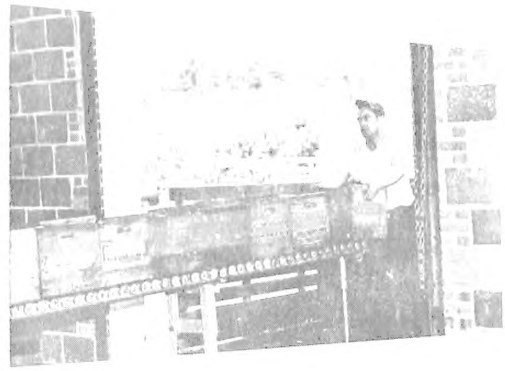
Marketing Research Report No. 476

U. S. DEPARTMENT OF AGRICULTURE
AGRICULTURAL MARKETING SERVICE
TRANSPORTATION AND FACILITIES
RESEARCH DIVISION

APPLE HANDLING and PACKING

in the Appalachian Area



Marketing Research Report No. 476

U. S. DEPARTMENT OF AGRICULTURE
AGRICULTURAL MARKETING SERVICE
TRANSPORTATION AND FACILITIES
RESEARCH DIVISION

APPLE HANDLING and PACKING

in the Appalachian Area

PREFACE

Much research into apple handling and packing has preceded this study; more will follow it. While the majority of work already done has been in other producing areas with different conditions, many of the results are applicable to the Appalachian area, or can be adapted to its requirements. The primary purpose of this report is to present costs of handling and packing apples by present methods; these costs to serve as a basis for determining possible savings with newer equipment types. Some of these newer equipment types--particularly forklift trucks, automatic box fillers, and semiautomatic tray packers--were already in plants studied, and are included in the comparisons. This study is part of a broad program of research aimed at improving marketing efficiency and expanding the market for farm products.

The Agricultural Experiment Station of West Virginia University, and the Marketing Economics Research Division of the Agricultural Marketing Service conducted companion studies. These were economic analyses of plantwide costs, based on the averages of selected plants. Publications have been issued by both agencies.

The study on which this report is based was under the general supervision of Joseph F. Herrick, Jr., Marketing Research Analyst, Transportation and Facilities Research Division, Agricultural Marketing Service. Many packers in the Appalachian area offered their support and facilities, and their contribution is acknowledged.

Other publications in the field include:

Marketing Research Report No. 49. "Apple Handling Methods and Equipment in Pacific Northwest Packing and Storage Houses," U. S. Dept. Agr., June 1953. (Out of print, may be consulted in libraries.)

AMS-236. "Handling and Storage of Apples in Pallet Boxes," U. S. Dept. Agr., Agricultural Marketing Service, April 1958.

AMS-330. "An Experimental Packing Line for McIntosh Apples," U. S. Dept. Agr., Agr. Mktg. Serv., August 1959.

AMS-300. "Costs of Marketing Appalachian Apples," U. S. Dept. Agr., Agr. Mktg. Serv., February 1959.

The West Virginia Agricultural Experiment Station, Morgantown, W. Va., published a bulletin entitled:

"Costs and Mechanical Injury in Handling and Packing Apples," Bul. 416, June 1958.

Information concerning motion pictures dealing with apple handling and packing can be obtained from the Office of Information, U. S. Department of Agriculture, Washington 25, D. C.

CONTENTS

June 1961

SUMMARY

At an annual volume of 50,000 crates, the forklift truck and pallet method of handling apples was the least costly, and the powered conveyor method the most costly of those studied. With the forklift truck and pallets, the cost was $33.93 per 1,000 crates received. This was $56.90 less than with the conveyor, and $17.04 less with the clamp type 2-wheel handtruck when both labor and equipment were considered. In each case labor represented about two-thirds of the total cost of handling apples, and equipment one-third.

In the packing line operations, mechanical dumping cost $10.78 per 1,000 crates, and manual dumping $21.96, or $11.18 more, where the annual volume was 50,000 crates. At this same volume, apples were tray-packed by use of semi-automatic tray-packers at a combined labor and equipment cost of $48.44 per 1,000 cartons or $18.26 less than when they were manually tray-packed from a return-flow belt.

The least costly way to bag apples was for one worker to do all the work, using an automatic bagger. This cost $78.98 per 1,000 cartons.

By combining the forklift truck method for handling with packing by semi-automatic tray-packers, it would be possible, at a volume of 50,000 crates annually, to effect a saving of $5,065 per year over conveyors and packing tubs.

At 100,000 crates dumped annually, performing handling operations by fork-lift truck and pallets would save $4,069 over powered conveyors, and $2,592 over clamp type 2-wheel handtrucks; packing with semiautomatic tray-packers would cost $3,742 less than manual packing from tubs. At this volume a combination of the efficient handling and packing line methods would save $7,732 over the least efficient methods.

Handling 200,000 crates a year with forklift trucks and pallets and packing by semiautomatic tray packers would cost $12,574 less than a method using conveyors for handling, coupled with manual packing.

Forklift trucks for the handling operations together with semiautomatic tray-packers for packing could greatly increase the productivity of workers engaged in these operations. The cost of this equipment would be greater than the cost of equipment for any other combination of methods studied; but, this additional cost would be saved many times over by the reduction in labor that it afforded.

Regardless of the method used, or volume packed, the cost of labor was much more than the cost of equipment, and the cost of packing much greater than the cost of handling. Where only labor and equipment costs were considered, economies associated with increasing scale of operation were sizable up to a volume of 100,000 crates annually. Beyond this volume additional unit savings were small. This was true in varying degrees, for each method tested. All these cost relationships are based on a labor cost of $1.25 per hour (which includes overtime, bonuses, unemployment insurance, social security contributions, and similar costs), representative transportation distances, and optimum crew arrangements for each method.

APPLE HANDLING AND PACKING IN THE APPALACHIAN AREA

By Stanley W. Burt, industrial engineer
Transportation and Facilities Research Division
Agricultural Marketing Service

BACKGROUND

For several years the United States Department of Agriculture has conducted a program to develop improved methods and equipment for handling and packing apples. The result has been a number of improvements which are already saving many thousands of dollars annually for the apple packing industry. This work has been concentrated in the Pacific Northwest and tailored to conditions and requirements of that area.

