handle fruit for 2 packing lines, and operations in the cycle were paced by the combined rates of the 2 lines which were 600 unpacked boxes of apples per hour. The total output of packed fruit was 420 boxes per hour. As this method has a potential handling rate of 1,220 boxes of unpacked fruit and 850 boxes of packed fruit per hour, considerable machine-regulated wait time resulted.

Table 13.—Labor required for 2 workers to move 1,000 unpacked boxes of apples from storage to packing line and 700 packed boxes of apples from the segregation area to the storage room by use of fork-lift trucks, pallets, and roller conveyors

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Pick up 48-box pallet loads of unpacked apples in storage area, from 1st, 2d, and 3d tiers by fork-lift truck, transport 375 feet, release unit load on roller conveyors at dumper (1,000 boxes)	1	0.96	0.0	0.96
Pick up 40-box pallet loads of packed apples in segregation area by fork-lift truck, transport 375 feet, and release unit load into 1st, 2d, and 3d tiers in storage (700 boxes)	1	.76	.0	.76
Total man-hours	-	1.72	.0	1.72

Table 14.--Comparative labor and equipment costs for moving 1,000 unpacked boxes of apples from storage to the packing line and for moving 700 packed boxes of apples from the segregation area to storage area by use of 2 specified methods

Method	Labor and equipment required			Labor and equipment costs			
	Workers	Equipment time	Total labor	Equipment	Labor	Total cost: Current wages	Total cost: Assumed wages
	Number	Machine-hours	Man-hours	Dollars	Dollars	Dollars	Dollars
Tractor-trailer, fork-lift trucks, and pallets:							
Fork-lift trucks load and unload trailer, tractor pulls loads to and from storage area.	3	1/ 11.69	5.01	14.28	6.51	20.79	22.05
Fork-lift trucks and pallets:							
Fork-lift trucks transport unit loads 375 feet to and from storage area	2	2/ 6.77	1.72	7.68	2.24	9.92	10.35

1/ 4,000-pound capacity fork-lift truck 3.34 machine-hours, 2,500-pound draw-bar pull gasoline-powered tractor (mule) 1.67 machine-hours, 20.8 pallets (48-box) 1.67 machine-hours, 3-trailer (36- by 72-inch) train 5.01 machine-hours, total 11.69 machine-hours.

2/ 4,000-pound capacity fork-lift truck 1.72 machine-hours, 20.8 pallets (48-box) 1.72 machine-hours, 30 feet gravity roller conveyor 3.33, total 6.77 machine-hours.

These data indicate that the most efficient use of tractor-trailer trains for moving fruit to and from the packing line could be obtained only in plants that: (1) Operate three packing lines simultaneously; (2) have transportation distances from storage points to the packing line of 400 feet or more on fairly smooth surfaces; and (3) have industrial lift trucks which can be used in loading and unloading trailers.

24-BOX INDUSTRIAL CLAMP-TYPE LIFT TRUCKS FOR HANDLING APPLES IN PLANTS USING BELT CONVEYORS AND HAND TRUCKS

Most of the apple packing and storage plants in Washington State are multistory structures and are equipped with belt conveyors. These conveyors run from the main floor to upper and lower floors for use in moving fruit to and from the docks and packing lines to storage rooms on other floors. Remodeling such plants so that industrial lift trucks could move between floors, would be costly and impractical. However, in these plants some of the heaviest apple-handling operations are performed inside the storage room after the fruit arrives on belt conveyors. Boxes must be off-loaded, piled in 5- or 6-high units, transported to storage position, and high-piled. When fruit is moved out of storage this operation is reversed. In a belt conveyor plant, approximately three-fourths of the workers employed for materials handling work in the storage room. There is an urgent need for some type of equipment that can take over most of this work, replacing the hand truck and manual methods, thus reducing the number of men in the crews.

In an effort to find one or more types of powered lift equipment that could be operated efficiently in belt conveyor plants, performance and installation specifications of 5 walkie-type high-lift pallet transporters were studied. It was found that their weights with the batteries ranged from 1,500 to 2,700 pounds. They had an average speed

of 2½ miles per hour. Most of these transporters were of the straddle-type which requires a special pallet. Because of relatively low ceiling heights and other space limitations in storage rooms it was felt that the use of pallets in the older storage houses would require considerable space needed for fruit storage; therefore, the use of pallets in such houses would not be economical. Moreover, these transporters have small wheels which, it was felt, would damage the floors.

Although one equipment manufacturer indicated that it would be possible to install clamping arms which would avoid the necessity of using pallets on a walkie-type high-lift transporter, such equipment was not available during the 1951-52 season when field studies were under way. The machine that might have been converted was the counter-balanced type and its weight was about 3,000 pounds. The wheels were large and would not damage floors. However, the handle on the transporter required additional turning space.

Lightweight, riding-type lift trucks with clamping arms, rather than forks, of the type shown in figure 16, also were studied. These lift trucks range in weight from 2,200 pounds for a gasoline-powered type to 2,500 pounds (without the battery) for battery operated machines. They could be operated with pneumatic or solid rubber tires at speeds of from 5 to 6 miles per hour which is about twice the speed of the walkie-type machine. A comparison of specified features of 2 walkie-type pallet transporters, one lightweight forklift truck, and a 24-box industrial clamp truck is shown in table 15.

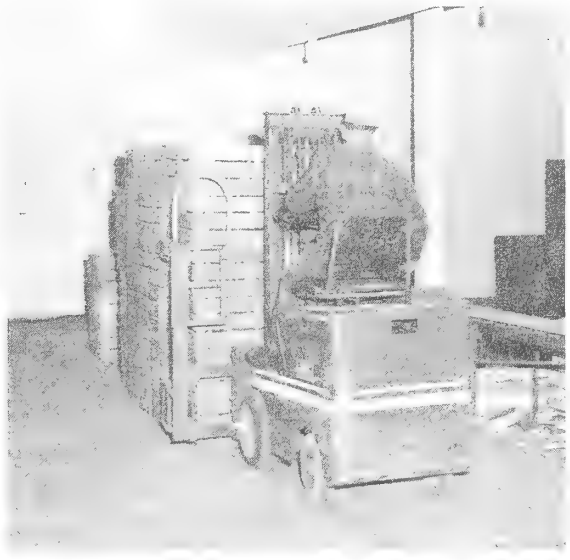

Figure 16.--24-box industrial clamp-type lift truck. A practical innovation for older cold-storage and packing plants.

Table 15.--Comparative specifications of selected walkie-type high-lift transporters and industrial trucks

Specification	Straddle-type walkie pallet transporter	Counterbalanced-type walkie pallet transporter	Space-saver fork-lift truck	24-box industrial clamp truck
Service weight. . . . . pounds . . .	2,050	2,860	2,480	2,500
Travel speed loaded . .miles per hour . . .	2.5	2.5	2.1	6.00
Capacity. . . . . pounds . . .	4,000	2,000	1,000	1,000
Center line of load . . . . . inches . . .		24	24	24
Overall length. . . . . inches . . .	77	100½	91½	84½
Outside turn radius . . . . . inches . . .	95	63	49½	58

Of the lightweight mechanized equipment available during the 1951-52 season, it appeared that the industrial clamp-lift truck offered the greatest possibilities as a substitute for clamp-type 2-wheel hand trucks for use in combination with belt conveyors to receive into storage and to perform other handling operations confined to storage rooms.

Figure 17 shows that for moving fruit the 24-box industrial clamp truck is more efficient than hand trucks even for distances under 100 feet. The industrial truck attains relatively greater efficiency for longer distances. As an example, over a distance of 100 feet, 2.35 man-hours of labor are required to move (pick up, transport, and release) 1,000 boxes of fruit by hand trucks compared with 0.72 man-hour by 24-box industrial clamp truck. However, over a distance of 200 feet, 4.06 man-hours are required by hand trucks and 1.04 man-hours by the industrial truck.

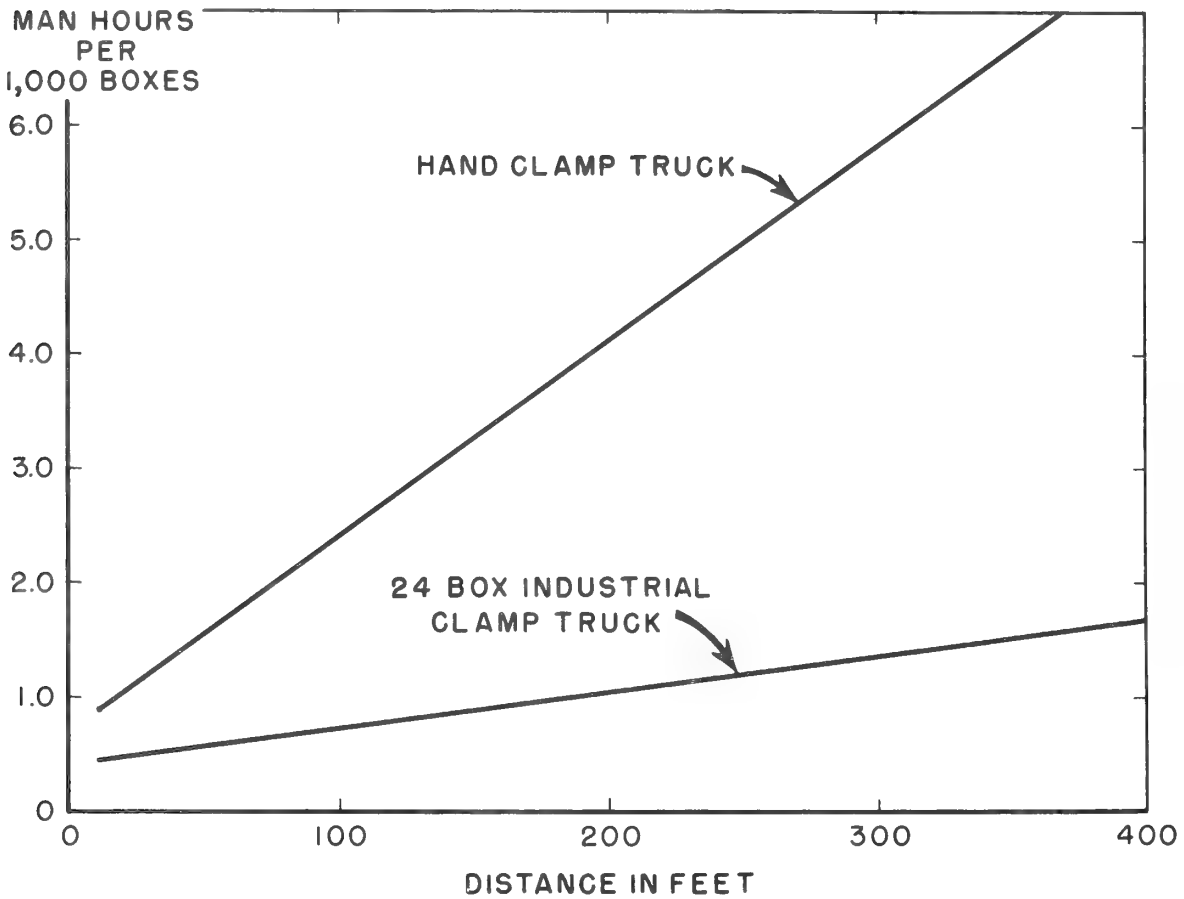

Figure 17.--Labor required to move (pick up, transport, and release) 1,000 boxes of apples through various distances by clamp-type 2-wheel hand truck and 24-box industrial clamp-type lift truck.

The method developed for receiving apples with the industrial clamp-lift truck is as follows: As fruit arrives in the storage room on a belt conveyor it is stacked in

unit loads beside the belt conveyor and the industrial clamp truck moves the unit loads to storage. The industrial clamp truck can tier the fruit and manual high-piling is eliminated. The industrial clamp truck and belt conveyor also can be used to move fruit from storage to the packing line, to receive fruit from the packing line, and to assist in moving fruit to the car for loading out.

In the tests with the 24-box industrial clamp truck in a belt conveyor plant the truck had to operate at times under somewhat crowded conditions. The results of studies made of this type of truck under open conditions were reported in Marketing Research Report No. 49, *Apple Handling Methods and Equipment in Pacific Northwest Packing and Storage Houses*.

Unloading from Road Trucks and Moving Boxes of Apples to Storage

When a clamp-type industrial lift truck is used in combination with belt conveyors for receiving fruit at storage points, unloading from the road truck proceeds as it normally does in a belt conveyor plant with a 5-man crew. Two workers on the road truck transfer boxes of apples, 1 box at a time, from the truck bed to a belt conveyor that moves the boxes into the cold-storage room. Inside the storage room 2 workers remove the boxes from the belt and stack them in unit loads of 24 boxes (4 stacks of 6 boxes each). The 24-box industrial clamp truck (fig. 18) then transports the fruit 50 feet to storage, and tiers the boxes into 2 unit loads of 12 boxes high. By this method 5.65 man-hours of labor were required to receive 1,000 boxes into storage, in an elapsed time of 1.13 hours (table 16). Of the total labor, 24 percent is wait time, most of which occurs in placing fruit on and removing it from the belt.

Figure 18.--Belt conveyor and industrial clamp-type lift truck used during the receiving cycle of operations.

Table 16.--Labor required for a 5-man crew to unload and move 1,000 unpacked boxes of apples from a road truck to storage by use of a belt conveyor in combination with a clamp-type lift truck

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Setup and cleanup	5	0.16	0.24	0.40
Place boxes on belt conveyor (conveyor moves boxes 50 feet)	2	1.54	.56	2.10
Transfer boxes from belt conveyor into double stacks--6 high	2	1.57	.53	2.10
Pick up 24-box unit loads by industrial clamp-type lift truck	1	.17	.0	.17
Transport unit load 50 feet	1	.40	.0	.40
Release unit load in storage area, average 1st and 2d tiers	1	.41	.0	.41
Place 3 boards between 1st and 2d tiers	1	.07	.0	.07
Total man-hours	-	4.32	1.33	5.65
Elapsed time--hours				1.13

To do this work in approximately the same elapsed time per 1,000 boxes of fruit by use of belt conveyors, hand trucks, and manual high-piling, a 10-man crew would be necessary. Table 17 shows that labor requirements per 1,000 boxes are 10.15 man-hours.

Table 17.--Labor required for a 10-man crew to unload and move 1,000 unpacked boxes of apples into storage by use of a belt conveyor and clamp-type 2-wheel hand truck and manually high-pile boxes 12 high as fruit is being received

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Setup and cleanup	1/ 10	0.16	0.69	0.85
Place boxes on belt conveyor (conveyor moves boxes 50 feet)	2	1.54	.32	1.86
Transfer boxes from belt conveyor to 6-high stacks	2	1.57	.29	1.86
Pick up 6-high stacks by use of 2-wheel hand trucks	2	.32	.0	.32
Transport 6-high stacks 50 feet by use of 2-wheel hand trucks	2	1.07	2/ .08	1.15
Release 6-high stacks from 2-wheel hand trucks	2	.39	.0	.39
High-piling boxes 12 high (500 boxes)	4	2.83	.89	3.72
Total man-hours	-	7.88	2.27	10.15
Elapsed time--hours				1.01

1/ Two of the workers do the setup work at the road truck while 8 workers spend most of their time waiting.

2/ Waiting caused by crew interference.

The cost comparison in table 18 shows that $3.22 per 1,000 boxes can be saved by substituting the industrial clamp truck for the hand truck and manual high-piling. All this saving is on labor, the machine costs being $1.78 per 1,000 boxes greater. The size of the receiving crew has been reduced from 10 to 5 men.

Table 18.--Comparative labor and equipment costs for unloading and moving 1,000 unpacked boxes of apples from a road truck into storage by 2 specified methods

Method	Labor and equipment required			Labor and equipment costs			
	Workers	Elapsed time	Equipment time	Total labor	Equipment	Labor	Total cost: Current wages	Total cost: Assumed wages
	Number	Hours	Machine-hours	Man-hours	Dollars	Dollars	Dollars	Dollars
Belt conveyor and 2-wheel hand trucks: 2 men place boxes on conveyor, 2 men transfer boxes from conveyor, 2 men hand truck 50 feet, 4 men high-pile	10	1.01	1/ 4.04	10.15	0.93	11.67	12.60	15.14
Belt conveyor and industrial clamp-type lift truck: 2 men place boxes on conveyor, 2 men transport boxes from conveyor, 1 industrial clamp truck transports 50 feet and tiers.	5	1.13	2/ 4.52	5.65	2.71	6.67	9.38	10.79

1/ 15-foot gravity roller conveyor 1.01 machine-hours, 100-foot belt conveyor 1.01 machine-hours, and clamp-type 2-wheel hand truck 2.02 machine-hours, total 4.04 machine-hours.

2/ 15-foot gravity roller conveyor, 100-foot belt conveyor, 1,000-pound capacity electric industrial clamp-type lift truck, and 41.6 board feet of dunnage 1.13 machine-hours each, total 4.52 machine-hours.

High-Piling Unpacked Boxes of Apples

Much of the fruit that goes into storage customarily is manually high-piled by piling 3, 4, or 6 boxes on the original 6-high piles as positioned. This is heavy and disagreeable work and workers avoid this form of employment if easier jobs are available. It also subjects the fruit to undesirably rough handling. Percentagewise manual high-piling accounts for a relatively large part of handling costs. In a belt-conveyor plant in which unpacked fruit is stacked 12-high, the work of stacking the upper 6 boxes accounts for 38.5 percent of the total labor used in receiving.

To improve efficiency in piling, earlier studies led to development of a mechanical high-piler as reported in Marketing Research Report No. 49, *Apple Handling Methods and Equipment in Pacific Northwest Packing and Storage Houses*. Tests with this high-piler showed that its use reduced the labor required for piling in 10-high stacks by 52 percent and in 12-high stacks by about 68 percent.

One of the tests of the introduction of industrial clamp trucks covered the use of a 24-box truck for high-piling unpacked boxes of apples in 12-high stacks following transport by belt conveyor.

In the tests, the lower 6-high stacks of boxes were positioned and released in storage position by use of clamp-type 2-wheel hand trucks. After rows 6 boxes high and

2 boxes deep were built, the hand truckers released, alongside these stacks, 6-high stacks of boxes in 24-box unit loads. The industrial clamp truck picked up the 24-box load, raised it to the second tier level, moved forward, and released the load on the original 6-high stacks to form 12-box high stacks (2 tiers).

The method used for high-piling the second tier was for the operator to bring the load up to position, stop the lift truck, lean forward and place dunnage strips to tie and stabilize the load, release the load on top of the stacks, and return for another load.

On the basis of labor requirements for high-piling boxes in 12-high stacks, the 24-box industrial clamp truck was over 6 times more efficient than manual labor, and required only one-third as much elapsed time (table 19). The 24-box industrial clamp truck also was more efficient for high-piling than was the mechanical high-piler--requiring 60 percent less labor and less than one-half the elapsed time when piling boxes 12 high.

Table 19.--Comparative labor and elapsed time required to high-pile 1,000 unpacked boxes of apples in 12-box high stacks and to high-pile 500 of each 1,000 boxes received by 3 specified methods

Method	Labor required		Elapsed time required per 1,000 boxes received
	Per 1,000 boxes high-piled	Per 1,000 boxes received 1/	
	Man-hours	Man-hours	Hours
Manually high-piling with a 2-man crew	5.66	2.83	1.41
Mechanically high-piling with a 2-stack mechanical lift--1 worker	1.78	.89	.89
Mechanically high-piling with a 24-box industrial clamp-type lift truck, operator places divider boards--1 worker	2/ .84	.42	.42

1/ Labor required for high-piling 500 boxes.
2/ Pick up 24-box unit load from floor level surface in relatively crowded area 0.16 man-hour; stack and release 24-box unit load in second tier only (crowded area--numerous ducts and posts) 0.58 man-hour; place divider boards between 1st and 2d tiers 0.07 man-hour; fatigue allowance 0.04 man-hour; total 0.84 man-hour.

Labor and equipment costs for high-piling 500 of each 1,000 boxes of fruit received in 12-box high stacks were $1.20 by industrial clamp-type truck (table 20). Savings of $2.05 per 1,000 boxes handled could be made when high-piling 12-high if the 24-box industrial clamp truck were substituted for manual methods. The saving would be $0.35 per 1,000 boxes if the truck were substituted for the 2-stack mechanical high-piler.

Breaking Out Unpacked Boxes of Apples from High Piles

The operation of breaking boxes out of high piles is the reverse of high-piling. When fruit is moved out of storage in belt-conveyor plants high piles must be broken down to the 6-high stacks, and the boxes removed from above this height must be built into

Table 20.--Comparative labor and equipment costs for high-piling 500 of each 1,000 unpacked boxes of apples received in 12-box high stacks by 3 specified methods

Method	Equipment cost	Labor cost 1/	Total cost
	Dollars	Dollars	Dollars
Manually high-piling with a 2-man crew	0.0	3.25	3.25
Mechanically high-piling with a 2-stack mechanical lift--1 worker	2/ .53	1.02	1.55
Mechanically high-piling with a 24-box industrial clamp-type lift truck, operator places divider boards--1 worker	3/ .65	.55	1.20

1/ Computed on the basis of current wage rates.
2/ Portable mechanical lift 0.89 machine-hour at $0.59 per hour.
3/ 1,000-pound (24-box) capacity, electric industrial clamp-type lift truck 0.42 machine-hour at $1.42 per hour, $0.60; and 41.6 board feet dunnage strips 0.42 machine-hour at $0.11 per hour, $0.05; total $0.65.

6-high stacks. As the fruit is moved from the high pile, it is placed in temporary storage near a conveyor belt. Stackbreaking is more intermittent than high-piling, because the packing line sets the pace for the operation.

In the manual method a 2-man crew breaks down high-piled stacks to 6 high. Under the mechanical lift method 1 worker using 1 machine breaks out boxes from the stacks by grasping and lifting the high-piled boxes which then can be pulled back with the high-piler and lowered to the floor. Breaking stacks by the high-piler is not as rough on the fruit and is not as fatiguing as is the manual method.

In trials with the 24-box industrial clamp truck for breaking out high-piled boxes only, the operator maneuvered the truck in position, lifted the high-piled boxes of fruit, leaned forward and removed the dunnage strips, and maneuvered again to release the load.

Use of the 24-box industrial clamp truck for breaking boxes out of 12-box high piles requires less than one-fourth as much elapsed time as does manually breaking out 12-high stacks, and slightly more than one-half the time of the mechanical high-piler (table 21). The total labor required was 0.29 man-hour, compared with 2.42 man-hours required by the manual method.

Table 22 shows that labor and equipment costs for breaking the stacks with the 24-box industrial clamp truck or the mechanical 2-stack high-piler are only $0.82 per 1,000 boxes moved to the packing line compared with $2.78 for the manual method.

Breaking Out Unpacked Boxes of Apples from High Piles and Moving from Storage to the Packing Line

In belt-conveyor plants high-piled boxes usually are broken out manually and moved from the storage stacks to the belt conveyor by clamp-type 2-wheel hand trucks. Of the 190-foot standard distance, boxes are moved from storage stacks to the dumper, 50 feet is by hand trucks and 140 feet is by belt conveyors. Part of the 140-foot distance over

Table 21.--Comparative labor and elapsed time required to break out of high-piles 1,000 unpacked boxes of apples in 12-box high stacks and to break out 500 of 1,000 boxes moved to the packing line by 3 specified methods

Method	Labor required		Elapsed time required per 1,000 boxes moved to the line
	Per 1,000 boxes broken out	Per 1,000 boxes moved to the line 1/	
	Man-hours	Man-hours	Hours
Manually breaking down high-piled boxes with a 2-man crew	4.83	2.42	1.21
Mechanically breaking down high-piled boxes with a 2-stack mechanical lift	.93	.47	.47
Mechanically breaking down high-piled boxes with a 24-box industrial clamp-type lift truck, operator returns divider boards	2/ .58	.29	.29

1/ Labor required for breaking out 500 high-piled boxes.
2/ Pick up 24-box unit loads in 2d tier only of storage stacks (open area except for numerous ducts and posts) 0.32 man-hour; release unit in bank at floor-level surface (crowded area--maneuvering necessary) 0.19 man-hour; remove divider boards 0.04 man-hour; fatigue allowance 0.03 man-hour; total 0.58 man-hour.

Table 22.--Comparative labor and equipment costs to break out of high-piles 1,000 unpacked boxes of apples in 12-box high stacks and to break out 500 of each 1,000 boxes moved to the packing lines, by 3 specified methods

Method	Equipment cost	Labor cost 1/	Total cost
	Dollars	Dollars	Dollars
Manually breaking down high-piled boxes with a 2-man crew	0.0	2.78	2.78
Mechanically breaking down high-piled boxes with a 2-stack mechanical lift--1 worker	2/ .28	.54	.82
Mechanically breaking down high-piled boxes with a 24-box industrial clamp-type lift truck, operator returns divider boards--1 worker	3/ .44	.38	.82

1/ Computed on the basis of current wage rates.
2/ Portable mechanical lift 0.47 machine-hour at $0.59 per hour, total $0.28.
3/ 1,000-pound capacity (24-box capacity) electric industrial clamp-type lift truck 0.29 machine-hour at $1.42 per hour, $0.41; 41.6 board feet dunnage strips 0.29 machine-hour at $0.11 per hour, $0.03; total $0.44.

which boxes are conveyed is accounted for by lateral conveyors, in the storage rooms, which connect with the main conveyor line.

Industrial lift trucks cannot be used, of course, for transporting boxes of apples between floors in multistory plants. Their use must be limited to operations, including

transportation, on the storage-room floor. As the transport on the storage-room floor is relatively short, the comparative efficiency of clamp-type 2-wheel hand trucks and 24-box industrial clamp trucks for transporting fruit over short distances is a major consideration in the use of lightweight industrial clamp trucks in belt-conveyor operations in multistory plants.

In plants that are accustomed to using a 5-man crew for manually breaking out boxes of fruit from 12-box-high stacks and hand trucks for moving the fruit to the conveyor, 7.27 man-hours of labor are required per 1,000 unpacked boxes of fruit moved from storage to the packing line (table 23). Use of a mechanical high piler for breaking out permits a reduction from 5 to 3 workers, and reduces labor requirements per 1,000 boxes to 5.32 man-hours (table 24). These methods provide a basis for comparing the results of tests with the 24-box clamp truck.

Table 23.--Labor required for a 5-man crew to manually break out 500 boxes from 12-box high stacks and to move 1,000 unpacked boxes of apples from storage to the packing line by use of clamp-type 2-wheel hand trucks and belt conveyor

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Break out boxes from 12-box-high stacks by manual method 1/	2	2.42	0.0	2.42
Pick up 6-high stacks at storage position by use of hand trucks	2	.32	.0	.32
Transport stacks 35 feet to temporary bank	2	.78	2/ .10	.88
Release stacks at bank	2	.32	.0	.32
Pick up 6-high stacks from bank by use of hand truck	1	.32	.0	.32
Transport stacks 15 feet to belt	1	.41	.0	.41
Release stacks at belt conveyor	1	.26	.0	.26
Place boxes from single row stacks on belt conveyor	1	1.08	1.26	2.34
Total man-hours	-	5.91	1.36	7.27

1/ Labor required to break out 500 boxes.
2/ Wait time caused by crew interference.

This truck, in combination with belt conveyors, can be used in two basically different ways. By one method the clamp truck operator moves the fruit to the belt conveyor, dismounts, and places the boxes on the belt. By the second method the clamp truck moves up a bank of supply alongside the belt conveyor and moves on to other work while a second worker places the boxes on the belt.

In each of these methods, the question arises as to whether greater efficiency would be attained by using the industrial truck for transporting fruit 50 feet to a 140-foot belt conveyor, which is comparable to present hand-truck operations, or whether the industrial truck should transport the fruit 90 feet to a 100-foot belt. In most plants the latter method would permit the removal of part or all of the lateral conveyor in the storage room.

Table 24.--Labor required for a 3-man crew to break out 500 boxes from 12-box high stacks and to move 1,000 unpacked boxes of apples from storage to the packing line by use of mechanical high piler, clamp-type 2-wheel hand trucks, and belt conveyors

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Break out boxes from 12-box-high stacks by mechanical high piler 1/	2	0.47	0.0	0.47
Pick up 6-high stacks at storage position by use of hand trucks	2	.32	.0	.32
Transport stacks 35 feet to temporary bank.	2	.78	2/ .10	.88
Release stacks at bank.	2	.32	.0	.32
Pick up 6-high stacks from bank by use of hand truck	1	.32	.0	.32
Transport stacks 15 feet to belt.	1	.41	.0	.41
Release stacks at belt conveyor	1	.26	.0	.26
Place boxes from single row stacks on belt conveyor	1	1.08	1.26	2.34
Total man-hours.	-	3.96	1.36	5.32

1/ Labor required to break out 500 boxes.
2/ Wait time caused by crew interference.

One Worker and 24-Box Industrial Clamp Truck

When the operator of an industrial clamp truck moves fruit to the belt conveyor and places boxes on the belt from 2-row stacks, the truck stands idle during the belt-loading (fig. 19). As the packing line can use fruit at a rate of only 300 boxes per hour, the truck is idle most of the time.

Figure 19.--Operator of an industrial clamp-type lift truck placing boxes on the belt conveyor.

When the industrial truck moves fruit 50 feet to the conveyor and the operator places boxes of apples on the belt, the truck stands idle 2.59 hours of the 3.33 hours required to handle 1,000 boxes (table 25). The truck operator also is idle 1.27 hours of this time because of the rate of the packing line. As shown in table 26, this idle time is only slightly reduced when fruit is moved 90 feet by the truck to a 100-foot belt conveyor; however, the reduction in equipment costs because of a 40-foot shorter conveyor line should prove significant.

Table 25.--Labor required for 1 worker to break out 500 boxes from 12-box-high stacks and to move 1,000 unpacked boxes of apples from storage to the packing line by 24-box industrial clamp truck and belt conveyor when truck moves fruit 50 feet and conveyor 140 feet

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
24-box industrial clamp truck:	1			
Pick up 24-box unit load		0.23	0.0	0.23
Transport 50 feet to belt conveyor		.40	.0	.40
Release unit load beside conveyor		.07	.0	.07
Remove boards between 1st and 2d tiers		.04	.0	.04
Place boxes on belt conveyor from 2-row stacks (conveyor moves fruit 140 feet from storage room to packing line)	1	1.32	1.27	2.59
Total man-hours	-	2.06	1.27	3.33

Table 26.--Labor required for 1 worker to break out 500 boxes from 12-box-high stacks and to move 1,000 unpacked boxes of apples from storage to the packing line by 24-box industrial clamp truck and belt conveyor when truck moves fruit 90 feet and conveyor 100 feet

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
24-box industrial clamp truck:	1			
Pick up 24-box unit load		0.23	0.0	0.23
Transport 90 feet to belt conveyor		.54	.0	.54
Release unit load beside conveyor		.07	.0	.07
Remove boards between 1st and 2d tiers		.04	.0	.04
Place boxes on belt conveyor from 2-row stacks (conveyor moves fruit 100 feet from storage room to packing line	1	1.32	1.13	2.45
Total man-hours	-	2.20	1.13	3.33

Two Workers and 24-Box Industrial Clamp Truck

The 24-box industrial clamp truck can be used to move boxes of apples to a bank of supply at the belt conveyor and then as its operator uses it for other work a second worker places the boxes on the belt conveyor supplying the packing line (fig. 20).

As the elapsed time is set by the packing line rate, there is no reduction in this time by employing 2 workers. The use of 2 men increases the total labor required as the worker placing fruit on the conveyor is paced by the packing line. Labor requirements were 4.07 man-hours per 1,000 boxes when the industrial truck moved the fruit 50 feet to a 140-foot belt conveyor (table 27). These requirements were increased to 4.21 man-hours when the truck moved fruit 90 feet to a 100-foot conveyor (table 28). But, the industrial clamp truck is not standing by idle during the wait period and a 40-foot shorter conveyor is used.

Figure 20.--One worker operating an industrial clamp-type lift truck moves fruit to the conveyor and another worker places boxes on the conveyor.

Table 27.—Labor required for 2 workers to break out 500 boxes from 12-box-high stacks and move 1,000 unpacked boxes of apples from storage to the packing line by 24-box industrial clamp-type lift truck and belt conveyor when fruit is moved 50 feet by truck and 140 feet by conveyor

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Pick up 24-box unit load by 24-box industrial clamp-type lift truck	1	0.23	0.0	0.23
Transport 50 feet to belt conveyor	1	.40	.0	.40
Release unit load beside belt conveyor	1	.07	.0	.07
Remove boards between 1st and 2d tiers	1	.04	.0	.04
Place boxes on belt conveyor from 2- row stacks (conveyor moves fruit 140 feet from storage room to packing line.	1	1.32	2.01	3.33
Total man-hours	-	2.06	2.01	4.07

Comparison of Methods

Comparative labor and equipment costs for breaking out of high piles and moving 1,000 boxes of apples to the packing line by the 6 methods previously discussed are given in table 29. When high-piled boxes of apples are broken out manually and moved to the packing line by hand truck to the belt conveyor, labor and equipment costs are $12.40 per 1,000 boxes. When stack-breaking is done by the mechanical high-piler, the total cost is $10.70 per 1,000 boxes, or $1.70 under the manual method. When 1 worker and a 24-box industrial clamp truck are used to move fruit 50 feet only to a 140-foot belt conveyor, costs per 1,000 boxes are increased to $12.92 largely because of the idle truck time. But, when the truck transports the fruit 90 feet, costs are $11.82

Table 28.--Labor required for 2 workers to break out 500 boxes from 12-box-high stacks and move 1,000 unpacked boxes of apples from storage to the packing line by 24-box industrial clamp-type lift truck and belt conveyor when fruit is moved 90 feet by truck and 100 feet by conveyor

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Pick up 24-box unit load by 24-box industrial clamp-type lift truck	1	0.23	0.0	0.23
Transport 90 feet to belt conveyor	1	.54	.0	.54
Release unit load beside belt conveyor	1	.07	.0	.07
Remove boards between 1st and 2d tiers	1	.04	.0	.04
Place boxes on belt conveyor from 2-row stacks (conveyor moves fruit 100 feet from storage room to packing line)	1	1.32	2.01	3.33
Total man-hours	-	2.20	2.01	4.21

Table 29.--Comparative labor and equipment costs for breaking out 500 boxes from 12-box-high stacks and moving 1,000 unpacked boxes of apples from storage to the packing line by 6 specified methods

Method	Workers	Labor and equipment required		Labor and equipment costs			
		Equipment time	Total labor	Equipment	Labor	Total costs	
						Current wages	Assumed wages
	Number	Machine-hours	Man-hours	Dollars	Dollars	Dollars	Dollars
140-foot belt conveyor and clamp-type 2-wheel hand trucks: 2 men break down high-piled boxes, 2 men hand-truck 35 feet to temporary bank, 1 man hand-trucks 15 feet from bank to belt and places boxes on the conveyor	5	1/ 10.60	7.27	4.04	8.36	12.40	14.21
140-foot belt conveyor, clamp-type 2-wheel hand trucks, and mechanical high piler: 2 men break down stacks from 12 high with mechanical high-piler and hand-truck 35 feet to a temporary storage, 1 man hand-trucks 15 feet from bank to belt conveyor and places boxes on a conveyor	3	2/ 9.65	5.32	4.58	6.12	10.70	12.03
140-foot belt conveyor and 24-box industrial clamp truck: Industrial lift truck picks up from 1st and 2d tiers, transports 50 feet to conveyor, lift-truck operator places boxes on belt	1	3/ 6.66	3.33	8.59	4.33	12.92	13.75
100-foot belt conveyor and 24-box industrial clamp truck: Industrial lift truck picks up from 1st and 2d tier transports 90 feet to belt then lift-truck operator places boxes on the belt conveyor	1	4/ 6.66	3.33	7.49	4.33	11.82	12.65
140-foot belt conveyor and 24-box industrial clamp truck: Industrial lift truck picks up from 1st and 2d tiers, transports 50 feet to conveyor, releases at conveyor and moves on to other work. 1 worker places boxes on conveyor	2	5/ 4.07	4.07	4.91	4.79	9.70	10.72
100-foot belt conveyor and 24-box industrial clamp truck: Industrial lift truck picks up from 1st and 2d tiers, transports 90 feet to belt and moves on to other work. 1 worker places boxes on belt conveyor	2	6/ 4.21	4.21	4.01	4.97	8.98	10.04

1/ Clamp-type 2-wheel hand truck 7.27 machine-hours, 140-foot belt conveyor 3.33 machine-hours; total 10.60 machine-hours.
2/ Clamp-type 2-wheel hand truck 5.32 machine-hours, mechanical high piler 1.00 machine-hour, 140-foot belt conveyor 3.33 machine-hours; total 9.65 machine-hours.
3/ 24-box industrial clamp-type lift truck 3.33 machine-hours, 140-foot belt conveyor 3.33 machine-hours; total 6.66 machine-hours.
4/ 24-box industrial clamp-type lift truck 3.33 machine-hours, 100-foot belt conveyor 3.33 machine-hours; total 6.66 machine-hours.
5/ 24-box industrial clamp-type lift truck 0.74 machine-hour, 140-foot belt conveyor 3.33 machine-hours; total 4.07 machine-hours.
6/ 24-box industrial clamp-type lift truck 0.88 machine-hour, 100-foot belt conveyor 3.33 machine-hours; total 4.21 machine-hours.

per 1,000 boxes. Greatest efficiency is attained when 2 workers are employed and the industrial truck transports fruit 90 feet to a 100-foot conveyor. Costs incurred by this method are $8.98 per 1,000 boxes.

Moving Boxes of Apples from Packing Line to Storage

The 24-box industrial clamp-type lift trucks can be used in combination with belt conveyors for moving packed boxes of apples back to storage by having the lift truck pick up unit loads in the segregation area on the storage room floor and move them into storage. The transportation distance from the segregation area to storage was 60 feet. Boxes were moved 100 feet on the belt conveyor from the end of the packing line to the segregation area. Because packed boxes are handled on their sides, 20 boxes, or four 5-box-high stacks, make up a unit load.

When a 24-box capacity industrial clamp truck and 2-man crew, comprised of 1 segregator and 1 truck operator, are used in a belt conveyor plant, 1,000 packed boxes of apples can be moved from the packing line to storage with 5.92 man-hours of labor (table 30). Most of this labor is the time of 1 man in segregating boxes from the belt conveyor. More than one-third of his time is spent waiting. The industrial clamp truck and its operator were engaged in this work only 20 percent of the total time.

Table 30.--Labor required for a 2-man crew to move 1,000 packed boxes of apples from the packing line to storage and stack boxes 10 high by belt conveyor and 24-box industrial clamp-type lift truck

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Segregate boxes from belt conveyor into 20-box unit loads	1	2.72	2.04	4.76
Pickup 20-box unit loads in the segregation area with industrial clamp-type lift truck	1	.14	.0	.14
Transport unit loads 60 feet from belt conveyor to storage	1	.53	.0	.53
Release unit load, average 1st and 2d tiers	1	.49	.0	.49
Total man-hours	-	3.88	2.04	5.92

Belt conveyor plants that move packed boxes by hand trucks from the segregation area to the storage area, and high-pile them by manual labor, normally employ a 3-man crew--1 segregator and 2 hand truckers. This method requires 14.28 man-hours of labor per 1,000 boxes (table 31).