To bring these improvements to a larger portion of the apple packing industry, another research program was inaugurated; this one to determine how new equipment and methods developed in the Pacific Northwest could be adapted to conditions in the Appalachian area. Where this could be done successfully, savings would accrue to still more growers and packers, in an area which produces about one-fifth of the Nation's apples.

A description of how the study was developed, methodology used, procedure for cost determinations, and the methods and operations which were studied are in the appendix, together with supporting statistical material.

APPLE HANDLING OPERATIONS

Handling operations are those in which the fruit is picked up, moved, and set down in another place; the composition of the fruit is not affected. In the Appalachian area handling operations were performed with conveyors, clamp type 2-wheel handtrucks, and forklift trucks and pallets, as well as by entirely manual means. Handling operations included: 1. Receiving, 2. bringing-up, 3. segregating, 4. putting packed apples into storage, and 5. loading out.

Receiving

In the Appalachian area, as in others, receiving apples from the orchard into the packinghouse is a major handling operation. It is the first handling of fruit that will finally leave the plant as a graded and packaged product. Receiving consists of unloading, transporting, and stacking field crates of apples, either in storage or at the dumper.

Some flat bed trailers were used to deliver full crates from the orchard to the packing plant, but most of the deliveries were by stake body truck. Trucks carried approximately 200 crates. While the manner of loading in the orchard can bear directly on the method used to receive fruit at the packinghouse, only those operations taking place at the packing plant were studied.

Many clamp type 2-wheel handtrucks were used, but most packinghouses in the Appalachian area used conveyors in their receiving operation. Conveyors could be either gravity operated, powered, fixed in place, or movable. Fork-lift trucks and pallets were used in some larger-volume houses.

Clamp Type 2-Wheel Handtruck

In smaller houses clamp type 2-wheel handtrucks were often employed as the main type of handling equipment. They were light, maneuverable, and capable of handling fruit in many different types of rigid containers. In some houses this was the only handling equipment used. This equipment handled loads of up to 5 containers, and could adjust automatically to containers of different sizes. Highly maneuverable, clamp trucks could negotiate in confined areas where other larger equipment types could not.

Unloading.--With the orchard truck in unloading position, tie ropes were removed and a bridge plate set down across the truck bed and unloading platform. A worker assigned to the truck set the crates up 5 high on the truck bed. A transporter then picked them up and removed them from the truck; he stepped on a foot lever, causing the clamps to engage the load.

Transporters sometimes did their own setting up. When this was the method, one transporter at a time worked inside the truck. If another arrived at the truck, he waited on the platform until the other transporter had left. As unloading progressed, transporters spent increasing time on the platform.

Transporting.--Loaded clamp type 2-wheel handtrucks were pushed out of the truck to the stacking area and returned to the truck for other loads. The number of workers assigned to do this (as well as the total man-hours required) was based on the distance between the unloading platform and the stacking point. Transporting crews of 2 or 3 men were most common. With clamp type 2-wheel handtrucks, size of the transportation crew could be varied, within limits, without disrupting crew balance. This feature gave the system a flexibility other handling systems did not have.

Stacking.--This was performed in two parts. The first 5 crates were set down in place with clamp type 2-wheel handtrucks. Crates above this height had to be stacked either manually or with a powered high-stacker. High-stacking was not done when crates were moved directly to the dumper.

Where fruit was received and moved directly to the dumper for manual dumping, field crates were set down adjacent to the dumping table; where a drum-type dumper was used, crates were deposited along the conveyor supplying the dumper.

With clamp type 2-wheel handtrucks there was very little unproductive labor in delivering fruit to the dumper or in placing it in lower tiers in storage. Additional labor was necessary when crates were stacked over 5 high. Where high-piling was done manually two stackers were added to work in the storage room. A transporter would deposit a 5-crate load, and one stacker would remove crates from this load and lift them to the second stacker who

placed them in storage. While doing this he stood on stacked crates (fig. 1). In addition to the extra labor involved, there was danger to the stacker from standing and working on stacked crates, and apples were handled roughly.

A second method of high-piling utilized a mechanical device for lifting fruit to the correct height (fig. 2). Power for clamping onto loads and lifting them to stacking height was supplied through a reel-type cord plugged into an electrical outlet. Maneuvering of the high-piler was done manually. With this equipment only one additional worker was required to do the high-piling, and there was no walking about on stacked fruit.

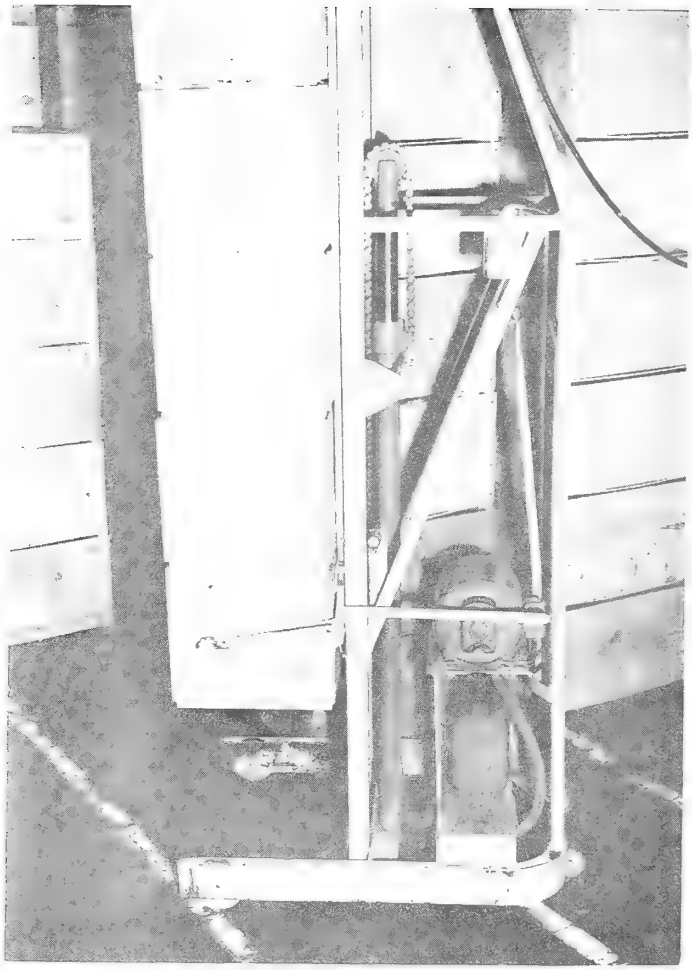
Gravity and Powered Conveyors

Two types of conveyor--gravity and powered--were used in handling apples, and they were used both separately and in combination. Transportation was the only function they could perform. It was necessary to manually handle each crate in placing it on, and again in removing it from the conveyor line; but, because the conveyor could solve some difficult transportation problems, it was a popular and sometimes economical piece of equipment.