Total labor and equipment costs per 1,000 boxes for each of the 2 methods are shown in table 32. Use of the industrial clamp truck saves $8.01 per 1,000 boxes handled. This saving is due largely to the reduction in labor costs. But, this saving can be made only under circumstances in which the industrial clamp truck can intermittently do other work rather than remain idle when waiting for fruit to accumulate as it comes from the

Table 31.--Labor required for a 3-man crew to move 1,000 packed boxes of apples from the packing line to storage and stack boxes 10 high by use of clamp-type 2-wheel hand trucks, belt conveyor, and gravity roller conveyor

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Segregate boxes at roller conveyor and build 6-high stacks	1	2.63	2.13	4.76
Pickup 6-high stacks of boxes in segregation area by use of 2-wheel hand truck	2	.25	5.51	5.76
Transport 60 feet by use of 2-wheel hand truck	2	1.25	1/ .07	1.32
Release stacks in storage by use of 2-wheel hand truck	2	.39	.0	.39
Manually high-pile boxes in 10-high stacks	2	2.05	.0	2.05
Total man-hours	-	6.57	7.71	14.28

1/ Wait time caused by crew interference.

Table 32.--Comparative labor and equipment costs for moving 1,000 packed boxes of apples from the packing line to storage and stack boxes 10 high by 2 specified methods

Method	Workers	Labor and equipment required		Labor and equipment costs			
		Equipment time	Total labor	Equipment	Labor	Total cost Current wages	Total cost Assumed wages
	Number	Machine-hours	Man-hours	Dollars	Dollars	Dollars	Dollars
Belt conveyor and 2-wheel hand trucks: 1 man segregates, 2 men hand-truck 60 feet to storage and high pile boxes 10 high	3	1/ 19.04	14.28	4.37	16.42	20.79	24.36
Belt conveyor and industrial clamp-type lift truck: 1 man segregates, 1 clamp-type lift truck transports 60 feet and stacks boxes 10 high	2	2/ 10.68	5.92	5.80	6.98	12.78	14.26

1/ Clamp-type 2-wheel hand truck 9.52 machine-hours; 100-foot belt conveyor 4.76 machine-hours; 15-foot gravity-type roller conveyor 4.76 machine-hours; total 19.04 machine-hours.

2/ 24-box industrial clamp-type lift truck 1.16 machine-hours; 100-foot belt conveyor 4.76 machine-hours; 15-foot gravity-type roller conveyor 4.76 machine-hours; total 10.68 machine-hours.

packing line. In some plants, where the layout is such that the industrial clamp truck cannot do other work in the room in which packed boxes are stored, this method would not be economical.

Conclusions and Recommendations

The 24-box industrial clamp-type lift truck is relatively lightweight in comparison with other types of mechanized equipment. This fact should permit its use on the floors

of some plants that were originally constructed for hand-truck and belt-conveyor operations. In these plants the ceiling heights usually are from 10 to 13 feet and boxes of apples that are moved into these rooms are high-piled.

The 24-box lift truck should prove to be satisfactory in most multistory, belt-conveyor plants. Compared with the other types of mechanized equipment available, this truck weighs approximately the same as the straddle-type walkie, counterbalanced walkie, or space-saver forklift truck. Maneuverability, travel speed, and lifting ability all favor the 24-box clamp-type lift truck. Some straddle-type, walkie forklift truck pallet transporters weigh considerably less and can handle the 24-box load, but these require pallets, additional room to turn the equipment, and the small wheels on the straddle arms tend to increase building maintenance. Therefore, at warehouses having structural strength to mechanize, the 24-box clamp-type lift truck is recommended. In the other warehouses where the construction of the floor will not warrant the use of the lift truck, the mechanical high-piler is recommended for saving on the costs of high-piling and breaking-down and also in reducing physical effort in warehouse work.

The 24-box clamp-type lift truck can efficiently pile boxes 10 or 12 high at considerably lower costs than by high-piling either manually or by use of the 2-stack mechanical high-piler. In addition to high-piling, its ability to transport unit loads is another advantage, particularly where the distances are long, as when fruit is moved from storage to the packing line. Also in this cycle of operations boxes of fruit must be broken out of high-piled stacks. The 24-box clamp-type lift truck proved to be a very economical means of breaking out stacks of boxes although the 2-stack high-piler compares favorably in this operation. However, the 24-box clamp-type lift truck would not effect savings in moving fruit from storage to the packing line if the work performed by the truck were paced by the packing line because machine costs are excessive.

The industrial clamp truck used in combination with belt conveyors would add considerably to the efficiency of receiving and other fruit-handling operations. The man-hours required to do the work as well as the costs would be reduced. As much as $8.01 per 1,000 boxes could be saved in moving fruit back to storage and the fruit would be handled more gently as well. However, to achieve high efficiency with industrial clamp trucks in moving fruit from the packing line to storage requires that the trucks be intermittently used for other work such as bringing loose fruit from storage to packing line. If the plant layout will not permit the performance of other work at the same time, much of the efficiency of the industrial clamp truck is lost, but there still would be an added advantage in the more gentle handling given the fruit.

12-BOX INDUSTRIAL CLAMP-TYPE TRUCK FOR MOVING APPLES FROM STORAGE TO THE PACKING LINE AND FOR LOADING REFRIGERATOR CARS

One of the newer types of materials-handling equipment tested in the search for more efficient apple-handling methods was the 12-box industrial clamp-type truck. This truck is powered by a gasoline engine. Its greatest advantage is for transporting materials over relatively long distances within the warehouse. Studies indicated that the 12-box industrial clamp truck could be used very satisfactorily in the receiving cycle of operations (fig. 21). This truck can move onto a road truck without a stabilizing unit, pick up the unit load, and move the boxes to storage places down aisles approximately

Figure 21.--Picking up boxes of apples from a road truck bed with a 12-box industrial clamp-type truck.

the same width as those used for the clamp-type 2-wheel hand truck. The 12-box truck cannot maneuver backwards as well as other industrial equipment because of its front-wheel steering arrangement, but on the whole the truck can operate satisfactorily within a cold-storage room. A major disadvantage of this equipment is the truck's inability to high-pile or tier boxes of fruit. However, when unloading into temporary storage or into rooms where the fruit cannot be tiered over 8-high, this equipment may prove satisfactory as a replacement for a hand-truck crew.

The results of tests with the 12-box industrial clamp truck for: (1) Moving apples from storage to the packing line; and (2) solid loading refrigerator cars, are presented in the sections that follow.

Moving Apples from Storage to the Packing Line

The 12-box industrial clamp truck has potentialities for effecting savings in the costs of moving unpacked boxes of apples from storage to the packing line in plants where clamp-type 2-wheel hand trucks currently are used for moving fruit relatively long distances. In plants where a transportation distance of 190 feet is required in this cycle of operations, a 3-man crew generally is used. Two of these workers hand truck 6-high stacks of boxes 170 feet from the storage points to a bank of supply about 20 feet from the dumper. The third worker hand trucks the stacks of boxes the remaining 20 feet. His work is regulated by the rate of the packing line, or 3.33 hours per 1,000 boxes. Use of this method requires 7.28 man-hours of labor per 1,000 boxes (table 33).

One 12-box industrial clamp truck and operator can be substituted for the 2 hand truckers who move fruit 170 feet, with a substantial saving of labor (fig. 22). But, there would be no saving in the labor required for moving fruit from the bank of supply to the dumper. Total labor requirements would be 4.98 man-hours of labor per 1,000 boxes compared with 7.28 man-hours by the hand-truck method (table 34).

Table 33.--Labor required for a 3-man crew to move 1,000 unpacked boxes of apples from storage to the packing line by use of clamp-type 2-wheel hand trucks 1/

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Pick up 6-high stacks by use of hand truck	2	0.32	0.0	0.32
Transport stacks 170 feet to temporary bank	2	3.31	.0	3.31
Release stacks at temporary bank	2	.32	.0	.32
Pick up 6-high stacks by use of hand truck at temporary bank	1	.32	.0	.32
Transport stacks 20 feet to dumper	1	.50	.0	.50
Release stacks at dumper	1	.26	2.25	2.51
Total man-hours	-	5.03	2.25	7.28

1/ Labor requirements do not include breaking out boxes above 6-high stacks in storage rooms.

Figure 22.--Moving stacks of boxes from storage to the packing line with a 12-box industrial clamp-type truck.

Table 34.--Labor required for a 2-man crew to move 1,000 unpacked boxes of apples from storage to the packing line by use of 12-box industrial clamp truck and clamp-type 2-wheel hand truck 1/

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Pick up 12-box unit load by 12-box industrial clamp truck	1	0.22	0.0	0.22
Transport stacks 170 feet to temporary bank	1	1.28	.0	1.28
Release stacks at temporary bank	1	.15	.0	.15
Pick up 6-high stacks by use of hand truck at temporary bank	1	.32	.0	.32
Transport stacks 20 feet to dumper	1	.50	.0	.50
Release stacks at dumper	1	.26	2.25	2.51
Total man-hours	-	2.73	2.25	4.98

1/ Labor requirements do not include breaking out boxes above 6-high stacks in storage rooms.

Labor and equipment costs are $8.55 per 1,000 boxes for the hand truck method and $7.33 per 1,000 boxes for the industrial truck method (table 35). The latter method shows a saving of $1.22 per 1,000 boxes.

Table 35.--Comparative labor and equipment costs for moving 1,000 unpacked boxes of apples from storage to the packing line by use of 2 specified methods 1/

Method	Labor and equipment required		Labor and equipment costs			
	Equipment time	Total labor	Equipment	Labor 2/	Total cost Current wages	Total cost Assumed wages
	Machine-hours	Man-hours	Dollars	Dollars	Dollars	Dollars
2 workers hand-truck stacks 170 feet from storage to build up a day's supply in bank near the dumper, then move to another job, 1 worker supplies dumper from the bank 20 feet away by use of hand truck	7.28	7.28	0.18	8.37	8.55	10.37
1 worker moves 12-box unit loads 170 feet from storage to supply in bank near dumper by 12-box industrial clamp truck, 1 worker supplies dumper from bank 20 feet away by hand truck	3/ 4.98	4.98	1.60	5.73	7.33	8.57

1/ Costs do not include breaking out boxes above 6-high stacks in storage rooms.
2/ Computed from current wage rates.
3/ 12-box industrial clamp truck 1.65 machine-hours, clamp-type 2-wheel hand truck 3.33 machine-hours, total 4.98 machine-hours.

Loading Refrigerator Cars

Because of difficulties in using industrial forklift trucks in refrigerator cars, loading them at palletized packing plants presents a number of problems. In loading, the forklift truck customarily releases the 40-box pallet load on the platform at the car door and boxes of fruit are moved by belt conveyor into the car where they are stacked for transit. Although this method is fairly efficient, the fruit is handled roughly. A set pace or rhythm attained when stacking boxes in a car from a belt conveyor is likely to cause the loaders to drop the boxes into place. When loading refrigerator cars from pallet loads released on pallet dollies inside the car, the fruit is handled more gently, but the additional work of moving the pallet load to the stacking point increases the work of the carloading crew. In the development of improved methods, it therefore was felt that the present methods of loading refrigerator cars have disadvantages which possibly might be overcome by moving the fruit to the stacking point in the car with some type of lightweight, powered, industrial truck.

This tentative conclusion was reached after observations of the method used by at least one plant which loads refrigerator cars by forklift truck, pallet, and clamp-type 2-wheel hand trucks. This plant found this method of loading satisfactory when the pallet load was placed close enough to the door of the car. However, the hand truck could not place the boxes in the car in permanent storage position for transit. Labor requirements by this method are shown in table 36. It was hoped that by substituting the 12-box clamp truck, boxes could be placed in permanent position in the car.

Table 36.--Labor required for a 4-man crew to move 1,000 packed boxes of apples out of storage and solid-load refrigerator cars by use of fork-lift trucks, pallets, clamp-type 2-wheel hand trucks, and box jack 1/

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Setup and cleanup	3	0.21	0.11	0.32
Pick up 40-box pallet load by use of fork-lift truck	1	.12	.0	.12
Transport 60 feet to temporary bank	1	.29	.0	.29
Release pallets in temporary bank	1	.05	.0	.05
Separate stacks of boxes on pallets for insertion of clamps	2	.10	.0	.10
Pick up 5-high stacks on pallets by clamp-type 2-wheel hand truck	2	.39	.0	.39
Transport 5-high stacks 65 feet into car	2	1.62	2/ .06	1.68
Release 5-high stack on car floor	2	.86	.50	1.36
Position stacks in place by use of box jack	1	1.17	.0	1.17
Fill in doorway solid with boxes	1	.60	.0	.60
Total man-hours	-	5.41	.67	6.08

1/ Labor requirements shown do not cover blocking-out and manifesting loads.
2/ Wait time due to crew interference.

Trials with the 12-box clamp truck included removing the fruit from loaded pallets, transporting the 10-box unit loads into the refrigerator car, and releasing the boxes in front of the carloader. 2/ One of the first discoveries was that the 12-box clamp truck could not pick up boxes of fruit from the pallet because of the height of the pallet above the floor (approximately 6 inches). Attempts were made to use bridge plates to overcome the difference in levels. However, with the industrial truck on a slight angle its clamping arms could not properly engage the bottom of the stacks. It finally was found necessary to place the pallet in a recess in the floor so that the top of the pallet was level with the floor. The industrial truck then could remove the first 2 stacks of boxes from the pallet and could roll onto the pallet to remove subsequent stacks of boxes.

In tests the average transportation distance from the area in which fruit was blocked out for loading to the doorway of the refrigerator car was 65 feet. A long bridge plate having a rise of about 18 inches was used because the loading dock was 18 inches lower than the floor of the car. The 12-box industrial clamp truck moved to the storage bank, picked up two 5-high stacks of packed fruit, moved into the car, and released the unit load in front of the carloader. The release in the car began as the front end of the truck rolled into the car and ended as it came out of the car. Consequently, all the maneuvering inside the car was timed as part of the release operation.

Labor requirements for stacking boxes into final position inside the car were no greater than those required by use of clamp-type 2-wheel hand trucks. Although both transporting vehicles released the stacks in front of the carloader, the hand-truck operator could release a stack more directly in front of the carloader than could the industrial-truck operator, as the hand truck was more maneuverable than the powered 12-box industrial clamp truck.

Labor requirements for the solid-loading of refrigerator cars by use of forklift truck, pallets, 12-box industrial clamp truck, and box jack were 4.84 man-hours per 1,000 boxes (table 37). This is a reduction of 1.24 man-hours in the requirements by use of the hand-truck method. But, part of this saving can be attributed to a reduction in wait time, particularly in filling in the car doorway with boxes, rather than to efficiencies brought about by the 12-box powered clamp truck. Moreover, in properly designed facilities the forklift truck would release pallet loads of packed boxes at the doorway of the car, thus materially reducing the 65-foot distance from the temporary bank to the stacking point in the car. For the shorter transportation distance the clamp-type 2-wheel hand truck would be more efficient than the industrial forklift truck.

At current wage rates, the use of the clamp-type 2-wheel hand truck would cost $0.08 less per 1,000 boxes loaded (table 38).

Conclusions and Recommendations

The 12-box industrial clamp truck could not be used economically to unload pallets and move fruit to a roller conveyor largely because the transportation distance was so short that the operations could be performed equally as well, or more efficiently, with hand trucks.

2/ The 12-box industrial clamp truck carries two 5-high stacks or 10 boxes of packed fruit. Twelve boxes of loose fruit are carried in two 6-high stacks.

Table 37.--Labor required for a 3-man crew to move 1,000 packed boxes of apples out of storage and to solid-load refrigerator cars by use of fork-lift truck, pallets, 12-box industrial clamp truck, and box jack 1/

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Setup and cleanup	3	0.21	0.11	0.32
Pick up 40-box pallet load by use of fork-lift truck	1	.12	.0	.12
Transport 60 feet to temporary bank	1	.29	.0	.29
Release pallets in temporary bank	1	.05	.0	.05
Pick up 10-box unit loads on pallets by 12-box industrial clamp truck	1	.25	.0	.25
Transport unit loads 65 feet into car	1	.84	.0	.84
Release unit loads in car	1	.64	.0	.64
Position stacks in place by use of box jack	1	1.17	.56	1.73
Fill in doorway solid with boxes	2/ 2	.60	.0	.60
Total man-hours	-	4.17	.67	4.84

1/ Labor requirements shown do not cover blocking-out and manifesting load.
2/ Clamp-truck operator assists in filling doorway. Wait time on part of workers is eliminated but clamp truck waits 0.30 machine-hour.

Table 38.--Comparative labor and equipment costs for moving 1,000 packed boxes of apples out of storage and for solid-loading refrigerator cars by 2 specified methods

Method	Workers	Labor and equipment required		Labor and equipment costs			
		Equipment time	Total labor	Equipment	Labor	Total cost	
						Current wages	Assumed wages
	Number	Machine-hours	Man-hours	Dollars	Dollars	Dollars	Dollars
Fork-lift truck, pallets, clamp-type 2-wheel hand truck, and box jack: Pick up off pallet, transport 65 feet to car, and release inside car	4	1/ 4.45	6.08	2.06	7.06	9.12	10.64
Fork-lift truck, pallets, 12-box industrial clamp-type truck, and box jack: Pick up off pallet, transport 65 feet to car, and release inside car	3	2/ 2.65	4.84	3.57	5.63	9.20	10.41

1/ 4,000-pound capacity electric fork-lift truck 0.46 machine-hour, 20.8 pallets (40- by 48-inch) 0.46 machine-hour, clamp-type 2-wheel hand truck 3.53 machine-hours; total 4.45 machine-hours.
2/ 4,000-pound capacity electric fork-lift truck 0.46 machine-hour, 20.8 pallets (40- by 48-inch) 0.46 machine-hour, 12-box industrial clamp truck 1.73 machine-hours; total 2.65 machine-hours.

The 12-box industrial clamp truck appears to be of greatest value when transportation distances are relatively long. The light weight of the truck permits its operation over floors in cold-storage plants that cannot accommodate other types of industrial equipment. Because of its light weight it also can roll on and off a truck bed without the use of a hydraulic stabilizer. One of the greatest disadvantages of this truck is its inability to high-pile. Another disadvantage is that it cannot be operated in reverse with the maneuverability of other industrial trucks.

BROAD-BLADE INDUSTRIAL FORKLIFT TRUCK FOR HANDLING UNPALLETIZED UNIT LOADS

One of the major cost items in handling unit loads on pallets is the cost of owning and maintaining the pallets. An innovation which appeared to offer promise for reducing pallet costs was the broad-blade forklift truck. On this truck the two narrow or conventional forks have been replaced by broad blades having chisel points (fig. 23). A truck equipped with forks of this type is used with dunnage strips rather than pallets. The theory behind these trials was that the broad blades could lift the boxes without a pallet, because the width of the forks would span the width of the apple boxes thereby stabilizing the 6-high stacks of boxes.

Tests were conducted with a 2,000-pound capacity, gasoline-powered industrial lift truck equipped with 2 broad, solid, semichisel-point forks. These forks were each 10 inches wide and 36½ inches long. The forks provided space for handling 6 stacks of boxes which could be either 5-boxes-high making a unit of 30 boxes, or 6-boxes high making a 36-box unit load.

Tests covered: (1) Unloading apples from road trucks and moving them to storage; and (2) moving apples from storage to the packing line. In connection with tests of receiving operations, it was necessary that orchard handling methods be developed which would permit the use of the broad-blade fork truck for unloading at the warehouse.

Figure 23.--Broad-blades, which are semi-chisel-point, of a forklift truck supporting a unit load of 36 boxes of apples.

Orchard Loading and Plant Receiving Operations

In connection with tests of the broad-blade forklift truck for unloading apples from road trucks and moving them to storage, a change in the method of using industrial forklift trucks at the warehouse necessitated a change in the method of loading road trucks in the orchard. Therefore, changes at both locations must be analyzed in measuring the efficiency of the broad-blade forklift truck.