For the most part conveyors were fixed in place; particularly those which were powered. They often caused congestion, blocked off aisles and walkways, and restricted the usability of storage and operating areas.

BN-12127

Figure 1.--Manual high-piling. One stacker lifts crate up to second stacker who places it in storage.



BN-10022

Figure 2.--Mechanical high-piler. With this equipment one worker, alone, can place 5 crates at a time in high storage position.

Unloading.--Regardless of the type and arrangement of conveyors in the rest of the plant, a gravity type conveyor was used at the unloading platform. This conveyor was a permanent installation, and a loaded orchard truck had to back against the platform so as to center its load on the conveyor. The unloading crew consisted of one or two workers. Where two were used they worked independently, with each worker taking crates from his side of the truck and placing them on the conveyor (fig. 3). The gravity conveyor section at the platform either extended to the storage area, or connected with a powered belt conveyor which delivered crates to the storage room.

When part of the truck had been unloaded, a short conveyor section was placed in the truck and joined with the conveyor on the platform. This reduced the walking distance. When the carrying distance was again too great, another short section of gravity conveyor was joined to the first.

BN-10012

Figure 3.--An unloader places crate on gravity conveyor from an orchard truck.

Stacking.--Either a gravity or a powered conveyor was used to deliver crates to the workers stacking them. But either way, the crates still had to be removed manually from the conveyor, one at a time.

There were two ways of handling crates delivered by conveyor. One was to remove each crate and carry it directly to its storage place. This procedure was followed when the conveyor was quite near the storage area. The second method was to build 5-high stacks alongside the conveyor (fig. 4). These stacks were removed by clamp type 2-wheel handtruck and deposited in their storage positions. Stacks to be high-piled were deposited in front of the stacks on which they were to rest. The high-piler would clamp onto a load, elevate it to the proper height, and set it down on the stack (fig. 2). Half of the loads of crates stacked 5-high were positioned and deposited in the stack by clamp type 2-wheel handtrucks; the other half were placed in position by the mechanical high-piler.

After stacks had been built alongside the conveyor, apples were always handled in unit loads of 5 crates. Additional handlings occurred with this method, but it was still more efficient than carrying each crate to its storage position. Equipment replaced labor, and the apples were handled in unit loads; also, the transporters and the high-piler could perform work elsewhere while stacks were being built alongside the conveyor. When enough stacks were ready, these workers could remove them. This way, there was no time lost waiting for the 5-high loads to be made up.

BN-12128

Figure 4.--Five-high stacks alongside conveyor. These stacks are built manually with crates taken from the conveyor. They are later removed by clamp type 2-wheel handtruck.

When crates were delivered directly to the dumper, they remained on the conveyor until they were dumped. The only operation performed in this case was unloading from trucks at the receiving platform. With this method considerable wait time was incurred by the unloader.

Forklift Truck and Pallets

Forklift trucks and pallets are the newest type of handling equipment in the Appalachian area. They were found in several of the larger plants. Even some medium-size packinghouses were using this equipment. Most of these forklift trucks were gas powered, with a rated capacity of 2,000 pounds.

Forklift trucks should be used as part of an integrated handling system, with each handling step taking advantage of a forklift truck's ability to handle large unit loads quickly. An integrated handling system begins in the orchard. Getting crates into unit loads at the earliest stage eliminates later individual handling during receiving (fig. 5).

Unloading.--When it was not possible or practical to deliver them already palletized, crates were palletized at the receiving point. The workers who built crates into pallet loads made up the unloading crew. The first two pallets

BN-10002

Figure 5.--Forklift truck removing loaded pallet from orchard truck. Note concrete apron and uncluttered appearance of receiving area.

were loaded on the platform apron. The worker in the truck handed the crates down to his co-worker who put them on a pallet. After a load of 24 crates was complete, it was removed by forklift truck. When enough crates had been removed from the truck, empty pallets were set on the truck bed and loaded there.

Transporting and stacking.--This includes picking up the loaded pallets, moving them to storage, setting the pallets in storage position, and returning for the next load. For each orchard truck this cycle occurred 6 or 7 times, since each pallet load consisted of 24 crates. However, where pallet loads were set aside near the truck until the entire truck was unloaded, and then later picked up and moved to storage, this cycle occurred twice for each pallet. This was often done when there was need to unload the truck quickly.

Cost of Receiving

Labor and equipment costs for receiving apples by use of three different types of equipment are shown in table 1. There were wide differences in optimum crew sizes, man-hours required, and labor and equipment costs. At a volume of 50,000 crates annually, the conveyor method cost over 100 percent more than the forklift truck method (where crates were palletized in the orchard), and the clamp type 2-wheel handtruck method cost 17 percent more.

Table 1.--Labor and equipment costs for receiving and placing in storage 1,000 field crates of apples by three different methods--annual volume 50,000 crates 1/

Method	Crew size	Elapsed time	Labor required	Cost		
				Labor 2/	Equipment 3/	Total
	Number	Hours	Man-hours	Dollars	Dollars	Dollars
3 clamp type 2-wheel handtrucks and 1 high-piler	4	1.42	5.67	7.09	0.44	7.53
10 feet of gravity conveyor, 100 feet of powered conveyor to deliver apples, 2 clamp type 2-wheel handtrucks, and 1 high-piler used in storing	6	1.72	10.32	12.90	3.01	15.91
1 forklift truck and 42 pallets:						
Palletized before arrival	1	1.11	1.11	1.39	5.06	6.45
Palletized at receiving	3	1.65	4.94	6.18	7.52	13.70

1/ Elemental labor requirements for each method are in tables 29, 31, and 33, appendix.

2/ Based on a labor cost of $1.25 per hour, and a receiving distance of 100 feet.

3/ Clamp type 2-wheel handtruck at $0.018 each per hour, high-piler at $0.263, 10-foot gravity conveyor at $0.024, 100-foot powered conveyor at $1.24 per hour, forklift truck at $1.62 per hour, and pallets at $0.07 each per hour.

Clamp type 2-wheel handtruck.--Equipment represented a minor cost item when apples were unloaded, transported, and placed in storage by clamp type 2-wheel handtrucks, and high-piling was performed mechanically. Three clamp type 2-wheel handtrucks used 1.42 hours for receiving 1,000 crates of apples to storage cost only $0.07 and a high-piler $0.37. This equipment is relatively inexpensive, requires practically no maintenance, has no power cost, and lasts for many years. No other method of receiving fruit can match the low equipment cost of the clamp type 2-wheel handtruck method.

Four workers could receive 1,000 crates and, with a high-piler, stack them 10 to a stack in 5.67 man-hours. At $1.25 per hour, the labor cost totaled $7.09. Had the high-piling been performed manually, 6.96 man-hours would have been required at a labor cost of $8.70.

The combined labor and equipment cost would have been $5.19 per 1,000 crates handled if receiving had been to the dumper, eliminating high-piling. High-piling one-half of the crates mechanically raised the cost to $7.53 for 1,000 crates received. High-piling manually would have raised the cost to $8.70.

Gravity and powered conveyors.--Combined labor and equipment costs to receive 1,000 crates of apples with conveyors delivering fruit from the orchard truck to the storage area, and clamp type 2-wheel handtrucks and a high-piler for setting them in storage totaled $15.91. Of these costs, $12.90 was for labor and $3.01 for equipment. Stacking crates along the conveyor, transporting them to the storage point, and placing crates in storage cost $6.60, or 42 percent of the labor cost for receiving. The remainder was divided between setup, cleanup, removing crates from the truck, placing them on the conveyor, and unavoidable delay time.

Of the total equipment cost, $1.94 was for 10 feet of gravity conveyor at the receiving platform and 100 feet of powered belt conveyor to deliver crates into the room. The conveyors were 64 percent of the total cost of equipment.

Forklift truck and pallets.--Labor cost for receiving fruit that had been palletized before arrival at the packing plant totaled $1.39 per 1,000 crates. Only one worker was needed to operate a gas type forklift truck for each of the steps in receiving: Unloading, transporting, and stacking. Equipment used with this method included one forklift truck and 42 pallets (1,000 crates at 24 crates per pallet). The cost of this equipment was $5.06 per 1,000 crates received. Labor and equipment together totaled $6.45 per 1,000 crates.

Cost of labor for receiving, for crates that have to be palletized at the packing plant, is $6.18; cost of equipment, $7.52, for a total of $13.70. This is $7.25 more than the cost of receiving crates already palletized. Some of this saving becomes a cost in the orchard operation. However, there is no question of the dollar saving that results from palletizing crates in the orchard, permitting one man and a forklift truck to perform the entire receiving function at the packing plant.

"Bringing-Up" Apples from Storage to Dumper

The function of the "bringing-up" operation is to maintain a supply of fruit at or near the dumper at all times. Since the entire packing line would stop if there were no apples to dump, stoppage would be costly. For this report "bringing-up" applies only to apples delivered from a storage area within the packinghouse.

When apples were brought to the dumper directly from orchard trucks, a receiving operation took place. The same equipment is used for both "bringing-up" and for receiving.

Except when a forklift truck was used, one-half of the crates brought up to the dumper were broken out of high storage positions. This was done either mechanically or by manual means. The mechanical break-out device was the same item of equipment described in the receiving operation as a high-piler. It clamped onto a 5-crate stack and lowered it to the floor. Where breaking out was performed manually, one worker stood on piled crates to remove other crates (one at a time), handing them to a second worker who built the crates into stacks of five for later removal.

Clamp Type 2-Wheel Handtruck

Where destacking was done manually two men were required to bring-up, whereas only one man was necessary when a mechanical destacker was used. With manual destacking, the worker removing high crates was productive less than one-third of his time, yet it was necessary that he be there to hand down crates to the second worker who transported them to the dumper. The transporter picked up a 5-crate stack with a clamp type 2-wheel handtruck, transported it to the vicinity of the dumper, and released the stack in the nearest, most convenient place to the dumper. If an automatic dumper was used, the stacks were deposited along its feeder conveyor.

Gravity and Powered Conveyors

Gravity and powered conveyors were invariably used in combination to bring apples from the storage room to the dumper. A gravity section of conveyor supplied full crates to a powered section, which delivered them to the dumper. Conveyors performed the transportation function without labor; however, two men were required to break out crates and put them on the conveyor. The powered portion of the conveyor system was almost always permanently fixed in position; whatever maneuverability the system had was achieved through the gravity sections.

In manual destacking, one worker broke out field crates and set them on a gravity conveyor, and the second worker transferred crates from the gravity conveyor to a powered belt conveyor. Gravity conveyor sections were laid across crates which made up the 4th layer (the 5th to 10th layers having already been removed), and alongside the workface of the crates to be broken out (fig. 6). The break-out man removed full crates from their storage positions and set them down on the gravity conveyor. Crates rolled to the end of the gravity conveyor where a second worker transferred them to the powered conveyor.

From time to time it became necessary to move the gravity conveyors in closer to the crates being broken out. This usually occurred after 3 or 4 tiers had been removed. After the conveyor had been moved in nearer the workface, crates that had supported the roller conveyor were cleared out. Then the worker began again to break out the 5th to 10th layers.