Loading Apples on a Road Truck Equipped with Dunnage Strips by Stevedore-Type 2-Wheel Hand Truck

To unload 36-box unit loads of apples from a road truck by the broad-blade forklift truck, it was necessary that the road truck be equipped with dunnage strips which would permit the insertion of the forks under each load preparatory to the pickup operation. The tests were made with an open-bed truck, on the bed of which pieces of 2- by 4-inch lumber were nailed across the flooring on 19½-inch centers (fig. 24). These dunnage strips made it necessary for the road truck to be loaded from the side rather than over its tailgate. It was found that the clamp-type 2-wheel hand truck could not be used to load the road truck because the clamping arms were too low to clear the tops of the dunnage strips when its wheels rolled on the truck bed between these strips. This problem was solved by replacing the clamping arms with a stevedore-type plate, which permitted the wheels on the hand truck to roll on the truck bed free from interference of the dunnage strips and allowed the workers to set the stacks of boxes close enough together to eliminate the necessity for hand jacking the stacks of boxes into place (fig. 25). The clamp-type 2-wheel hand truck must have from 1 to 2 inches clearance on each side of a stack of boxes to permit the release of the clamping arms.

Figure 24.--Dunnage strips on road truck bed.

Figure 25.--2-wheel hand truck with stevedore plate, used in loading a road truck equipped with dunnage strips.

The load was secured for transit by tying it with ropes and making it tight crosswise of the truck bed (fig. 26). This method of tying is the same as that used by some growers who hand truck onto pallets. It required no extra time above that required for palletized loads.

When fruit is received at the warehouse by the regular narrow-blade forklift truck, boxes are loaded on pallets placed on the bed of the road truck. Six-high stacks of boxes are moved from the orchard platform to the road truck by clamp-type 2-wheel hand truck and released on the pallets. They are positioned on the pallet by a box jack. Use of this method requires 2.95 man-hours of labor per 1,000 boxes (table 39).

Figure 26.--Tie cable with corner plates to secure load on a road truck bed.

Table 39.--Labor required for a 2-man crew to load 1,000 unpacked boxes of apples onto 48-box pallets on road trucks by clamp-type 2-wheel hand trucks and box jack 1/

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Load pallets on truck at warehouse by fork-lift truck	2	0.06	0.06	0.12
Setup and cleanup	2	.09	.0	.09
Spread pallets on bed of road truck	2	.10	.0	.10
Hand-truck boxes 30 feet from temporary storage on orchard platforms to bed of road truck	1	1.32	.0	1.32
Hand jack stacks into position on pallets.	1	.75	.57	1.32
Total man-hours	-	2.32	.63	2.95
Elapsed time--hours				1.48

1/ Data from Washington State Apple Commission.

The use of a stevedore-type 2-wheel hand truck for loading road trucks equipped with dunnage strips requires 2.08 man-hours of labor per 1,000 boxes and saves 0.87 man-hour per 1,000 boxes loaded (table 40). Elapsed time per 1,000 boxes of apples, however, was 0.60 hour greater when the stevedore-type hand truck was used because only 1 worker was used to load the road truck. When the clamp-type 2-wheel hand truck was used in conjunction with a box jack to load pallets 21 percent of the total labor was wait time. This wait time occurred because the man jacking the stacks into position waited for the hand trucker to bring the fruit to the road truck.

Table 40.--Labor required for 1 worker to load 1,000 unpacked boxes of apples on road trucks, equipped with dunnage strips, by stevedore-type 2-wheel hand truck 1/

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Setup and cleanup	1	0.09	0.0	0.09
Hand-truck boxes 30 feet from temporary storage on orchard platform to bed of road truck	1	1.99	.0	1.99
Total man-hours	-	2.08	.0	2.08
Elapsed time--hours				2.08

1/ Data from Washington State Apple Commission.

By the stevedore-type 2-wheel hand truck method 1,000 boxes can be loaded on road trucks at a cost for labor and equipment of $2.44 (table 41). Of this amount 98 percent is labor cost. The clamp-type 2-wheel hand truck, box jack, and pallet method of loading road trucks costs $1.21 more per 1,000 boxes than did loading with the stevedore hand truck.

Table 41.--Comparative labor and equipment costs for loading 1,000 unpacked boxes of apples on road trucks from orchard platforms by 2 specified methods

Method	Workers	Elapsed time	Labor and equipment required: Equipment time	Labor and equipment required: Total labor	Labor and equipment costs: Equipment	Labor	Total cost: Current wages	Total cost: Assumed wages
	Number	Hours	Machine-hours	Man-hours	Dollars	Dollars	Dollars	Dollars
Clamp-type 2-wheel hand truck and pallets: 1 worker transports boxes 30 feet from temporary storage to road truck and releases boxes on pallets and 1 worker hand jacks stacks into position	2	1.48	1/ 1.60	2.95	0.25	3.40	3.65	4.39
Stevedore-type 2-wheel hand truck and dunnage strips: 1 worker transports boxes 30 feet from temporary storage and releases boxes on dunnage strips	1	2.08	2/ 2.08	2.08	.05	2.39	2.44	2.96

1/ 2,000-pound capacity gasoline-powered industrial fork-lift truck 0.06 machine-hour, 20.8 pallets (40- by 48-inches) 0.06 machine-hour, clamp-type 2-wheel hand truck 1.48 machine-hours, total 1.60 machine-hours.

2/ Stevedore-type 2-wheel hand truck 2.08 machine-hours.

Unloading from the Road Truck and Moving Apples into Storage by a Broad-Blade Forklift Truck

To handle 30- and 36-box unit loads by the broad-blade forklift truck, it is necessary that the 6 stacks comprising the load be tied together at the top by a special top tie frame. These tie frames, which also serve as dunnage for the second and

third tiers, are made of 3 pieces of 2- by 4-inch lumber bolted at each end of 2 pieces of angle iron so that the 2-inch pieces run across the width of boxes (fig. 27). After the top tie frames were in place, the operator of the broad-blade forklift truck removed unit loads from the road truck by the same method used for palletized unit loads (fig. 28). The first unit load in each storage stack was set on 2- by 4-inch dunnage strips placed on the storage room floor by the forklift operator who stopped his truck, dismounted, and positioned the strips. The load was released onto the dunnage strips in normal operating manner (fig. 29). Greater caution was necessary in making the release on dunnage strips as these strips provide only 1-5/8-inch clearance compared with 3-inch clearance provided by pallets. Less difficulty was experienced in releasing the second unit load on top of the first load as the top tie frames, which took the place of the dunnage strips on the floor, were tied together rather than lying loosely as were the dunnage strips. Also, the operator could see the forks and more quickly judge when they were clear.

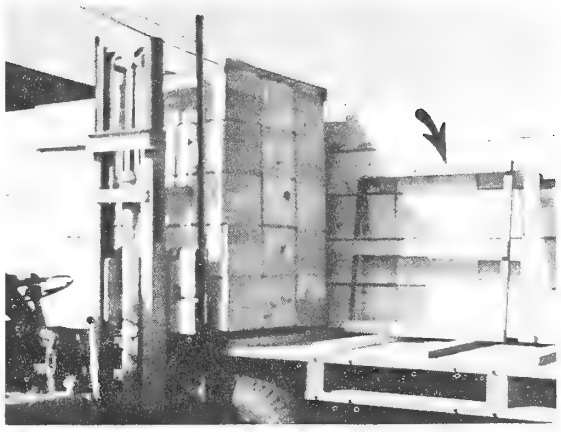

Figure 27.--Top tie frame, made of 2 by 4's and angle iron tie rods, resting on motortruck bed.

Figure 28.--Unloading a road truck with the broad-blade forklift truck.

Third tier releases required considerable experience on the part of the operator in judging when the forks were clear and could be removed (fig. 30).

Figure 29.--Release of a unit load of boxes on dunnage strips as the first tier of a stack.

Unloading from road trucks and moving 1,000 boxes into storage in 36-box unit loads by a broad-blade forklift truck required 2.24 man-hours of labor (table 42). Forty-three percent of this labor was wait time. Placing bottom dunnage strips on the floor was an extra operation, not required in the regular forklift truck and pallet receiving cycle of operations. The elapsed time required by the broad-blade forklift truck method was 1.12 hours per 1,000 boxes or 19 minutes per 288-box truckload.

The total labor required for unloading a road truck by forklift truck and regular pallets was 1.70 man-hours as compared with the broad-blade forklift truck and dunnage-strip method which required 2.24 man-hours--an increase of 0.54 man-hour (table 43).

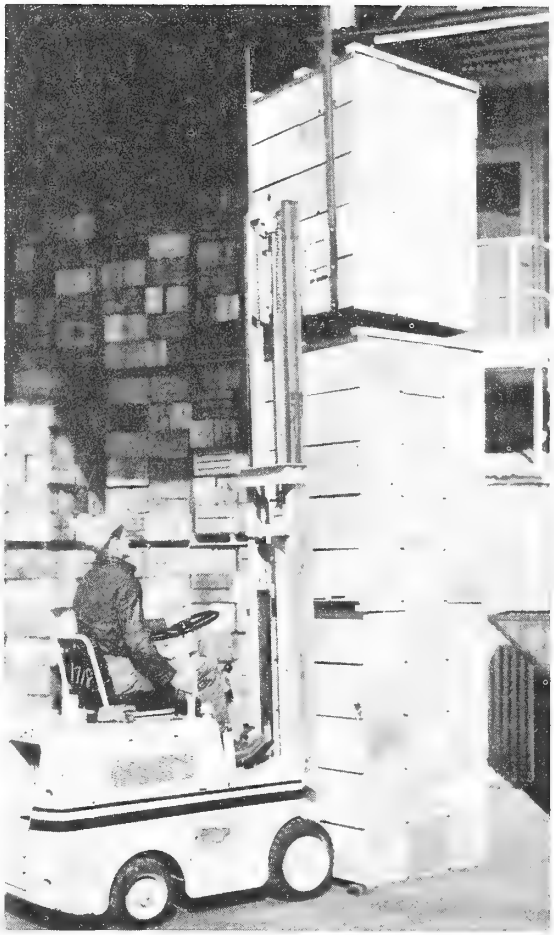

Figure 30.--Release of third tier of boxes by broad-blade forklift truck. Top tie frame on second tier allows fork to be retracted.

Comparative labor and equipment costs per 1,000 boxes incurred by the 2 methods are shown in table 44. This table shows that use of the broad-blade forklift truck fails to reduce the costs normally charged to pallets, as the cost of top tie-frames and dunnage strips slightly exceeds pallet costs in the regular pallet handling method. Moreover, both equipment and labor costs are increased above those incurred by the regular pallet handling method. Total costs are increased from $5.11 per 1,000 boxes when pallets are handled to $6.23 per 1,000 boxes when unit loads are handled without pallets.

Comparative Costs of Receiving Apples When Orchard-Handling Costs Are Added

When the costs of loading road trucks in the orchard are added to the costs incurred at the plant for unloading the fruit and moving it to storage, there is a slight reduction

Table 42.--Labor required for a 2-man crew to unload 1,000 unpacked boxes of apples from road trucks in 36-box unit loads and move them into storage by use of a gasoline-powered, broad-blade fork-lift truck when road trucks are equipped with dunnage strips

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Setup and cleanup	2	0.13	0.0	0.13
Place top tie frames on road truck	1	.06	.0	.06
Place top tie frames on each 36-box unit load	1	.10	.89	.99
Pick up 36-box unit load off road truck bed by broad-blade fork-lift truck	1	.19	.07	.26
Transport unit load 100 feet	1	.44	-	.44
Place dunnage on storage room floor for 1st (bottom) tier	1	.13	-	.13
Release unit load average of 1st, 2d, and 3d tiers	1	.23	-	.23
Total man-hours	-	1.28	.96	2.24
Elapsed time--hours				1.12

Table 43.--Labor required for a 2-man crew to unload 1,000 unpacked boxes of apples from road trucks in 36-box pallet loads and move them into storage by use of a gasoline-powered, regular-blade fork-lift truck

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Setup and cleanup	2	0.13	0.13	0.26
Pick up 36-box pallet load off road truck bed by fork-lift truck	2	.17	.17	.34
Transport pallet load 100 feet	2	.41	.41	.82
Release pallet load in cold-storage room (average 1st, 2d, and 3d tiers--18 boxes high)	2	.14	.14	.28
Total man-hours	-	.85	.85	1.70
Elapsed time--hours				.85

made by use of the stevedore-type 2-wheel hand truck in the orchard and the broad-blade fork truck at the plant. Table 45 shows total labor and equipment costs by the pallet method to be $8.76 per 1,000 boxes. By the unpalletized method these costs were reduced to $8.67.

Table 44.--Comparative labor and equipment costs for unloading 1,000 unpacked boxes of apples in 36-box unit load and moving them to storage by 2 specified methods

Method	Workers	Elapsed time	Labor and equipment required		Labor and equipment costs				
			Equipment time	Total labor	Pallet 1/	Equipment	Labor	Total cost	
								Current wages	Assumed wages
	Number	Hours	Machine-hours	Man-hours	Dollars	Dollars	Dollars	Dollars	Dollars
Fork-lift truck regular pallets	2	0.85	2/ 1.70	1.70	1.64	1.39	2.08	5.11	5.54
Broad-blade fork truck bottom dunnage, 3 top tie frames	2	1.12	3/ 2.24	2.24	1.65	1.83	2.75	6.23	6.79

1/ Pallet cost computed on basis of the following hourly costs of ownership and yearly maintenance:
(a) Regular pallets $1.93 per hour per 1,000 boxes. (Based on initial cost of $77.84 per 1,000 boxes, 15-year depreciation, interest on investment 5 percent, 2 percent allowance for insurance and taxes, and an annual use of 4.74 hours, plus 46¢ per 1,000 boxes per year for maintenance.)
(b) Top tie frames and dunnage strips $1.47 per hour per 1,000 boxes. (Based on initial cost of $60.06 per 1,000 boxes, 15-year depreciation, interest on investment 5 percent, 2 percent allowance for insurance and taxes, and an annual use of 4.87 hours, plus 46¢ per 1,000 boxes per year for maintenance.)

2/ 2,000-pound capacity gasoline-powered industrial fork-lift truck 0.85 machine-hour, 27.8 pallets (36-box) 0.85 machine-hour; total 1.70 machine-hours.

3/ 2,000-pound capacity gasoline-powered industrial truck 1.12 machine-hours, top tie frames and dunnage strips 1.12 machine-hours; total 2.24 machine-hours.

Table 45.--Comparative elapsed times, labor requirements, and labor and equipment costs for loading 1,000 unpacked boxes of apples on road trucks in the orchard and for unloading and moving them into storage at the plant by 2 specified methods at each location

Method	Workers	Elapsed time	Labor and equipment required		Labor and equipment costs				
			Equipment time	Total labor	Equipment	Pallets, tie frames, or dunnage	Labor	Total cost	
								Current wages	Assumed wages
	Number	Hours	Machine-hours	Man-hours	Dollars	Dollars	Dollars	Dollars	Dollars
Pallet method:									
Orchard: 1 worker transports boxes 30 feet from temporary storage to road truck by clamp-type 2-wheel hand truck and releases boxes on pallets and 1 worker handjacks stacks into position	2	1.48	1.60	2.95	1/ 0.25	-	3.40	3.65	4.39
Warehouse: 1 worker and fork-lift truck pick up 36-box pallet loads off road truck, transports them 100 feet, releases boxes in storage, 1 worker mostly waits	2	.85	1.70	1.70	1.39	1.64	2.08	5.11	5.54
Total	4	2.33	3.30	4.65	1.64	1.64	5.48	8.76	9.93
Unpalletized method:									
Orchard: 1 worker transports boxes 30 feet from temporary storage to road truck by stevedore-type 2-wheel hand truck and releases on road truck equipped with dunnage strips	1	2.08	2.08	2.08	1/ .05	-	2.39	2.44	2.96
Warehouse: 1 worker places top tie frames on each 36-box unit load, 1 worker with broad-blade fork picks up 36-box unit loads, transports them 100 feet, and releases boxes in storage	2	1.12	2.24	2.24	1.83	1.65	2.75	6.23	6.79
Total	3	3.20	4.32	4.32	1.88	1.65	5.14	8.67	9.75

1/ Pallet or dunnage charges included with equipment costs.

Moving Boxes of Apples from Storage to the Packing Line

Tests were conducted with the broad-blade forklift truck for moving fruit from storage to the packing line to determine the possibilities of eliminating the handling of pallets at the dumper. If this operation could be eliminated, there would be a saving in labor plus a smoother flow of fruit over the sorting and packing line as much of the interruption at the dumping station caused by removing empty pallets could be avoided.

In these tests, the broad-blade forklift truck picked up unit loads from the third and second tiers in the cold-storage rooms in a manner similar to that of the regular

forklift truck, although added time was required because of the narrow space for fork clearance between tiers. Considerable reduction in the time required for picking up second and third tiers could be expected as truck operators gained experience. After the first or lower tier was picked up, the forklift truck operator dismounted, picked up the dunnage strips from the floor and placed them in a storage stack before the unit load was moved to the dumper. The 36-box unit loads were released on roller conveyors at the dumping station. When a bank had been built on the roller conveyor, the forklift truck operator dismounted and removed the top tie frames from the 36-box unit loads. As the forklift truck operator removed the tie frames there was no interruption of the flow of fruit being dumped. In the pallet methods, after the last box from each pallet has been dumped, the dumper must remove the pallet and pull another pallet load into position.

When the broad-blade forklift truck was used for moving 36-box unit loads from storage to the dumper, 1.29 man-hours of labor per 1,000 boxes were required (table 46). Picking up the dunnage strips placed on the floor of the cold-storage room added 0.04 man-hour to the labor requirement for this cycle of operations. No wait time was involved as the unit loads were released on roller conveyors which provided a bank of supply for the dumper.

Table 46.--Labor required for 1 worker to move 1,000 unpacked boxes of apples from storage to the packing line by broad-blade fork-lift truck and gravity-type roller conveyors

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Pick up 36-box unit load in cold-storage room by broad-blade fork-lift truck (average 1st, 2d, and 3d tiers)	1	0.21	-	0.21
Transport unit load 190 feet	1	.88	-	.88
Release unit load on roller conveyors at dumper	1	.09	-	.09
Pick up and stack dunnage strips	1	.04	-	.04
Remove top tie frames	1	.07	-	.07
Total man-hours	-	1.29	-	1.29

In the usual forklift truck and pallet method, the forklift truck picks up 36-box pallet loads in the storage room from the first, second, and third tiers, transports them 190 feet to storage, and releases these loads on roller conveyors at the dumper. The dumper must remove the empty pallets. By this method, 0.90 of a man-hour of labor is required to move 1,000 boxes of apples to the dumper (table 47). The roller conveyor provides a bank of supply in this case as when the broad-blade forklift truck was used, thus eliminating wait time.

The use of a broad-blade forklift truck, top tie frames, and dunnage strips added 0.39 of a man-hour to the total labor required to move 1,000 boxes of apples to the packing line from storage by the regular forklift truck and pallet method. Increased costs per 1,000 boxes handled were: Pallets or top tie frames $0.16; equipment $0.63; and labor $0.51; or a total of $1.30 (table 48).

Table 47.--Labor required for 1 worker to move 1,000 unpacked boxes of apples from storage to the packing line by fork-lift truck, pallets, and gravity-type roller conveyors

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Pick up 36-box pallet loads in cold-storage room (average 1st, 2d, and 3d tiers). . .	1	0.12	-	0.12
Transport pallet load 190 feet	1	.64	-	.64
Release pallet load on roller conveyors at dumper.	1	.07	-	.07
Remove empty pallets	1	.07	-	.07
Total man-hours	-	.90	-	.90

Table 48.--Comparative labor and equipment costs for moving 1,000 unpacked boxes of apples from storage to the packing line in 36-box unit loads by 2 specified methods

Method	Labor and equipment required		Labor and equipment costs				
	Workers	Equipment time	Total labor	Pallet	Equipment	Labor	Total cost: Current wages	Total cost: Assumed wages
	Number	Machine-hours	Man-hours	Dollars	Dollars	Dollars	Dollars	Dollars
Fork-lift truck regular pallet	1	1/ 5.13	0.90	1.74	1.49	1.17	4.40	4.63
Broad-blade fork truck bottom dunnage, 3 top tie frames.	1	2/ 5.91	1.29	1.90	2.12	1.68	5.70	6.02

1/ 2,000-pound capacity gasoline-powered industrial fork-lift truck 0.90 machine-hour; 27.8 pallets (36-box) 0.90 machine-hour; 30 feet of gravity roller conveyor 3.33 machine-hours; total 5.13 machine-hours.
2/ 2,000-pound capacity gasoline-powered industrial fork-lift truck 1.29 machine-hours; top tie frames and dunnage strips 1.29 machine-hours; 30 feet of gravity roller conveyor 3.33 machine-hours; total 5.91 machine-hours.