Crates in the 1st to 4th layers were picked up and transported to the belt conveyor by a clamp type 2-wheel handtruck operated by the same worker who had been destacking. Crates stacked 4-high were transported and deposited alongside the belt conveyor. The transfer man set the crates on the conveyor, which carried them to the dumper. Transportation distance for the clamp type 2-wheel handtruck averaged only 12 feet per trip.

Forklift Truck and Pallets

Some larger volume packinghouses in the Appalachian area had installed forklift truck and pallet handling systems. Where this type of equipment was used, it was integrated into all the handling operations, from receiving

through loading out. Thus, apples were received on pallets, stored on pallets, and brought up on pallets.

In bringing-up fruit, the forklift operator entered a storage room, picked up the loaded pallet, and transported it to the vicinity of the dumper. Here he set the load down alongside the chain conveyor supplying the dumper. From here, the fork truck operator either returned to the storage room for another load, or proceeded to other work. It is assumed that where a forklift truck was used, an automatic dumper was also used.

Automatic dumpers were supplied by chain conveyors which held a backlog of around 20 crates. This meant that loaded pallets could be placed alongside the chain conveyor for its entire length, so that the full field crates they held could keep the dumper supplied for an hour (assuming 24 crates per pallet). By stacking pallets 2 deep, twice as many apples could be placed along the chain conveyor. Since 5 pallet loads were dumped each hour, and these were brought up in only 10 minutes, 50 minutes of each hour were left during which the forklift truck could perform other work.

Cost of Bringing-Up

The clamp type 2-wheel handtruck method of bringing-up cost twice as much, and the conveyor method 5 times as much, as the method using a forklift truck and pallets (table 2). With a forklift truck, one worker was able to bring-up fruit and do other jobs as well. In this way the cost of labor and equipment was distributed over a number of operations. With the other two methods, workers assigned to bringing-up fruit spent their full time in that one operation.

Clamp type 2-wheel handtruck.--Using this transportation equipment, together with a mechanical destacker, one worker was able to bring-up 1,000 crates in 8 hours, and still have 3.36 hours of wait time (table 35, appendix). But because this wait time was so interspersed throughout the day, it was not practical to give this man other work to do. This method cost $6.22 per thousand crates more than the forklift truck method, but was $17.87 less costly than the conveyor method.

Had the crates been destacked manually instead of mechanically, the cost would have increased to $20.14 for 1,000 crates (table 36, appendix).

Gravity and powered conveyors.--Labor needed to perform the bring-up operation by use of conveyors totaled 16.00 man-hours per 1,000 crates dumped. Two workers were necessary, though they were unable to perform other than bring-up work.

The capacity of two men to bring up apples with a conveyor system was much greater than the capacity of the dumper to feed apples into the line. Consequently, over 80 percent of the time of the two bring-up men, 13.51 man-hours per 1,000 crates, was spent waiting on the dumper. It might be possible for these two workers to perform certain other jobs during their waiting periods, but their first responsibility is always to maintain a supply of apples for the dumper.

Table 2.--Labor and equipment costs for bringing-up 1,000 field crates of apples from storage to the dumper by 3 different methods--annual volume 50,000 crates 1/

Method	Crew size	Elapsed time	Labor required	Cost		
				Labor 2/	Equipment 3/	Total
	Number	Hours	Man-hours	Dollars	Dollars	Dollars
1 clamp type 2-wheel handtruck and 1 high-piler	1	8.00	8.00	10.00	2.26	12.26
1 10-foot gravity conveyor, 1 clamp type 2-wheel handtruck, and 100 feet of powered belt conveyor	2	8.00	16.00	20.00	10.13	30.13
1 forklift truck and 42 pallets	1	1.04	1.04	1.30	4.74	6.04

1/ Elemental labor requirements for each method are in tables 35, 37, and 39, appendix.

2/ Based on a labor cost of $1.25 per hour, and a bring-up distance of 100 feet.

3/ Clamp type 2-wheel handtruck at $0.018 per hour, high-piler at $0.263, 10-foot gravity conveyor at $0.024, 100-foot powered conveyor at $1.24, forklift truck at $1.62, and pallets at $0.07 each per hour.

Productive labor for 1,000 crates totaled 2.49 man-hours. Less productive labor was required with conveyors, since transportation from storage to the dumper was performed mechanically, but more wait time occurred because two workers were associated with this method. An equipment cost of $10.13 per 1,000 crates was the highest of the methods studied.

Forklift truck and pallets.--No wait time was charged to this method since the forklift truck and its operator could transfer to another operation when they were not needed to bring-up fruit.

The lowest cost method, in terms of productive labor, was that utilizing a forklift truck and pallets. When 24 crates made up a pallet load the bring-up operation was performed with only 1.04 man-hours for each 1,000 crates destacked and delivered to the dumper. Had a pallet load consisted of 30 crates, this work could have been performed with only 0.84 man-hour. Equipment cost was greater than the cost of labor (table 40, appendix). To fully utilize a forklift truck there must be other work besides bringing-up for it to do. Where volume permits, and the equipment can be kept occupied, a forklift truck can prove to be an economical piece of handling equipment.

Forklift Truck and Pallets, Clamp Type 2-Wheel Handtruck, and Floor Chain Conveyor

Different equipment types are often combined to make up a handling system. When properly combined, they can work together for an efficient operation. A good example of this was observed in one packinghouse in the Appalachian area. A forklift truck received prepalletized crates and deposited them in a nearby holding area, and a clamp type 2-wheel handtruck brought up stacks from the pallets to a floor chain conveyor, which delivered them to a destacker. This combination was used to receive and bring-up fruit simultaneously. When receiving was to storage, a forklift truck was used to remove pallet loads and place them in storage.

More equipment was necessary to operate this way, but the entire job of receiving, bringing-up, and destacking was performed by only two workers--one to operate the forklift truck, and the other to operate the clamp type 2-wheel handtruck.

Receiving loaded pallets to temporary block.--Little time was spent maneuvering to pick up the load. The unloading apron was large and uncluttered, and the forklift truck operator was able to get to the truck, pick up the load, and clear it from the truck in very little time. From the orchard truck, loaded pallets were transported to a nearby area and set down for temporary holding. Distance from the truck to this temporary block averaged only 30 feet, so that less time was spent in transit than when loads were taken to storage. Also, there was no tiering of pallets.