Conclusions and Recommendations

Although the broad-blade forklift truck used with dunnage strips and top tie frames appeared to have possibilities for reducing pallet costs, time studies revealed that because additional time was required to handle the unit loads of fruit and stack them on dunnage strips the ownership charges of dunnage strips based on 400 hours of use were greater than for pallets used for a similar period. 3/ Additional labor and machine time required for handling when dunnage strips are used further reduces the possibility of effecting economies by use of this method. The slight reduction in combined costs for orchard loading and plant receiving does not warrant the recommendation of the broad-blade truck in preference to the regular narrow-blade truck and pallets.

3/ Both pallets and dunnage strips based on the same hours of use. Although the dunnage strips are used longer in the four major cycles of operation in the warehouse than the pallets, the dunnage strips cannot be used with empty boxes as are regular pallets.

INDUSTRIAL FORKLIFT TRUCKS AND ELEVATORS FOR MOVING PALLET LOADS BETWEEN FLOORS IN MULTISTORY BUILDINGS

The newer apple houses constructed for palletized handling and storage usually are of one-floor design. In these facilities there is no problem of moving fruit between floors. Although it would not be feasible to replace all of the existing multistory plants, many of the older facilities could be remodeled, in whole or in part, and adapted to forklift truck and pallet handling. In some instances, the plants could use forklift trucks as elevators to move pallet loads of fruit from one floor to another (fig. 31). Elevators are rather expensive and generally cost more than one forklift truck and sometimes as much as the two trucks that are necessary when this equipment is substituted for elevators. The high initial cost of elevators and their relatively low hours of annual use indicated the desirability of studying the use of the forklift trucks for elevators. The forklift truck has mobility and can be used for many handling operations other than moving fruit between floors. The elevator stands idle except during the interfloor movement of materials.

Figure 31.--Forklift truck elevating a pallet load to the upper floor of the plant.

Studies were made in one plant where a forklift truck was used to elevate or lower 40-box unit loads 8½ feet from or into a basement storage room. Data accumulated at this plant showed that the rate of elevating or lowering pallet loads between floors by the forklift truck was not significantly different from the rate of elevating when the forklift truck was used for tiering pallet loads in a one-floor operation. Thus, standard data can be applied to operations where the forklift truck is used as an elevator.

The belt conveyor is the most widely used type of equipment for moving fruit between floors in older multi-story plants. Boxes of apples arrive at these warehouses on road trucks in 6-box-high stacks or unit loads. These unit loads must be broken down as single boxes are placed on the belt conveyor for movement to the storage room. Inside the warehouse the unit loads are rebuilt for handling by 2-wheel hand trucks. If a belt-conveyor system in a plant were changed to a pallet-handling system, unit loads arriving at the warehouse on pallets might be moved into the cold-storage rooms on the second floor or in the basement by use of a forklift truck. A second forklift truck stationed on the floor of the storage room would move pallet loads into storage. It is doubtful, however, whether forklift trucks could be used on upper floors of many of the conventionally built plants without

considerable remodeling work to make the floors strong enough to carry a 36-box or 48-box forklift truck. Another consideration is the extra work that would be necessary in handling pallets on the upper floors in most plants, and the loss of space. 4/ However, there undoubtedly are some older multistory plants having floor structures on which forklift trucks could work.

For purposes of analysis, it was assumed that transportation distances, when moving boxes of apples into storage are 100 feet and, when moving fruit from storage points to the packing line, 190 feet. The distance between floors was assumed to be 8½ feet.

Unloading and Moving 40-Box Pallet Loads of Apples to Storage Rooms on Upper or Lower Floors

Industrial Forklift Trucks Alone

The plant in which tests were conducted was an old multistory building that had been remodeled for pallet-handling operations. The floors of two large first-floor rooms had been torn out and rebuilt from the ground level. Posts had been removed and a truss-roof was built on. However, there still were storage rooms in one section of the building in a basement and on the second floor. This plant uses two forklift trucks for the inter-floor movement of pallet loads instead of installing an elevator system.

When the fruit is unloaded at the first or main floor level and placed in storage in basement rooms, 1 forklift truck picks up a loaded pallet on the receiving apron, transports the fruit through the 2 large pallet rooms and deposits the pallet at the edge of a square opening in the pallet room floor. In the basement, a second forklift truck moves into a small cutout in the wall of the basement and elevates its empty forks 8½ feet to the floor of the room above. The lift truck then moves forward, inserting the forks into the pallet resting on the floor above, picks up the pallet, lowers the load into the basement, and moves the fruit to storage position (fig. 32). When the fruit is moved from the basement storage room to the packing line, the procedure is reversed.

By this method 1,000 unpacked boxes of apples can be unloaded at the first floor level and moved into storage in the basement with 1.83 man-hours of labor and in an elapsed time of 0.61 hour (table 49). Part of this labor is lost through wait time as the operator of the road truck stands by during the unloading operation.

Industrial Forklift Trucks and Elevators

Time studies of receiving operations were made in one plant that used an elevator to move pallet loads of fruit from the main floor apron on which they were unloaded to storage rooms at a lower level. When the elevator was used to move pallet loads from the

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4/ Most conventional plants probably would use the 24-box industrial clamp truck, thus avoiding the loss of storage space occupied by pallets and also avoiding the handling of empty pallets to and from the storage room floor and main floor. Pallet costs also would be eliminated.

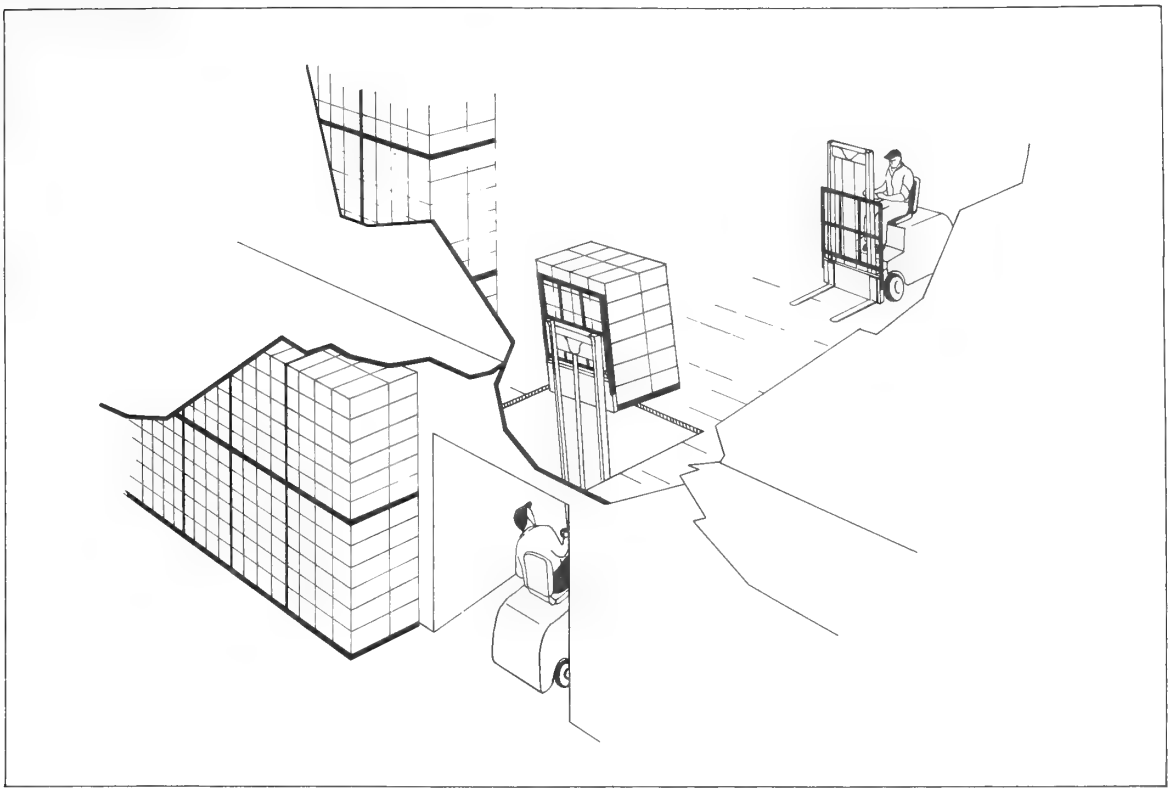

Figure 32.--Lift truck in basement picking up pallet load on upper floor.

Table 49.--Labor required for a 3-man crew to unload 1,000 unpacked boxes of apples in 40-box pallet loads from road trucks and move them into storage rooms on lower floor by 2 industrial fork-lift trucks alone

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Setup and cleanup	3	0.13	0.48	0.61
Pick up 40-box unit load off road truck bed by fork-lift truck	1	.09	.13	.22
Transport 50 feet from road truck to elevator cutout on first floor	1	.23	.0	.23
Release unit load on first floor	1	.04	.12	.16
Elevate empty forks on second lift truck to upper floor 8½ feet. Pick up unit load and lower loaded fork	1	.18	.13	.31
Transport 50 feet from the elevator hole to the storage point on basement floor	1	.23	.0	.23
Release unit load in storage area (average 1st and 2d tiers)	1	.07	.0	.07
Total man-hours	-	.97	.86	1.83
Elapsed time--hours				.61

main or ground level floor to the lower floor, one forklift truck was used to unload the road truck and transport pallets into the elevator where they were released. The elevator operator standing on the receiving apron at the edge of the elevator doorway controlled the movement of the elevator to the lower floor. A second lift truck in the storage room on the lower floor picked up the pallet loads in the elevator, transported them, and stacked the pallet loads in final storage position. As each load was removed from the elevator its operator brought the elevator back to the main floor level.

When fruit is moved into storage by 2 forklift trucks and 1 elevator, 2.00 man-hours of labor are required to move 1,000 boxes into storage in an elapsed time of 0.50 hour (table 50). Forty-six percent of this time is wait time. The wait time occurs mainly because the road-truck operator is standing by during the unloading operation and the elevator operator waits more than one-half of the time. It is possible that the use of an automatic elevator would eliminate much of the latter wait time.

Table 50.--Labor required for a 4-man crew to unload 1,000 unpacked boxes of apples in 40-box unit loads from road trucks and move them into storage rooms on lower floor by 2 industrial fork-lift trucks and 1 elevator

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Setup and cleanup	4	0.13	0.37	0.50
Pick up 40-box unit load off road truck bed by fork-lift truck	1	.09	.13	.22
Transport 50 feet on first floor from road truck into elevator	1	.23	.0	.23
Release pallet in elevator	1	.05	.0	.05
Elevator cycle 8½ feet between floors	1	.22	.28	.50
Pick up 40-box unit load off elevator by second fork-lift truck	1	.06	.14	.20
Transport 50 feet from elevator to stacking point on lower floor	1	.23	.0	.23
Release unit load in storage area (average 1st and 2d tiers)	1	.07	.0	.07
Total man-hours	-	1.08	.92	2.00
Elapsed time--hours				.50

Comparison of Methods

When a forklift truck was used as an elevator, 1,000 boxes of apples could be received at storage points at a cost of $7.11, or $1.00 per 1,000 boxes less than when forklift trucks were used in combination with an elevator (table 51). Although the use of elevators requires less elapsed time to receive 1,000 boxes, this advantage was offset by slightly larger total labor requirements, increased crew size, and greater machine costs.

Table 51.--Comparative labor and equipment costs for unloading 1,000 unpacked boxes of apples from road trucks in 40-box pallet loads and moving them to storage room on lower or basement floors by 2 specified methods

Method	Work-ers	Elapsed time	Labor and equipment required		Labor and equipment costs			
			Equipment time	Total labor	Equipment	Labor	Total cost: Current wages	Total cost: Assumed wages
	Number	Hours	Machine-hours	Man-hours	Dollars	Dollars	Dollars	Dollars
Elevator, fork-lift trucks and pallets: 1 fork-lift truck transports 50 feet to elevator, 1 fork-lift truck transports 50 feet from elevator to storage.	4	0.50	1/ 2.23	2.00	5.66	2.45	8.11	8.61
Fork-lift trucks and pallets with 1 fork-lift truck used as an elevator: 1 fork-lift truck transports 50 feet to cutout in the floor, 1 fork-lift truck picks up and transports 50 feet from the cutout to storage.	3	.61	2/ 2.06	1.83	4.82	2.29	7.11	7.56

1/ 8,000-pound capacity cable elevator 0.50 machine-hour, 4,000-pound capacity electric fork-lift truck 1.00 machine-hour, and 25 40- by 48-inch pallets 0.73 machine-hour; total 2.23 machine-hours.

2/ 4,000-pound capacity electric fork-lift truck and 48-box pallets 1.22 machine-hours and 25 40- by 48-inch pallets 0.84 machine-hour; total 2.06 machine-hours.

Moving 40-Box Pallet Loads of Apples from Storage Rooms on Upper or Lower Floors to the Packing Line on the Main Floor

Industrial Forklift Trucks Alone

Because the rate of the packing line sets the pace for the operations in moving fruit from storage to the dumper, most of the conventional-type belt conveyor plants remodeled for handling pallet loads will continue to utilize belt conveyors for these operations. However, extensive remodeling in some plants would provide for upper or lower floors between which fruit must be moved by some means other than belt conveyors. Therefore, tests were conducted to measure the efficiency of industrial forklift trucks for doing this work.

The moving of boxes of apples from storage on a lower floor to the packing line on the first floor by forklift trucks is the reverse of the receiving cycle of operations, except that the receiving cycle is not machine regulated. It is assumed that the transportation distance is 190 feet. A forklift truck in the basement is used to move the pallet load 90 feet, elevate it to the first or main floor, and release the load there. A second forklift truck on the main floor is used to pick up the load, move it 100 feet to the dumping area, and release it on sections of gravity-type roller conveyors leading to the dumper.

The use of forklift trucks to move fruit from the storage room on a lower floor to the packing line on the first floor required 1.08 man-hours of labor per 1,000 boxes (table 52). Use of roller conveyors to accumulate boxes at the dumper eliminated most of the wait time as the dumper could move up pallet loads as needed.

Table 52.--Labor required for 2 workers to move 1,000 unpacked boxes of apples in 40-box pallet loads from storage rooms in the basement to the packing line on the main floor by 2 industrial fork-lift trucks and two 15-foot roller conveyors

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Pick up 40-box unit load in basement storage room by fork-lift truck (average 1st and 2d tiers)	1	0.08	0.0	0.08
Transport unit load 90 feet on basement floor to cutout in floor	1	.28	.0	.28
Elevate unit load 8½ feet and release on upper floor level	1	.18	.0	.18
Pick up 40-box unit load off first floor level by second fork-lift truck	1	.06	.06	.12
Transport unit load 100 feet to dumper	1	.29	.0	.29
Release unit load on roller conveyor at dumper	1	.13	.0	.13
Total man-hours	-	1.02	.06	1.08
Elapsed time--hours				.54

Industrial Forklift Trucks and Elevator

When an elevator is used in combination with forklift trucks to move apples from storage on one floor to the packing line on another floor, the conditions are set up so that the forklift truck transports the apples 90 feet, releasing the unit load onto an elevator. An elevator operator standing on an upper floor moves the elevator so that a second forklift truck operator on the main floor can pick up the fruit, transport it 100 feet, and release it on roller conveyors at the packing line.

By use of forklift trucks in combination with elevators 1.44 man-hours of labor were required to move 1,000 boxes to the packing line (table 53). Twenty-three percent was wait time. Most of the wait time constituted idle time of the elevator operator.

Comparison of Methods

Forklift trucks can move 1,000 boxes of apples from storage rooms on one floor to the packing line on another floor, over a transportation distance of 190 feet, at a cost of $6.36 per 1,000 boxes, or $1.36 less than when forklift trucks were used in combination with elevators (table 54). The greater efficiency of the forklift trucks used as elevators arises not only from savings in labor but from reduced machine costs as well.

Conclusions and Recommendations

Data from these tests indicate that forklift trucks when used alone are more efficient than when they are used in combination with elevators for moving pallet loads of fruit

Table 53.--Labor required for a 3-man crew to move 1,000 unpacked boxes of apples in 40-box pallet loads from storage rooms in the basement to the packing line on the main floor by 2 industrial fork-lift trucks, 1 elevator, and two 15-foot sections of roller conveyors

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
Pick up 40-box unit load in basement storage room by fork-lift truck (average 1st and 2d tiers)	1	0.08	0.0	0.08
Transport unit load 90 feet on basement floor to elevator	1	.28	.0	.28
Release unit load in the elevator	1	.05	.07	.12
Elevator cycle (8½ feet between floors)	1	.22	.26	.48
Pick up 40-box unit load off elevator at first floor by second fork-lift truck	1	.06	.0	.06
Transport unit load 100 feet on first floor to dumper	1	.29	.0	.29
Release unit load on roller conveyor	1	.13	.0	.13
Total man-hours	-	1.11	.33	1.44
Elapsed time--hours				.48

Table 54.--Comparative labor and equipment costs for moving 1,000 unpacked boxes of apples in 40-box pallet loads from storage rooms on 1 floor to the packing line on another floor by 2 specified methods

Methods	Labor and equipment required		Labor and equipment costs			
	Workers	Equipment time / Total labor	Equipment	Labor	Total cost Current wages	Total cost Assumed wages
	Number	Machine-hours / Man-hours	Dollars	Dollars	Dollars	Dollars
Elevator, fork-lift truck, and pallets: 1 fork-lift truck transports unit load 90 feet to elevator, another fork-lift truck transports 100 feet from elevator to dumper	3	1/ 5.66 / 1.44	5.92	1.80	7.72	8.08
Fork-lift trucks and pallets with 1 lift truck used as an elevator: 1 fork-lift truck transports 90 feet to cutout in floor and elevates load to upper floor, another fork-lift truck transports 100 feet to dumper	2	2/ 5.43 / 1.08	4.96	1.40	6.36	6.63

1/ 8,000-pound capacity cable elevator 0.48 machine-hour, 4,000-pound capacity electric fork-lift truck 0.96 machine-hour; 25 40- by 48-inch pallets 0.89 machine-hour; and 30-feet gravity roller conveyor 3.33 machine-hours; total 5.66 machine-hours.

2/ 4,000-pound capacity electric fork-lift truck 1.08 machine-hours; 25 40- by 48-inch pallets 1.02 machine-hours; and 30 feet gravity roller conveyor 3.33 machine-hours; total 5.43 machine-hours.

between floors in multistory plants. This efficiency might be even greater if sections of roller conveyors could be used to accumulate banks of supply near the opening in the floor through which loads are moved. The use of the forklift trucks also reduces the number of men added in the crew and permits the investment in equipment to be kept at a minimum.

The use of elevators in most remodeled belt-conveyor plants would increase labor and equipment costs. In some plants, however, it would be necessary to install either an elevator or some kind of hoist to move lift trucks from one floor to another. Thus, the investment in an elevator may be unavoidable in many cases.

In multistory, belt-conveyor plants that are to be remodeled to use industrial lift trucks, it appears to be more desirable to use lightweight industrial clamp trucks rather than forklift trucks and pallets. In many of the older plants, the floors in the rooms above ground level would have to be reinforced to stand up under the weight of a forklift truck. The lightweight industrial clamp truck probably could operate in most plants after the floors were reinforced. The use of pallets also results in the loss of considerable storage space in low-ceilinged rooms. Moreover, interference from posts and ducts in these storerooms is likely to increase labor and machine costs for handling pallets.