In setting pallet loads in place, the fork truck operator took care that each pallet butted against the one ahead of it. This was necessary because the clamp type 2-wheel handtruck operator pushed his handtruck across the pallet surfaces to pick up loads. As this worker emptied pallets of field crates, he removed them to a pallet pile. The forklift truck pushed full pallets ahead to occupy the space made vacant by removal of empty ones.

Bringing-up crates from block to floor chain conveyor.--One worker with a clamp type 2-wheel handtruck transferred all the crates from pallets in the temporary block to a floor chain conveyor. This conveyor was on a concrete platform which was at the same level as the pallets; when a pallet butted against the platform, one continuous surface was formed (fig. 7). The floor chain delivered stacks to a destacker which automatically fed boxes one at a time to an automatic dumper (fig. 8).

Transportation distance varied with location of the pallet from which stacks were taken, but the average distance was about 20 feet. As pallets were emptied, they were removed to a pallet pile. When this pile contained 6 or 8 pallets, it was removed by the forklift truck.

Cost of receiving and bringing-up by forklift truck and pallets, clamp type 2-wheel handtruck, and floor chain conveyor.--Receiving and bringing-up with a combination-equipment system provides more independence of operation for each worker than other methods. This means that each worker can proceed with his task regardless of what other workers are doing. One worker need not wait on another.

BN-10013

Figure 6.--A gravity and powered conveyor system for bringing-up apples. Worker on floor at right transfers apples to powered conveyor.

BN-10274-X

Figure 7.--Floor chain conveyor installed on a platform at pallet height. This permits easy transfer of crates from pallets to the floor chain conveyor.

Total labor required to receive and bring-up 1,000 crates by this method was 2.85 man-hours (table 3). The forklift truck operator removed 1,000 crates in 0.74 man-hour, and the clamp type 2-wheel handtruck operator supplied 1,000 crates to the destacker in 1.98 man-hours. Setup and cleanup took an additional 0.13 man-hour. While the forklift truck operator required only about one-third as much time as the second worker, he still did not have to wait idly. He worked in other parts of the plant and returned to the unloading apron only when an orchard truck appeared.

Equipment made up 49 percent of the cost of this operation; labor 51 percent. Cost of labor totaled $3.56 per 1,000 crates, of which $2.48 was for bringing-up, $0.92 for receiving, and $0.16 for setup and cleanup.

BN-10017

Figure 8.--Clamp type 2-wheel handtruck operator pushing his truck across the surface of an empty pallet in order to reach a load.

Table 3.--Labor and equipment costs for receiving and bringing-up 1,000 field crates of apples by use of forklift truck, clamp type 2-wheel handtruck, and floor chain conveyor--annual volume 50,000 crates

Time item	Crew size	Elapsed time	Labor required	Cost		
				Labor 1/	Equipment	Total
	Number	Hours	Man-hours	Dollars	Dollars	Dollars
Setup, cleanup	1	0.13	0.13	0.16	2/ 0.21	0.37
Receive pallet loads 30 feet to block	1	.74	.74	.92	3/ 3.19	4.11
Bring-up stacks 20 feet from block to floor chain	1	1.98	1.98	2.48	4/ .04	2.52
Total	2		2.85	3.56	3.44	7.00

1/ Based on a labor cost of $1.25 per hour.
2/ 1 forklift truck at $1.62 and 1 clamp type 2-wheel handtruck at $0.018 per hour for 0.13 hour.
3/ 1 fork truck at $1.62 per hour and 42 pallets at $0.07 per hour for 0.70 hour.
4/ 1 clamp type 2-wheel handtruck at $0.018 per hour for 1.98 hours.

Segregating

Apples come off a packing line in a random array of sizes, grades, and package types. Before they can be loaded out or placed in storage, it is necessary first to segregate them into common lots. This is done by checking each container as it comes from the packing line, noting the apple size and grade, and placing that container in the area designated for such apples. Segregating was usually performed by one man and took place either on the warehouse floor or in the storage area.

Segregating on the Warehouse Floor

Segregating took place on the warehouse floor when: (1) Shipments were made up as packed containers came from the packing line, (2) packed apples were stored on pallets, and (3) clamp type 2-wheel handtrucks were used for delivering apples to the holding area.

The segregator did his work along the packed-carton conveyor. Cartons, which were to be either loaded out or taken to storage by clamp type 2-wheel handtruck, were put into 5-high stacks alongside the conveyor. If handling was by forklift truck and pallets, cartons were removed from the conveyor and set down on designated pallets. When a pallet was full it was removed by a forklift truck (fig. 9).

The number of classifications into which packed apples were separated was determined by the number of sizes and grades that the company offered for sale, and sometimes by the number of different lots packed. A usual number was 8 sizes in 2 grades. This meant that as many as 16 combinations had to be provided for. Unless the stacks were taken away regularly, considerable floor space was taken up by the segregation operation. Segregating apples on the warehouse floor required the full time of one worker, plus transporters to carry away full stacks.

It was possible to load pallets at the packing station, making segregating unnecessary. When this was done one man worked only part time to load packed cartons onto pallets. Each packer released packed containers from the packing stand to a short conveyor section, with a separate section for each packing station. This section held 4 or 5 cartons. On the floor at the end of each rested a pallet. One worker moved up and down the packing line removing accumulated cartons from the conveyors and loading them onto their pallets. Full pallets were removed by a forklift truck. With this method only apples of one size and grade could be packed at a station.

Segregating into Storage

In some plants a conveyor carried cartons directly from the packing line to the storage area. Here they were segregated and placed in storage, all in one operation. At least two, and usually three, men did this work. These workers were stationed in the storage room. As cartons came to them on the conveyor, a worker determined where they would be stored. He lifted a carton

BN-10015

Figure 9.--Segregating onto pallets. One worker removes cartons from conveyor and places them on designated pallets. Forklift truck removes full pallets.

from the conveyor and, if the distance were short enough, carried it to and placed it manually in its proper storage position. When the distance to the storage position was too great to permit carrying cartons manually, 5-high stacks were made up alongside the conveyor and these stacks were transported to storage by clamp type 2-wheel handtrucks. At the storage position cartons were piled high by hand.

Cost of Segregating

Segregating is invariably associated with another handling operation, making its cost virtually impossible to isolate. When apples are segregated on the warehouse floor they are at the same time set up in 5-high stacks or pallet loads for transportation to loading-out or to storage. In the storage area the operations of segregating and placing in storage were performed simultaneously and by the same workers, so that separate costs could not be determined. Sorting out and deciding where each carton was to go added some to the cost of either loading-out or placing in storage. But since this cost cannot be separated, it will be included in the cost of the storage operation.

Putting Packed Apples Into Storage

Soon after apples were packed they were loaded-out for shipment, or else delivered to a cold room for storage. They could not be held long at room temperature on the warehouse floor or the fruit would soon deteriorate. Whether packed fruit was held in cold storage depended on the policy of the company. Some plants packed all their fruit immediately after harvest, and that which could not be marketed at the time was placed in storage. Other companies packed only on orders from customers, so that none or very little of their packed fruit was returned to cold storage.

The placing of packed fruit in storage was essentially different from the storing of orchard-run fruit. Packed fruit was arranged in storage according to grade and size, whereas these were not considerations with orchard-run fruit; packed fruit was received at a fairly consistent rate from the packing line, but orchard-run fruit was received in scattered batches subject to arrival of orchard trucks; and there were considerable differences in the container types that were handled.

Putting packed fruit into storage was done in two parts: (1) Transporting apples to storage, and (2) placing them in storage.

Transporting Packed Apples to Storage

The transporting operation includes picking up a load, depositing it at the storage point, and returning. In the Appalachian area this operation was performed by clamp type 2-wheel handtrucks, powered conveyor, or forklift truck and pallets.

Clamp type 2-wheel handtruck.--Stacks of five cartons were built by the segregator as he separated packed cartons by the grade and size of apples they contained. When a stack was complete, he began building another. A transporter moved the 5-high stack to the storage point with a clamp truck. If it were to be the bottom stack, the transporter set the load in its storage place, and returned to the segregating area for another load. Stacks to be high-piled were first set in front of the carton on which they were to set. The stacks were later picked up and placed in storage by a high-piler.

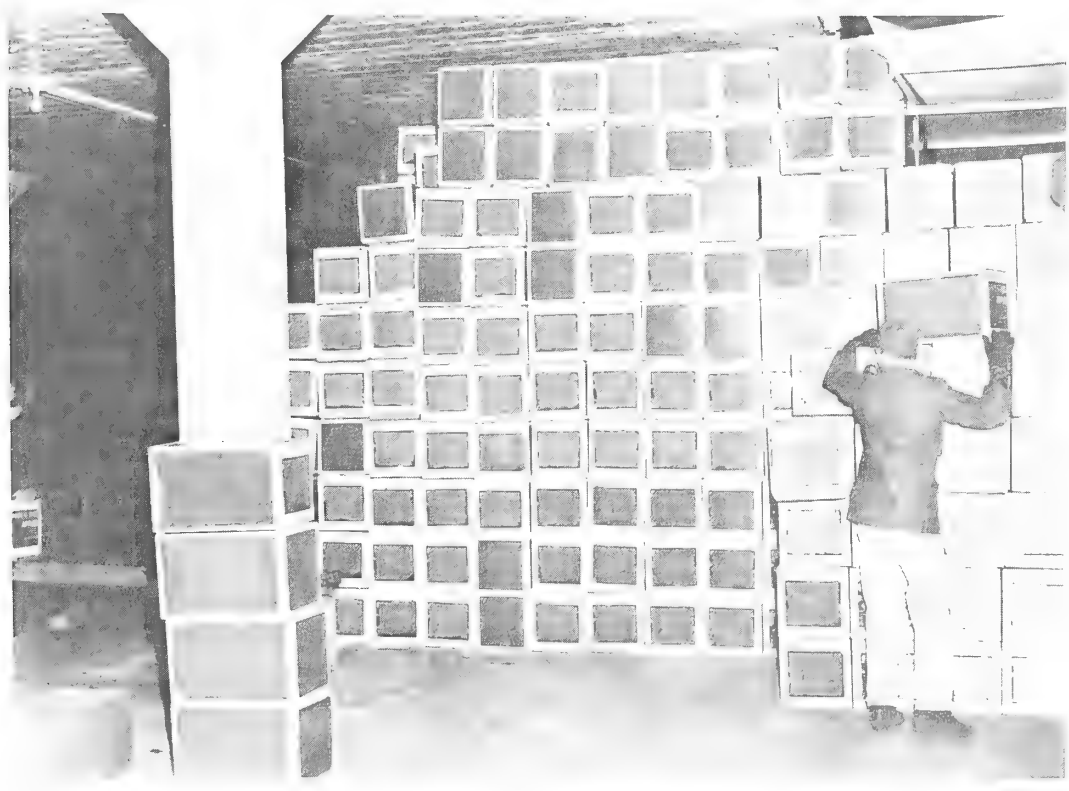
Powered conveyor.--The use of powered conveyors for delivering packed apples to storage is described in the section dealing with segregating into storage. With powered conveyors there was an uninterrupted flow of cartons from packers to the workers who placed them in storage. With this equipment, no labor was required for transporting packed apples to storage.

Forklift truck and pallets.--Cartons from the packing line were delivered by the conveyor. Pallet loads consisting of 30 packed cartons were made up on the warehouse floor by a segregator who was stationed along this conveyor. When a pallet load was complete, it was removed by the forklift truck (fig. 9). The load was either taken to a road trailer for loading-out, placed in a temporary block on the warehouse floor, or delivered to a cold room. There was nearly always ample time between pallet loads for the forklift truck to do other work.

A forklift truck combined transporting and stacking into a single operation, whereas each was performed separately when transportation was by clamp type 2-wheel handtruck or powered conveyors. A clamp type 2-wheel handtruck was able to set the bottom 5 cartons in their storage position, but the top 5 were put up another way. With a powered conveyor, every carton had to be removed individually from the conveyor. It was possible to stack by either manual or mechanical means.