LOADING 36-BOX PALLET LOADS OF APPLES IN REFRIGERATOR CARS AT PACKINGHOUSE AND UNLOADING CARS AT DESTINATION

As the number of Washington State apple houses using pallet handling methods has increased, interest has developed in the possibilities of increasing the efficiency of pallet handling methods by loading fruit in refrigerator cars on disposable pallets. The use of disposable or expendable pallets would permit the car to be loaded one pallet load at a time. Theoretically, loading refrigerator cars with pallet loads would permit unit loads to be maintained all the way from the segregation area in the packinghouse to the order assembly operation in the wholesaler's warehouse. Moreover, studies have revealed that carloading causes more damage to fruit than any other handling operation. Palletized loading of the fruit should assure more gentle handling and less bruising of the apples.

Most refrigerator cars are loaded 7 apple boxes across the width of the car. To load the width of the car solidly with boxes of apples on pallets would require the use of 2 sizes of pallets--a 3-box width and a 4-box width pallet. As it is impractical for an apple house to handle and store pallet loads of 2 sizes, the 36-box pallet (3 boxes wide) appeared to be the most logical size for loading cars. Its use would permit the loading of 2 pallets and a single unpalletized row across the car.

A few of the newer refrigerator cars with side-wall flues and steel bottoms are loaded 8 boxes wide. Although these cars might be suitable for the use of the 4-box width pallets, the dimensions are so close that, with slight shifting in transit, the pallet loads might become wedged so that they could not easily be removed at their destination.

Because fiber pallets cost about $1.50, a less expensive wooden pallet costing about $1 was tested. This was made from 1" x 4" slats. Four boards 39" long are crossed at right angles by 3 boards 36" long. A 2" x 4" block is nailed under each intersection, and a lath tie strip is nailed to the bottom of each row of blocks (figs. 33 and 34).

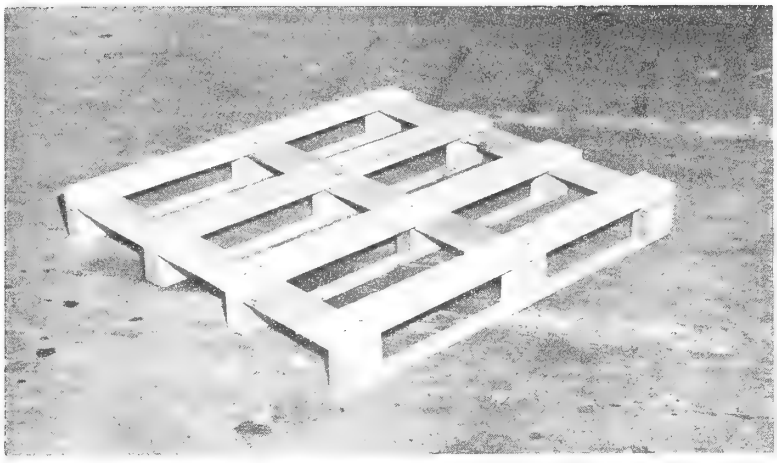

Figure 33.--Pallet used in palletized shipment of apples.

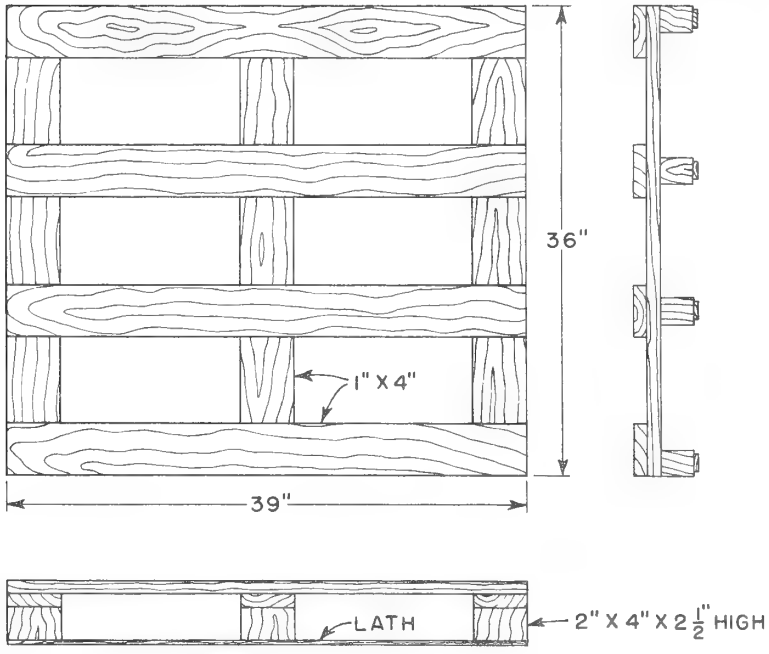

Figure 34.--Diagram of pallet shown in figure 33.

A problem in the test shipment was the necessity for building special pallet loads based on the manifest for the car. Boxes of packed fruit were blocked out by the regular industrial forklift truck method and these boxes were transferred in the blocked-out area from the regular 40-box storage pallets to the 36-box expendable pallets. Thus, the unit loads built in the segregation area as the packed fruit came off the line were not maintained any longer than they normally would have been maintained if the boxes had been loaded in the usual pattern.

After the boxes of fruit were positioned on expendable pallets, it was determined that there were two basic loading procedures that might be used. One was to strap each pallet load so that it would be maintained as a unit in shipment. The other was to leave the pallet loads unstrapped and strip the car. Cost estimates indicated that stripping the car would be the more economical method but that strapping the pallet loads would be the more convenient and would facilitate unloading at the car's destination, as there would be less likelihood of boxes in pallet loads shifting in transit. Accordingly, pallet loads were strapped as shown in figure 35.

To load the refrigerator car by an industrial forklift truck it was necessary to place bridge plates on the floor racks to keep the truck from breaking through the racks. The carloading pattern was to place pallet loads alongside both sides of the car, leaving the usual amount of space on each side for air circulation, and to place a row of single boxes down the center lengthwise of the car (fig. 36). In the center crosswise of the car, 2 tiers of boxes were stacked on each side just inside the door and 2 pallets were placed in the doorway (fig. 37). The single-row stacks were 5 boxes high. The row could have been 6 boxes high if necessary for a larger load.

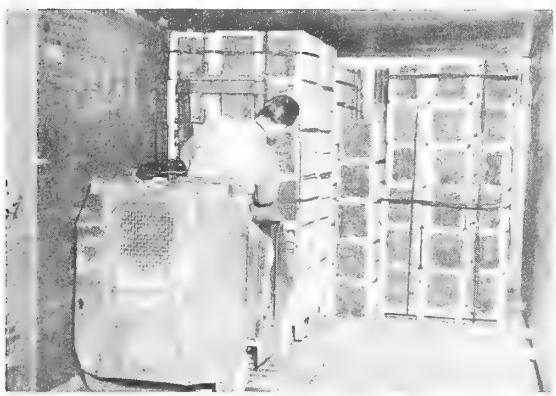

Figure 36.--Placing a unit load in a refrigerator car.

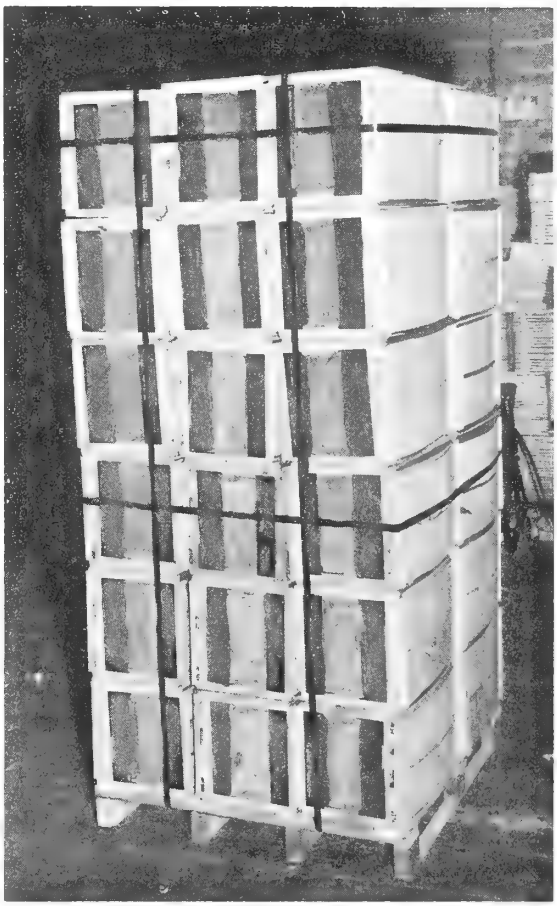

Figure 35.--Packed boxes of apples in position on the pallet unit load have been strapped for shipment in refrigerator car.

The car was loaded by a forklift truck which first placed 1 pallet load in a corner of the car. While the forklift truck and operator were returning to the blocked-out area for the next load, a hand trucker placed 2 stacks of fruit in the middle of the car against this pallet load. The lift-truck operator placed his next load in the opposite corner but in the same end of the car up against the center stacks. This pattern of loading was continued until all fruit had been loaded up to the doorway. To load the doorway the hand-truck operator placed the 2 tiers of loose boxes in position while

Figure 37.--Loading the doorway of a refrigerator car when boxes are partially palletized.

the lift-truck operator stood by. Then the last 2 pallet loads were placed in the doorway.

To unload the car, the consignee had the greatest difficulty removing the 2 pallet loads stacked on each side of the doorway. Trouble also was experienced by the consignee with the industrial lift truck's breaking through the floor racks until plates were placed on the floor. It also was reported that 1 of the pallets in the doorway had moved about 2 inches in transit, breaking the sideboards of the car. Two boxes of apples in the doorway were broken and the boxes of apples not on pallets had shifted about 6 inches but all of the pallet loads were intact.

Total labor required for loading and unloading the car of 798 packed boxes of apples was 6.80 man-hours (table 55). 5/ Of this total, 5.46 man-hours were required for loading

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5/ Data on labor requirements for unloading are from standard data on operations involved and do not necessarily reflect requirements in the consignee's warehouse.

Table 55.--Labor required for a 3-man crew to move 798 packed boxes of apples (1 carload) out of storage and load a refrigerator car with 18 36-box pallet loads and 150 unpalletized boxes, and for a 2-man crew to unload the car and place the fruit in storage by expendable pallets, fork-lift truck, and clamp-type 2-wheel hand truck 1/

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
At packinghouse:				
Setup and cleanup (798 boxes)	3	0.20	0.10	0.30
Pick up 18 36-box pallet loads (648 boxes) by fork-lift truck	1	.08	.0	.08
Transport 18 36-box pallet loads 60 feet to temporary storage for strapping operation	1	.21	.0	.21
Release 18 36-box pallet loads at temporary storage	1	.05	.0	.05
Strap 18 36-box loads onto expendable pallets	2	3.29	.0	3.29
Pick up 18 36-box pallet loads by fork-lift truck	1	.04	.0	.04
Transport 50 feet into refrigerator car	1	.19	.0	.19
Release 18 36-box pallet loads in refrigerator car	1	.05	.23	.28
Pick up 5-high stacks (150 boxes) by use of clamp-type 2-wheel hand truck	1	.06	.0	.06
Transport 110 feet into refrigerator car	1	.39	.0	.39
Release 5-high stacks in refrigerator car	1	.06	.0	.06
Stack boxes 150 in refrigerator car	1	.26	.25	.51
Total man-hours per 798 boxes (1 carload)	-	4.88	.58	5.46
At terminal market:				
Open car door, place and remove bridge plate, and close door	2	.34	.0	.34
Pick up 18 36-box pallet loads (648 boxes) by fork-lift truck	1	2/ .14	.04	.18
Transport 100 feet to storage point by fork-lift truck	1	.27	.0	.27
Release 18 36-box pallet loads at storage point by fork-lift truck	1	3/ .05	.0	.05
Pick up 5-high stacks (150 boxes) in refrigerator car by clamp-type 2-wheel hand truck	1	.08	.0	.08
Transport 100 feet to storage point	1	.36	.0	.36
Release 5-high stacks at storage point	1	.06	.0	.06
Total man-hours per 798 boxes (1 carload)	-	1.30	.04	1.34
Total man-hours per 798 boxes (1 carload) at both locations		6.18	.62	6.80

1/ Labor requirements shown do not cover blocking-out and manifesting loads.
2/ Double rate used to allow for maneuvering inside refrigerator car.
3/ Average 1st and 2d tiers.

and 1.34 man-hours for unloading. The commonly used methods of loading and unloading, respectively, in packinghouses and terminal warehouses that handle apples in pallet loads require 9.33 man-hours of labor per 798-box carload (table 56).

The total costs of loading and unloading the carload of apples on disposable pallets were $41.94 (table 57). Of this amount, $30.78 covered the cost of 18 expendable pallets and the strapping for 18 pallet loads. In the usual loading operations in pallet plants, lumber for stripping and bracing the load amounts to about $5.00. Total costs for loading and unloading are $20.24 per 798-box carload. Thus, handling shipments on pallets increased handling costs $21.70 per carload or roughly 107 percent.

If it were possible to place the fruit on the disposable pallets as it is segregated, there would be additional advantages to the shipper in using disposable pallets as the

Table 56.--Labor required for a 3-man crew to move 798 packed boxes of apples (1 carload) out of storage and load a refrigerator car in a divided, braced and stripped load; and for a 3-man crew to unload the car and place the fruit in storage by pallets, fork-lift trucks, and pallet dollies when pallet loads are broken down for loading and rebuilt for handling and storage at the terminal 1/

Operation	Workers	Productive time	Wait time	Total labor
	Number	Man-hours	Man-hours	Man-hours
At packinghouse: 2/				
Setup and cleanup	3	0.27	0.12	0.39
Pick up 40-box load by fork-lift truck	1	.12	.0	.12
Transport 110 feet to refrigerator car doorway	1	.40	.0	.40
Release unit load on dolly in car	1	.15	.99	1.14
Push loaded dolly to stacking point and remove empty pallets from car	2	.40	.0	.40
Stack boxes in refrigerator car	2	1.88	.06	1.94
Strip every 2d tier of boxes in refrigerator car	2	.99	.0	.99
Brace doorway	1	.91	.0	.91
Total man-hours per 1,000 boxes	-	5.12	1.17	6.29
At terminal market: 2/				
Open car door, remove bracing, placing and removing bridge plate, and close door	3	.85	.42	1.27
Stack boxes from refrigerator car onto pallets	2	1.43	.0	1.43
Remove stripping from every other tier of boxes	2	.99	.0	.99
Place pallets on pallet dolly and push 40-box pallet load and dolly to doorway of car	2	.33	.0	.33
Pick up 40-box pallet load at doorway by fork-lift truck	1	.08	.80	.88
Transport 100 feet to storage point by fork-lift truck	1	.38	.0	.38
Release 40-box pallet load at storage point by fork-lift truck	1	.12	.0	.12
Total man-hours per 1,000 boxes	-	4.18	1.22	5.40
Total man-hours per 1,000 boxes at both locations		9.30	2.39	11.69
Total man-hours per 798 boxes (1 carload) at both locations		-	-	9.33

1/ Labor requirements shown do not cover blocking-out and manifesting loads.
2/ All standard data shown for specified operations are on a 1,000-box basis.

expense of loading the pallets in the carloading operation could be avoided and some costs in the warehousing operation could be reduced. If grower lots of fruit were large, permanent segregation by sizes and grades on pallets would be practical. For smaller lots, however, there would be insufficient fruit of one size or grade to make very many pallet loads, necessitating placing tag ends of some sizes and grades on mixed pallets. It is doubtful whether this loading would in many cases correspond with selling manifests.

Conclusions and Recommendations

Because of the additional cost, the difficulty of segregating fruit onto disposable pallets at the end of the packing line, and the problems of selling in preblocked pallet loads, it does not appear practicable to load cars at shipping points with disposable pallets. However, if future research at the terminal market indicates sufficient advantage for the receiver so that he would be willing to defray some of the expense at shipping points, reconsideration of this method of loading cars would be in order.

Table 57.—Comparative labor, equipment, and other costs for moving 798 packed boxes of apples out of storage and loading refrigerator cars at the packingplant and for unloading and placing them in storage in a warehouse at a terminal market by use of 2 specified methods which employ fork-lift trucks, pallets, expendable pallets, pallet dollies, and clamp-type 2-wheel hand trucks 1/

Method	Labor and equipment required		Labor, equipment, and other costs			
	Equipment time	Total labor	Equipment	Labor	Other	Total
	Machine-hours	Man-hours	Dollars	Dollars	Dollars	Dollars
Fork-lift truck, pallets, and pallet dolly. Pallet loads broken down and boxes loaded individually. Pallet loads rebuilt at terminal. Load is divided, braced, and stripped	2/ 5.21	9.33	4.08	11.16	4/ 5.00	20.24
Fork-lift truck, expendable pallets, clamp-type 2-wheel hand truck. Eighteen 36-box pallet loads loaded into car as units. 150 boxes handled individually	3/ 2.36	6.80	3.10	8.06	5/30.78	41.94

1/ Labor and equipment costs do not cover blocking-out and manifesting.

2/ 4,000-pound capacity electric fork-lift truck 1.00 machine-hour, 16.6 pallets (40- by 48-inch) 1.00 machine-hour, pallet dolly 3.21 machine-hours; total 5.21 machine-hours.

3/ 4,000-pound capacity electric fork-lift truck 1.35 machine-hours, clamp-type 2-wheel hand truck 1.01 machine-hours; total 2.36 machine-hours. Expendable pallets included under other costs.

4/ Lumber for stripping and bracing car.

5/ Includes 18 expendable pallets at $1.05 each plus an estimated cost of $0.66 per pallet for strapping.

APPENDIX

Computation of Labor and Equipment Requirements and Their Costs

In the following tabulations of standard data, base time comprises the leveled time for performing given work. Base time data were obtained through time studies of actual operations. The base time adjusted for fatigue allowance becomes the productive time. A tabulation showing fatigue allowance is included.

No allowance was made in these data for the personal needs of workers, as most Washington State apple houses allow two 15-minute rest periods during each 8-hour day. However, to make these data comparable to productive time data in which a personal allowance is made, an adjustment of 6.7 percent (0.5 hour divided by 7.5 hours) should be made in the base time shown.

When productive times for all operations comprising a cycle or group of operations are totaled and combined with appropriate unproductive times, total labor requirements are obtained. Wait time, or unproductive time, comprises the following classes of unavoidable delays: (1) Crew interference; (2) machine regulated wait time; (3) lack of balance within crews; (4) job regulated wait time; (5) waiting for other crews; and (6) changing jobs. As this report is limited to analyses of methods on a 1,000-box basis for specific operations, only the first three classes of wait time are applicable.

Crew intereference results when several workers engaged in a common operation interfere or get in the way of each other. Machine regulated wait time results from equipment or machines that are being operated at full capacity and that require constant attendance but do not provide sufficient productive work to keep the attendant fully occupied. Such wait time occurs in short cycles interspersed with productive time. Lack of crew balance wait time results from differences in productive time for the various participants in an identified operation.

In this report, labor and equipment costs for performing identified cycles or groups of fruit-handling operations by use of specified methods and types of equipment have been computed. These costs provide a basis for comparing the relative efficiency of different methods and types of equipment under variable conditions. They were computed because valid comparisons cannot be made solely on the basis of physical labor and equipment inputs. That is, man-hours of labor and machine-hours of equipment use cannot be totaled as a basis for making comparisons. Nor can valid comparisons be made solely on the basis of labor requirements, unless equipment costs are constant.

Labor costs shown in these computations are based on the productive time required to perform the operation, plus the wait time inherent in

the method. The amount of time lost by workers in changing jobs, waiting for trucks to arrive for unloading, and other idle time not inherent in the method, is not included in these costs. As unproductive time may, in some instances, account for as much as 50 percent of the total labor employed in a plant, the inclusion of unproductive time, not inherent in the method, would destroy the cost relationships.

Moreover, because of the variability of management and facility costs between plants of the same capacity and output, these costs have not been included in the costs shown for performing fruit-handling operations by use of different methods and types of equipment. Therefore, the cost data shown do not reflect total costs to the plant and should not be used by plant managers for budgetary purposes. However, in plants that allocate labor and equipment costs to various operations, these costs might serve as desirable goals to be attained in achieving cost reductions.

Hourly Rates Used for Computing Equipment Costs

The costs incurred when materials-handling equipment is used in fruit handling can be grouped into two major categories: (1) Ownership costs, which are considered to be fixed or relatively stable from year to year over a wide range of equipment use; and (2) operational costs, which are variable and fluctuate in direct relationship with the hours of use of the equipment.

Equipment ownership costs include depreciation, taxes, interest, and insurance. When equipment is purchased, the owners are entitled to recover the purchase price of the equipment and accessories by the time it reaches the end of its economic life. This useful life, in years, varies for different types of materials-handling equipment and the use to which it is put. For purposes of straight line depreciation, the method used in this study to obtain the annual rate of depreciation was to divide the total cost of equipment by the number of years of its estimated life. State and municipal taxes, interest on the capital invested, and insurance premiums covering fire, disaster, and other forms of protection applicable to the materials-handling equipment, are the other items that round out the ownership costs, and are paid on an annual basis regardless of hours of use.

Costs of operation computed in this study for internal-combustion and electrical equipment include fuel, oil, electricity, maintenance, repairs, overhauling, inspection, servicing, and depreciation. Even when equipment is not used for extended periods, some wasting of the equipment is incurred in the form of deterioration of such parts as tires, hose connections, and batteries, and this factor is recognized in the depreciation rate.

Total hourly costs of ownership and operation of specified types of materials-handling equipment are shown in table 58. These hourly cost rates are based on assumed hours of annual use and other factors. Plants in which the actual annual hours of use of a specified type of equipment exceed the assumed hours of use probably would incur lower average hourly

Table 58.—Estimated costs of ownership and operation of specified types of materials-handling equipment in apple packing and storage plants, Washington State, 1952 1/

Type of equipment	Amount of equipment	Replacement cost 2/	Assumed annual use	Cost of ownership 3/		Cost of operation	Total cost per hour
				Per year	Per hour	Per hour	
	Unit	Dollars	Hours	Dollars	Dollars	Dollars	Dollars
Clamp-type 2-wheel hand trucks	one	74.10	400	7.03	0.017	0.007	0.024
Belt conveyor	100 feet	1,593.37	200	147.99	.74	.09	.83
Roller conveyor	100 feet	492.25	200	55.00	.275	.005	.28
Portable mechanical lift 4/	one	680.00	300	130.60	.43	.16	.59
Industrial clamp truck (800-pound capacity--gasoline powered--12-box load)	one	1,152.00	250	167.04	.67	.25	.92
Elevator for movement between floors 5/	one	13,375.00	400	1,270.62	3.17	.04	3.21
Hydraulic device to stabilize road truck 6/	one	1,150.00	150	128.42	.86	.06	.92
Nonhydraulic device to stabilize road truck bed 7/	one	50.00	150	5.58	.04	-	.04
Industrial clamp-lift truck (1,000-pound capacity--gasoline powered--24-box load)	one	3,032.00	400	439.64	1.10	.53	1.63
Industrial clamp-lift truck (1,000-pound capacity--electric--24-box load) and battery charger	one each	4,493.00	400	490.33	1.23	8/ .19	1.42
Industrial clamp-lift truck (2,000-pound capacity--gasoline powered--36 box load)	one	3,560.00	400	516.20	1.29	.53	1.82
Industrial clamp-lift truck (2,000-pound capacity--electric--36-box load) and battery charger	one each	6,064.00	400	667.08	1.67	.19	1.86
Industrial fork-lift truck (2,000-pound capacity--gasoline powered--36-box load) 9/	one	3,033.00	400	439.78	1.10	.53	1.63
Industrial fork-lift truck (2,000-pound capacity--electric--36-box load) and battery charger	one each	5,537.00	400	617.01	1.54	.19	1.73
Industrial fork-lift truck (4,000-pound capacity--gasoline powered--48-box load)	one	4,042.00	400	586.09	1.46	.64	2.10
Industrial fork-lift truck (4,000-pound capacity--electric--48-box load) and battery charger	one each	7,271.00	400	807.16	2.02	.26	2.28
Industrial trailer (36- by 72-inch)	one	114.00	267	16.53	.06	.01	.07
Industrial tractor (2,500-pound draw bar pull--gasoline powered)	one	3,000.00	400	435.00	1.09	.25	1.34
Dunnage strips used between industrial clamp truck unit loads to stabilize stacks in storage (24-box loads--2-loads high), 1- by 4- by 2-inch strips for 1,000 boxes at $50 per 1,000 board feet	41.6 board feet	2.08	10/ 4.69	.51	.11	-	.11
Pallets--36-box (36- by 40-inch):							
Pallets for 1,000 boxes at $2.80 per pallet	27.8	77.84	10/ 4.74	8.70	1.83	11/ .10	1.93
Pallets--48-box (40- by 48-inch):							
Pallets for 1,000 boxes at $3.00 per pallet	20.8	62.70	10/ 3.64	7.02	1.92	11/ .10	2.02
Pallet dolly for loading out	one	42.85	200	10.50	.055	.005	.06

1/ See Appendix of USDA Marketing Research Report No. 49, "Apple Handling Methods and Equipment in Pacific Northwest Packing and Storage Houses," for data used in preparing cost summaries.

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

3/ Includes interest on investment at 5 percent, allowance for taxes and insurance at 2 percent, and depreciation.

4/ Used for high piling and breaking out high-piled boxes of apples.

5/ Capacity 8,000 pounds, 40-foot lift, platform 8 by 10 feet.

6/ Hydraulic device that holds truck bed against projection of platform, eliminates spring action of truck, and permits industrial equipment to operate on the truck bed.

7/ Device consists of metal frame wedge projecting from the loading dock. As truck is backed up, the metal frame prys the end of truck bed to an even height with dock platform which allows industrial truck to operate on bed of road truck. (Device usually operates properly only with the road trucks for which it is made.)

8/ Cost data not available; interpolations made from cost data on 2,000-pound capacity electric-lift trucks.

9/ Recently there has been a trend toward the use of the 4,000-pound capacity fork-lift truck in 36-box pallet plants which tier 3-pallets high, because extra lift height is needed above that provided by a standard 2,000-pound model. The additional cost of about $100 for the 4,000-pound as compared with the cost of the 3,000-pound model makes the shift to 4,000-pound trucks worthwhile to most operators.

10/ Estimated annual hours of use determined by computing the time pallets or dunnage strips are involved in handling operations, based on the man-hours of labor required per 1,000 boxes in all groups or cycles of handling operations. (Storage time not included.) Allocations to groups of operations follow:

	Receiving at storage	Storage to packing line	Packing line to storage	Storage to shipping out point	Miscellaneous (culls, empty boxes, etc.)	Total per 1,000 boxes for all operations
	Man-hours	Man-hours	Man-hours	Man-hours	Man-hours	Man-hours
Dunnage strips	1.04	1.13	1.48	1.04	-	4.69
36-box pallet	.72	.78	.85	.81	1.58	4.74
48-box pallet	.55	.62	.63	.63	1.21	3.64

11/ Includes maintenance cost only at 25 cents per pallet over a life of 15 years.

costs than those shown in table 58. Conversely, plants in which annual usage of a machine falls below the assumed hours of use probably would incur higher average hourly costs.

Equipment inputs for all methods discussed are shown in terms of "machine-hours" for each type of equipment employed. Equipment costs can therefore be recomputed by any plant operator at any future time by substituting his own equipment costs for those used in this report.

Description of Standard Data on Labor Requirements

The man-hours of labor required to perform specific handling operations were determined to facilitate the comparison of alternative handling methods. Labor requirements can be developed for almost any level of worker activity whether it be for the mere grasping of a box or for the entire process of storing apples. The criterion used in delineating the level of activity for which labor requirement data were developed was entirely one of utility for the purpose at hand. In this study it was

desired to compare existing handling methods under comparable conditions of plant size and layout, to develop improved methods of materials handling, and to evaluate the improved methods in terms of current practice. Therefore, labor requirement data were developed for specific operations which could be conveniently pieced together in alternative operational patterns.

In general, the labor requirement values reported apply to a given piece of work done by an individual worker or crew of workers in a series of coordinated and uninterrupted movements. Exceptions to this general rule occurs when the time for performing part of a coordinated operation varies with some factor, such as plant layout or distance, and the balance of time required is independent. For example, the function of moving a product is divided into three parts: Pickup, transport, and release. Pickup and release occur under different degrees of congestion which influence the labor required, and the distance moved has a direct effect on the transport time. Thus, breaking the function of move into three parts facilitates the use of the data in a wide variety of circumstances.

Labor requirement data have been determined for specific operations which fall into the following general classifications: (1) Setup; (2) cleanup; (3) place on or remove from conveyors; (4) pickup or release load; (5) transport load; (6) high-pile or break out boxes; and (7) load trucks or railroad cars.

Setup

Preparatory to unloading a road truck or orchard trailer and to loading railroad cars, there are a number of miscellaneous operations which grouped together are called setup. These operations are grouped because no particular purpose would be served in determining labor requirements for all the individual operations which occur only once or a few times in the process of loading or unloading a highway truck or refrigerator car. The labor requirements for setup vary with the type of equipment employed, as well as with the type and capacity of truck or car involved.

In unloading, setup begins when the workers walk to the load and start preparing it for unloading by removing tie ropes or tailgates, and setup ends when the first boxes are grasped for unloading. It includes such operations as handling and placing bridge plates, moving handling equipment into position, and carrying out all other operations essential to preparing for unloading by the described equipment or method. In loading, setup begins with opening the car doors or with moving equipment into place whichever occurs first and includes the placing of bridge plates or conveyors and carrying out other operations essential to the method It ends when the first boxes are grasped for loading.

Cleanup

After a road truck or orchard trailer has been unloaded or a railroad car loaded, a number of miscellaneous operations, which are repetitive only for each truck or carload, remain to be done. These are all grouped together in one labor requirement value called cleanup. In unloading, the cleanup operation begins when the last stack of boxes has been cleared from the truck or trailer bed and ends when the truck is ready to be moved from the unloading platform or when the handling equipment has been stored away. Other operations common to cleanup are removing and storing bridge plates or conveyors; replacing V-boards, endgates, and ropes on the truck bed; and walking to the truck cab. The particular operations included depend on the type of conveyance and materials-handling equipment employed in unloading. After loading railroad cars the cleanup operation starts with removal of the bridge plate and ends with the storage of handling equipment or with the closing of the car doors.

Place on or Remove from Conveyors

Conveyors are used extensively in apple storage houses and packinghouses. The labor requirements for the various operations involving the use of conveyors consist of the time it takes to pick up the boxes in the position found, place them on the conveyor, and release them. When loading or unloading is done on conveyors the operation begins when the first box is grasped and ends when the last box is placed on the conveyor. In some instances the speed of the conveyor regulates the labor requirements but in most cases conveyor capacity is great enough so that speed is not the controlling factor.

Pickup or Release

Pickup and release are done in conjunction with transport to move fruit and other materials into, within, and out of apple houses. Separate man-labor requirements were determined for them because the time required to pickup or release is not related to the time required to transport a given distance, but rather depends on the congestion of the area and the equipment used. Pickup begins with the start of maneuvering to pick up a load or when the forks, clamps, or arms of the equipment pass the front of the load. Pickup consists of positioning the forks, clamps, or arms of the materials-handling equipment; setting the clamps; picking up, or, in the case of industrial trucks, lifting the load; and moving a short distance in the direction of the travel. At this point the operation called transport begins. Release begins when transport ends and consists of maneuvering the load into position, releasing the clamps, or, in the case of industrial trucks, lowering the load. This operation ends when the forks, clamps, or arms of the materials-handling equipment have moved free of the load.

Transport

The operation transport begins as soon as the worker with a hand truck or an industrial truck is in position to move or when the load has cleared its original position, and the operation ends when the worker with the hand or industrial truck reaches the release point and starts to maneuver for the purpose of releasing the load. Transport includes completing the necessary turn of the equipment in the direction of travel toward the release point and traveling from pickup point to release point including any and all turns en route. The labor required for returning empty with transportation equipment is combined with that required to move the load so that the labor requirements for transport apply to a round-trip cycle. This combination was made in the interest of simplification. All reported distances are given in terms of feet between pickup and release points. The same practice was followed in reporting labor requirements for elevator transport operations. That is, the time reported is for round trips while the distance reported is in terms of feet elevated.

High-Pile or Break-Out Boxes

Unpacked boxes of apples are transported in 6-box-high units and packed boxes in 5-box-high units. In the storage room the boxes commonly are high-piled in stacks 9 to 12 boxes high in conventional storages and 10, 12, or 18 high in storages using industrial clamp or forklift trucks. Both high-piling and breaking-out boxes from high piles are done manually or by mechanical equipment. The labor required for high-piling is expressed in terms of 1,000 boxes placed in storage rather than in terms of 1,000 boxes high-piled. Thus, the labor required per 1,000 boxes when stacked 12 high applies only to the time required to handle the 500 boxes which are high-piled. The same method of reporting labor requirements is used for breaking boxes out of high piles.

The time required to high-pile or to break-out boxes begins when equipment is moved into position for this operation or in the case of manual high-piling when the first box is handled, and the time ends when equipment is removed from the scene of activity or when the last box is handled. All avoidable delays in the work caused by any interference, such as waiting for other crews, are eliminated from the labor required to perform high-piling or breaking-out boxes from high piles.

Load Trucks or Railroad Cars

Some of the miscellaneous operations performed in loading-out apples do not directly involve the handling of boxes. The time required to load 1,000 boxes depends, in many instances, on the number of packages placed in a particular load. Refrigerator cars usually are loaded with 798 boxes but range in loads from 756 to 840 boxes per car. Highway trucks average 700 boxes per load with a 600- to 800-box range. The labor requirements are expressed in terms of man-hours per 1,000 boxes loaded regardless of whether all, none, or some fraction of the boxes are handled in a given operation.

Setup and cleanup operations for loading out are the same as those involved in unloading field trucks or orchard trailers. Setup begins with opening the car or truck door and ends when the first boxes are grasped for loading. It includes getting equipment from storage, moving it into position, and placing bridge plates or conveyors in position. Cleanup begins with the removal of bridge plates or loading conveyors and ends with the closing and sealing of the car doors. It includes the storing of equipment.

Pickup and moving of boxes to the railroad cars or highway trucks require the same man-hour labor as do these operations in other intraplant transportation, but the release operation requires more man-hour labor than that normally experienced within the plant. The labor requirements for the various operations in carloading are reported in such a way that the overall labor requirements for different combinations of operations can be determined. During loading, the stacks of boxes in the cars are stripped to prevent shifting of the load. Every second or third tier of boxes is stripped. After the ends of the cars are filled, the doorway may be filled in with boxes or with braces.

Fatigue Allowance

The following allowances were made for fatigue in computing the productive time shown under the headings that follow:

Job	Fatigue allowance Percent of base time
Manual stacking of boxes on or off orchard trailers and road trucks	20
Handling empty pallets	20
Jacking stacks of boxes into position on pallets in a railroad car	10
Manual unloading of boxes from orchard trailers and road trucks to belt conveyor and pallets or hand stacking loads for a hand truck	20
Manual stacking of boxes on or off a belt conveyor	20

Job	Fatigue allowance Percent of base time
Manual high-piling 10, 11, or 12 high	25
Manual high-piling 9 high	20
Manual breaking-out high-piled boxes from 10-, 11-, or 12-high stacks	20
Manual breaking-out high-piled boxes from 9-high stacks	15
Operating a mechanical high-piler in high-piling or breaking-down high-piled boxes	10
Manual stacking of boxes in loading out	20
Manual stripping of a carload with lath	10
Hand-trucking boxes of apples or empty boxes	10
Moving fruit by industrial fork-lift truck or industrial clamp truck	5

Standard Data on Labor Requirements for Handling 1,000 Boxes of Apples by Current Methods

	Base time Man-hours	Fatigue allowance Man-hours	Productive time Man-hours
Setup and cleanup for unloading boxes of apples from road trucks by:			
Hand trucks:			
Setup	0.07		
Cleanup	.05		
Total	.12	-	0.12
Hand trucks and conveyors:			
Setup	.09		
Cleanup	.07		
Total	.16	-	.16
Industrial-clamp truck:			
Setup	.09		
Cleanup	.06		
Total	.15	-	.15
Fork-lift truck palletized:			
Setup	.08		
Cleanup	.05		
Total	.13	-	.13

	Base time Man-hours	Fatigue allowance Man-hours	Productive time Man-hours
Fork-lift truck palletized (cross-tied load):			
Setup	0.14		
Cleanup	.06		
Total	.20	-	0.20
Setup and cleanup for unloading boxes of apples from orchard trailers by:			
Hand trucks:			
Setup	.05		
Cleanup	.05		
Total	.10	-	.10
Hand trucks and conveyors:			
Setup	.05		
Cleanup	.05		
Total	.10	-	.10
Industrial-clamp truck:			
Setup	.05		
Cleanup	.05		
Total	.10	-	.10
Fork-lift truck with pallets positioned manually (unpalletized load):			
Setup	.19		
Cleanup	.05		
Total	.24	-	.24
Fork-lift truck positions pallets on apron (unpalletized load):			
Setup	.12		
Cleanup	.05		
Total	.17	-	.17
Fork-lift truck positions pallets on apron (½ of trailer load palletized):			
Setup	.05		
Cleanup	.05		
Total	.10	-	.10
Fork-lift truck (completely palletized load):			
Setup	.18		
Cleanup	.05		
Total	.23	-	.23

	Base time Man-hours	Fatigue allowance Man-hours	Productive time Man-hours
Unload boxes of apples from road trucks:			
Manually remove boxes and place on belt conveyor:			
1-man crew	1.09	0.22	1.31
2-man crew	1.28	.26	1.54
Hand-stack boxes on pallets on platform	2.15	.43	2.58
Unload boxes of apples from orchard trailers:			
Manually remove boxes and place them on belt conveyor	1.18	.24	1.42
Build 6-high stacks on trailer bed	.97	.19	1.16
Hand-stack boxes on pallets on apron:			
Unpalletized loads	1.49	.30	1.79
Partially palletized loads	.84	.17	1.01
Manually place unpacked boxes of apples on conveyors from stacks alongside conveyor:			
Single-row stacks	.90	.18	1.08
Double-row stacks	1.10	.22	1.32
Pallet loads:			
Handle boxes	1.30	.26	1.56
Handle pallets (36-box)	.09	.02	.11
Handle pallets (48-box)	.07	.01	.08
Manually remove unpacked boxes of apples from conveyors and stack them alongside conveyor:			
Single-row	1.13	.23	1.36
Double-row	1.31	.26	1.57
Manually place packed boxes of apples on conveyors from stacks alongside conveyor:			
Single-row stacks	.94	.19	1.13
Double-row stacks	1.05	.21	1.26

	Base time Man-hours	Fatigue allowance Man-hours	Productive time Man-hours
Manually remove packed boxes of apples from conveyor and segregate:			
3 or 4 stacks	1.56	0.31	1.87
5 to 8 stacks	1.91	.38	2.29
9 or more stacks	2.19	.44	2.63
4 or 5 pallets	2.27	.45	2.72
Manually high-pile:			
6-high to 9-high stacks (2 men)—333 boxes handled	1.37	.27	1.64
6-high to 10-high stacks (2 men)—400 boxes handled	1.64	.41	2.05
6-high to 12-high stacks (2 men)—500 boxes handled	2.27	.57	2.84
Manually break-out of high piles:			
9-high to 6-high stacks (1 man)—333 boxes handled	.83	.12	.95
10-high to 6-high stacks (2 men)—400 boxes handled	1.46	.29	1.75
10-high to 4-high stacks using roller conveyor (2 men)—600 boxes handled	1.11	.22	1.33
12-high to 6-high stacks (2 men)—500 boxes handled	2.02	.40	2.42
Mechanically high-pile with portable lift:			
6-high to 9-high stacks—333 boxes handled:			
Single stack	1.13	.11	1.24
Double stack	.97	.10	1.07
6-high to 10-high stacks—400 boxes handled:			
Single stack	.94	.09	1.03
Double stack	.89	.09	.98
6-high to 11- or 12-high stacks—455 or 500 boxes handled:			
Single stack	.85	.08	.93
Double stack	.81	.08	.89

	Base time Man-hours	Fatigue allowance Man-hours	Productive time Man-hours
Mechanically break-out of high piles with portable lift:			
9-high to 6-high stacks--333 boxes handled:			
Single stack	1.02	0.10	1.12
Double stack	.75	.08	.83
10-high to 6-high stacks--400 boxes handled:			
Single stack	.77	.08	.85
Double stack	.47	.05	.52
11- or 12-high to 6-high stacks--455 or 500 boxes handled:			
Single stack	.70	.07	.77
Double stack	.43	.04	.47
Setup and cleanup for loading in railroad cars:			
Hand trucks:			
Setup	.16		
Cleanup	.06		
Total	.22	-	.22
Belt conveyor:			
Setup	.16		
Cleanup	.05		
Total	.21	-	.21
Fork-lift trucks:			
Setup	.18		
Cleanup	.07		
Total	.25	-	.25
Block-out for loading:			
Hand truck	-	-	3.58
Industrial fork-lift truck	-	-	.95
Industrial-clamp truck	-	-	1.79
Manifest load:			
Each box	-	-	.45
Each stack	-	-	.10

	Base time Man-hours	Fatigue allowance Man-hours	Productive time Man-hours
Load in railroad cars:			
Release 6-high stacks by hand truck. .	0.50	0.05	0.55
Manually load boxes placed by hand trucks.	1.43	.28	1.71
Release 5-high stacks by hand truck for jacking	.78	.08	.86
Position stacks by box jack.	1.06	.11	1.17
Manually load from belt conveyor . . .	1.19	.24	1.43
Transfer boxes from belt conveyor to roller conveyor and transport into car.	1.04	.10	1.14
Release loaded pallet on roller conveyor:			
30-box load.	.07	-	.07
40-box load.	.06	-	.06
Manually load boxes from pallets . . .	1.57	.31	1.88
Place pallet load on dolly with fork-lift truck:			
30-box pallet.	.18	.01	.19
Push dolly and 30-box pallets into car	.42	.08	.50
Place pallet load on dolly with fork-lift truck:			
40-box pallet.	.15	.01	.16
Push dolly and 40-box pallets into car	.33	.07	.40
Fill doorway with brace.	.83	.08	.91
Fill doorway with 70 boxes	.50	.10	.60
Strip stacked boxes in car:			
Strip 3 tiers.	.90	.09	.99
Strip 2 tiers.	.61	.06	.67
Load in trailer trucks:			
Release 6-high stacks by hand trucks .	.50	.05	.55
Manually load boxes placed by hand trucks.	1.43	.28	1.71
Manually load boxes from belt conveyors	1.25	.25	1.50
Release loaded pallet on roller conveyor:			
30-box load.	.07	-	.07
40-box load.	.06	-	.06
Manually load boxes from pallets . . .	1.61	.32	1.93

	Base time Man-hours	Fatigue allowance Man-hours	Productive time Man-hours
Move by hand truck—6-high stacks:			
Pickup load in cold-storage room or crowded area	0.39	0.04	0.43
Pickup load from truck bed or relatively crowded area	.29	.03	.32
Pickup load from open floor area	.23	.02	.25
Release load in storage or crowded area	.35	.04	.39
Release load on truck bed or relatively crowded area	.29	.03	.32
Release load by dumper or in open area	.24	.02	.26
Transport load 100 feet by 1-man crew (for different distances adjust productive time by 0.0189 per foot) (For 2-man crew, add 0.0012 per foot to productive time for distances under 116 feet. For 3- or 4-man crews add 0.0015 per foot to productive times for distances under 197 feet)	1.82	.18	2.00
Move by hand trucks—5-high stacks:			
Pickup load in cold-storage room or crowded area	.47	.05	.52
Pickup load from truck bed or relatively crowded area	.35	.04	.39
Pickup load from open floor area	.28	.03	.31
Release load in cold-storage or crowded area	.42	.04	.46
Release load on truck bed or relatively crowded area	.35	.04	.39
Release load in open area	.29	.03	.32
Transport load 100 feet by 1-man crew (for different distances adjust productive time by 0.0226 per foot) (For 2-man crew add 0.0012 per foot to productive time for distances under 116 feet. For 3- or 4-man crews add 0.0015 per foot to productive times for distances under 197 feet)	2.18	.22	2.40

	Base time Man-hours	Fatigue allowance Man-hours	Productive time Man-hours
Move by industrial-clamp truck--36-box load:			
Build 6-high stacks on trailer bed from 3-high stacks using industrial-clamp truck	0.35	0.02	0.37
Pickup load from orchard trailer bed	.12	.01	.13
Pickup load from open floor level	.10	.01	.11
Pickup load in cold-storage room--open area high piled (average of 2 tiers)	.10	.01	.11
First tier	.07	-	.07
Second tier	.13	.01	.14
Place boards between tiers	.05	.01	.06
Release load on roller conveyor at dumper	.12	.01	.13
Release load in cold-storage room--open area high piled (average of 2 tiers)	.11	.01	.12
First tier	.08	-	.08
Second tier	.14	.01	.15
Remove boards from tiers	.03	-	.03
Transport load 100 feet (for different distances adjust productive time by 0.0025 per foot)	.40	.02	.42
Move by industrial-clamp truck--30-box load:			
Pickup load from open floor level	.12	.01	.13
Pickup load in cold-storage room--open area high piled (average of 2 tiers)	.12	.01	.13
First tier	.08	-	.08
Second tier	.16	.01	.17
Place boards between tiers	.06	.01	.07
Release load on roller conveyor at dumper	.14	.01	.15
Release load in cold-storage room--open area high piled (average of 2 tiers)	.13	.01	.14
First tier	.10	.01	.11
Second tier	.16	.01	.17
Remove boards from tiers	.04	-	.04
Transport load 100 feet (for different distances adjust productive time by 0.0031 per foot)	.49	.02	.51

	Base time Man-hours	Fatigue allowance Man-hours	Productive time Man-hours
Move by industrial-clamp truck--24-box load:			
Pickup load from floor level in crowded area	0.16	0.01	0.17
Pickup load from truck bed	.11	.01	.12
Pickup load in cold-storage room--crowded area high piled (average of 2 tiers)	.57	.03	.60
First tier	.28	.01	.29
Second tier	.86	.04	.90
Pickup load in cold-storage room--open area high piled (average of 2 tiers)	.22	.01	.23
First tier	.12	.01	.13
Second tier	.32	.02	.34
Place boards between first and second tiers	.07	-	.07
Release load in crowded area near dumper	.19	.01	.20
Release load in relatively crowded area on flat surface	.13	.01	.14
Release load in open area near conveyor	.07	-	.07
Release load in cold-storage room--crowded area high piled (average of 2 tiers)	.39	.02	.41
First tier	.20	.01	.21
Second tier	.58	.03	.61
Release load in cold-storage room--open area high piled (average of 2 tiers)	.25	.01	.26
First tier	.10	.01	.11
Second tier	.40	.02	.42
Remove boards from tiers	.04	-	.04
Transport load 100 feet (for different distances adjust productive time by 0.0034 per foot)	.54	.03	.57
Move by industrial-clamp truck--20-box load:			
Pickup load from truck bed or level surface--open area	.13	.01	.14
Pickup load from floor level in crowded area	.19	.01	.20

	Base time Man-hours	Fatigue allowance Man-hours	Productive time Man-hours
Pickup load in cold-storage room--crowded area high piled (average of 2 tiers)	0.68	0.03	0.71
First tier	.34	.02	.36
Second tier	1.03	.05	1.08
Pickup load in cold-storage room--open area high piled (average of 2 tiers)	.26	.01	.27
First tier	.14	.01	.15
Second tier	.38	.02	.40
Place boards between first and second tiers	.08	-	.08
Release load in crowded area	.23	.01	.24
Release load in relatively crowded area on flat surface	.16	.01	.17
Release load in open area near conveyor	.08	-	.08
Release load in cold-storage room--crowded area high piled (average of 2 tiers)	.47	.02	.49
First tier	.24	.01	.25
Second tier	.70	.04	.74
Release load in cold-storage room--open area high piled (average of 2 tiers)	.30	.02	.32
First tier	.12	.01	.13
Second tier	.48	.02	.50
Remove boards from tiers	.05	-	.05
Transport load 100 feet (for different distances adjust productive time by 0.004 per foot)	.65	.03	.68
Move by electric industrial fork-lift truck--48-box load:			
Pickup load from truck bed	.07	-	.07
Pickup load from open floor level	.05	-	.05
Pickup load in cold-storage room--open area high piled (average of 3 tiers)	.09	-	.09
First tier	.05	-	.05
Second tier	.07	-	.07
Third tier	.14	.01	.15
Release load on 4-wheel dolly at dumper	.11	.01	.12

	Base time Man-hours	Fatigue allowance Man-hours	Productive time Man-hours
Release load and position on floor at dumper	0.10	0.01	0.11
Release load in open floor area	.04	-	.04
Release load in cold-storage room--open area high piled (average of 3 tiers)	.09	-	.09
First tier	.04	-	.04
Second tier	.08	-	.08
Third tier	.15	.01	.16
Transport load 100 feet (for different distances adjust productive time by 0.0016 per foot. Under 32 feet productive time = 0.0059d ∠ 0.0136)	.29	.01	.30
Move by electric fork-lift truck--40-box load:			
Pickup load from open floor level	.06	-	.06
Pickup load in cold-storage room--open area high piled (average of 3 tiers)	.10	.01	.11
First tier	.05	-	.05
Second tier	.08	-	.08
Third tier	.17	.01	.18
Release load in open floor area	.04	-	.04
Release load in cold-storage room--open area high piled (average of 3 tiers)	.11	.01	.12
First tier	.05	-	.05
Second tier	.10	.01	.11
Third tier	.18	.01	.19
Transport load 100 feet (for different distances adjust productive time by 0.002 per foot. Under 32 feet productive time = 0.007d ∠ 0.0168)	.36	.02	.38
Move by electric fork-lift truck--36-box load:			
Pickup load from truck bed	.10	.01	.11
Double pickup load from truck bed	.16	.01	.17
Pickup load from floor level	.06	-	.06
Pickup load in cold-storage room--open area high piled (average of 3 tiers)	.12	.01	.13

	Base time Man-hours	Fatigue allowance Man-hours	Productive time Man-hours
First tier	0.06	-	0.06
Second tier	.11	0.01	.12
Third tier	.19	.01	.20
Release load on roller conveyor at dumper	.07	-	.07
Release load on floor level	.04	-	.04
Release load in cold-storage room--open area high piled (average of 3 tiers)	.13	.01	.14
First tier	.06	-	.06
Second tier	.11	.01	.12
Third tier	.21	.01	.22
Transport load 100 feet (for different distances adjust productive time by 0.0023 per foot)	.39	.02	.41
Move by electric fork-lift truck--30-box load:			
Pickup load from floor level	.07	-	.07
Pickup load in cold-storage room--open area high piled (average of 3 tiers)	.14	.01	.15
First tier	.07	-	.07
Second tier	.13	.01	.14
Third tier	.23	.01	.24
Release load on floor level	.05	-	.05
Release load in cold-storage room--open area high piled (average of 3 tiers)	.16	.01	.17
First tier	.08	-	.08
Second tier	.13	.01	.14
Third tier	.26	.01	.27
Transport load 100 feet (for different distances adjust productive time by 0.0027 per foot)	.47	.02	.49
Move by gasoline-powered industrial fork-lift truck--48-box load:			
Pickup load from truck bed	.07	-	.07
Pickup load from open floor	.04	-	.04
Pickup load in cold-storage room--open area high piled (average of 3 tiers)	.09	-	.09

	Base time Man-hours	Fatigue allowance Man-hours	Productive time Man-hours
First tier	0.05	-	0.05
Second tier	.07	-	.07
Third tier	.14	0.01	.15
Release load on 4-wheel dolly at dumper	.11	.01	.12
Release load and position on floor at dumper	.10	.01	.11
Release load on open floor	.04	-	.04
Release load in cold-storage room--open area high piled (average of 3 tiers)	.06	-	.06
First tier	.04	-	.04
Second tier	.06	-	.06
Third tier	.08	-	.08
Transport 100 feet (for different distances adjust productive time by 0.0011 per foot)	.24	.01	.25
Move by gasoline-powered industrial fork-lift truck--40-box load:			
Pickup load from open floor	.05	-	.05
Pickup load in cold-storage room--open area high piled (average of 3 tiers)	.10	.01	.11
First tier	.05	-	.05
Second tier	.08	-	.08
Third tier	.17	.01	.18
Release load on open floor	.04	-	.04
Release load in cold-storage room--open area high piled (average of 3 tiers)	.07	-	.07
First tier	.04	-	.04
Second tier	.07	-	.07
Third tier	.10	.01	.11
Transport 100 feet (for different distances adjust productive time by 0.0013 per foot)	.29	.01	.30
Move by electric low-lift pallet transporter--48-boxes:			
Pickup load from open floor	.11	.01	.12
Release load on open floor	.12	.01	.13

	Base time Man-hours	Fatigue allowance Man-hours	Productive time Man-hours
Transport 100 feet (for different distances adjust productive time by 0.00148 per foot).	0.35	0.02	0.37
Move by electric low-lift pallet transporter--40 boxes:			
Pickup load from open floor	.12	.01	.13
Release load on open floor.	.14	.01	.15
Transport 100 feet (for different distances adjust productive time by 0.00177 per foot).	.42	.02	.44
Move by elevator:			
Release 6-box load in elevator by hand truck	.29	.03	.32
Release 24-box load in elevator by clamp truck.	.08	-	.08
Release 48-box load in elevator by fork-lift truck.	.05	-	.05
Pickup 6-box load in elevator by hand truck	.29	.03	.32
Pickup 24-box load in elevator by clamp truck.	.15	.01	.16
Pickup 48-box load in elevator by fork-lift truck.	.06	-	.06
Open and close elevator doors:			
72-box capacity elevator.	.24	.02	.26
80-box capacity elevator.	.21	.02	.23
138-box capacity elevator	.12	.01	.13
162-box capacity elevator	.10	.01	.11
Transport in 72-box capacity elevator:			
1 floor (14 feet)	.08	-	.08
2 floors (28 feet).	.15	-	.15
Transport in 80-box capacity elevator:			
1 floor (14 feet)	.07	-	.07
2 floors (28 feet).	.13	-	.13
Transport in 138-box capacity elevator:			
1 floor (14 feet)	.04	-	.04
2 floors (28 feet).	.08	-	.08

	Base time Man-hours	Fatigue allowance Man-hours	Productive time Man-hours
Transport in 162-box capacity elevator:			
1 floor (14 feet)	0.04	-	0.04
2 floors (28 feet)	.07	-	.07

Standard Data on Labor Requirements for Handling 1,000 Boxes of Apples by Specified Innovations

	Base time Man-hours	Fatigue allowance Man-hours	Productive time Man-hours
Unloading roller conveyor truck bed on plywood pallets:			
Placing pallets on truck:			
Setup	0.08		
Cleanup	.26		
Total	.34	-	0.34
Position pallets	.16	0.03	.19
Pulling loaded pallets off truck:			
Setup	.04		
Cleanup	.09		
Total	.13	-	.13
Move pallet loads 15 feet	.30	.06	.36
Stack boxes on belt conveyor and remove pallets	1.31	.26	1.57
Position pallet loads for unloading	.19	.04	.23
Move by gasoline-powered industrial broad-blade fork-lift truck--36-box load:			
Pickup load from floor level	.09	-	.09
Pickup load from truck bed equipped with dunnage strips	.18	.01	.19
Pickup load in cold-storage room (average of 3 tiers)	.21	.01	.22
First tier (floor level)	.09	-	.09
Second tier	.21	.01	.22
Third tier	.33	.02	.35
Release load on roller conveyor at dumper	.09	-	.09

	Base time Man-hours	Fatigue allowance Man-hours	Productive time Man-hours
Release load in cold-storage room (average of 3 tiers)	0.22	0.01	0.23
First tier (floor level)	.08	-	.08
Second tier	.18	.01	.19
Third tier	.39	.02	.41
Place special top tie frames on road truck preparatory to unloading	.06	.01	.07
Place special top tie frames on each unit load on road truck preparatory to unloading	.10	.02	.12
Transport load 100 feet (for different distances adjust productive time by 0.0035 man-hours per foot)	.42	.02	.44
Place dunnage on floor of cold-storage room to support first tier	.12	.01	.13
Stack 6-high from 3-high with pusher attachment on orchard trailer	.66	.07	.73
Elevating from basement to main floor by fork-lift truck--40-box load:			
Elevate load	.10	.01	.11
Release load on main floor	.05	-	.05
Lower forks	.03	-	.03
Lowering from main floor to basement by fork-lift truck--40-box load:			
Raise forks	.06	.01	.07
Pickup load on main floor	.07	.01	.08
Lower load	.04	-	.04
Move by gasoline-powered industrial clamp truck--12-box load:			
Pickup load on truck bed--manual tilt	.19	.01	.20
Pickup load from open floor level--manual tilt	.18	.01	.19
Pickup load from open floor level--hydraulic tilt	.21	.01	.22
Release load in open area--manual or hydraulic tilt	.14	.01	.15
Transport load 100 feet (for different distances adjust productive time by 0.00565 per foot)	.82	.04	.86
Separate stacks with truck prongs	.08	-	.08

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Washington State Apple Packing and Storage Plants in Which Research Was Conducted

Allen Brothers, Naches
Cashmere Fruit Growers, Cashmere
Congdon Orchards, Yakima
Cowiche Growers, Cowiche
Cubberly, F. H., Fruit Company, Tieton
Forney Fruit and Produce Company, Yakima
Garretson, Lloyd, Company, Yakima
Gilbert Orchards, Wiley City
Karr Warehouse, Yakima
Larabee Packing Company, Tonasket
Mahre Brothers, Gromore
Methow Valley Growers Service, Incorporated, Pateros
Monitor Federated Growers, Monitor
Ninth Street Skookum, Wenatchee
Okanogan Cooperative Growers, Okanogan
Okanogan Growers Union, Okanogan
Oroville United Growers, Oroville
Pacific Fruit and Produce, Yakima
Perham Fruit Corporation, Tieton
Peshastin Fruit Growers, Peshastin
Prentice Packing and Cold Storage Company, Westbrook
Ranier Fruit Company, Yakima
Scogin Orchards, Yakima
Snow King Orchards, Tieton
Thorndyke and Sons, Oroville
Tonasket Ellisforde Growers, Tonasket
Wenatchee-Wenoka Growers, Wenatchee
Yakima Fruit Growers Association, Wapato
Yakima Fruit Growers Association, Weikel

Equipment Manufacturers and Distributors Who Cooperated in Research

Air-Mack Equipment Company, Seattle, Wash.
Clark Equipment Company, Grand Rapids, Mich.
Food Machinery and Chemical Corporation, Yakima, Wash.
Grand Specialties Company, Chicago, Ill.
Mathews Conveyor Company, San Carlos, Calif.
Preston Faller Company, Seattle, Wash.
Van Doren Machine Shops, Wenatchee, Wash.
Youngs' Iron Works, Seattle, Wash.