Manual stacking.--Manual stacking occurred when cartons were placed in storage position without the use of equipment. Cartons were picked up by hand, carried to the stack, and set in place (fig. 10). Where a conveyor was used, cartons were removed from it by hand and carried to the stack.

The transporter stacked the cartons 8-high, in storage. He then either returned to the conveyor for another carton, or picked one from the 5-high stack delivered by clamp type 2-wheel handtruck. For those cartons stacked over 8-high the reach was too great, and another worker was needed to lift cartons to the first worker. This worker usually stood in a precarious position on previously stacked cartons. Besides being dangerous for the worker, this procedure could damage the fruit.



BN-10004

Figure 10.--A manual stacking operation. Worker removes carton from conveyor, carries it to the stack, and places carton in storage.

Proper crew size for manual stacking was determined by the packing rate, stacking height, and distance between the powered conveyor and stacking area. In most cases the crew consisted of 2 or 3 men.

Mechanical stacking.--This method differed considerably from manual stacking. The bottom 5 cartons were set in place either manually or by clamp type 2-wheel handtruck, but in order to pile high, cartons were lifted to their storage places by a mechanical device--5 at a time. The mechanical high-piler was the same item used in receiving operations, made suitable for fiberboard cartons by an attachment fitted to its clamp arms.

Mechanical high-piling of packed cartons was performed in the same manner described in the receiving operation for field crates.

Cost of Putting Packed Apples into Storage

To determine the cost of putting packed apples into storage by different methods and equipment types it was necessary to assume certain conditions. These were: (1) A steady dumping rate of 125 field crates (net weight 41 pounds) per hour, (2) 95 percent of the dumped fruit was packed into cartons (44 pounds net weight), (3) where clamp type 2-wheel handtrucks or powered conveyors were used, the workers were assigned full time to the storage operations, and (4) the forklift truck and operator were used in other operations as well. This procedure favors the forklift truck and pallet system in the cost comparisons because its cost is spread over more than one operation. Labor and equipment requirements and costs for three different methods of placing packed apples in storage are presented in table 4. These costs include segregation as well as storing.

The combined labor and equipment cost for storing 1,000 cartons with a clamp type 2-wheel handtruck and high-piler was $24.95. This is $9.12 less than the conveyor method, but $10.28 higher than the forklift truck method.

To place 1,000 cartons in storage with a powered conveyor required 17.94 man-hours. Labor and equipment cost for storing 1,000 cartons of apples by this method was $34.07.

Forklift trucks and pallets had the lowest labor cost, $12.03 for every 1,000 cartons stacked in storage. This method had an equipment cost of $2.64. The forklift truck operator transported the cartons to storage and also placed them in the stack, so that there was no need to assign full time stackers to the cold room. Also contributing to this low labor requirement was the ability of the forklift truck to handle 30 cartons at one time.

Loading-Out

Loading-out consisted of taking apples from the packing line or from a temporary storage area and transporting them to a truck or trailer where they were stowed for shipment. In the Appalachian area virtually all apples left the packinghouse in over-the-road trucks or trailers; the number of rail loadings was inconsequential.

Table 4.--Labor and equipment costs for segregating and putting 1,000 cartons of packed apples into storage by 3 different methods--annual volume 44,250 cartons 1/

Method	Crew size	Elapsed time 2/	Labor required 3/	Cost		
				Labor 4/	Equipment 5/	Total
	Number	Hours	Man-hours	Dollars	Dollars	Dollars
1 clamp type 2-wheel handtruck and 1 high piler	2	8.97	17.94	22.43	2.52	24.95
100-foot powered conveyor (manual high piling)	2	8.97	17.94	22.43	11.64	34.07
1 forklift truck and 34 pallets	2	8.97	9.63	12.03	2.64	14.67

1/ Based on 95 percent of dumped fruit being packed out. Crates 41 pounds net weight, cartons 44 pounds.

2/ Elapsed time set by dumping rate of 1,000 crates daily, with 885 cartons packed.

3/ Elemental labor requirements for each method are in table 41, appendix.

4/ Based on a labor cost of $1.25 per hour, and a transportation distance of 100 feet.

5/ Clamp type 2-wheel handtruck at $0.018 per hour, high piler at $0.263, 100-foot powered conveyor at $1.24, forklift truck at $1.62, and pallets at $0.07 each per hour.

Breaking Cartons Out of Storage

For packed cartons which had been put back into storage, the first step in loading was to break the packages out from their storage positions. A minimum of two workers was necessary to break-out apples manually. With a forklift truck and pallet system, only one worker was necessary.

Cartons stacked 5-high in storage were not handled manually when transportation was by clamp type 2-wheel handtruck. However, all cartons over 5-high were handed down one at a time. In storage, cartons would settle unevenly, so that a high-piler could not be used in destacking. One worker stood on a row of cartons and removed high-stacked cartons from adjoining rows. As they were removed, cartons were handed down to another worker who either built them into stacks for a clamp type 2-wheel handtruck, or set them on a conveyor for transportation to the loading-out area.

Transporting Cartons from Storage

Breaking cartons out of storage and loading them onto the transportation equipment was done simultaneously when: (1) The clamp type 2-wheel handtruck

removed a 5-high stack directly from its storage place, or (2) a forklift truck and pallets were used. These two work elements occurred separately when: (1) 5-high stacks were built on the floor for pick up by a clamp type 2-wheel handtruck, or (2) each package was carried to and placed on a conveyor for delivery to the loading-out area.

Clamp type 2-wheel handtruck.--Five-carton loads were picked up intact and transported directly to the trailer to be loaded. Stacks built along the packing line or from high-piled cartons were easy to pick up. Those stacks which were picked up directly from their storage positions required more careful maneuvering of the clamp type 2-wheel handtruck because of their proximity to other stacks.

Once picked up, the load was wheeled around and pushed toward the loading-out area. Transportation distance was the principal determinant of the labor required for this operation.

Forklift truck and pallets.--To remove a pallet load by forklift truck, the forks were raised to the level of the pallet and inserted. This was done whether the pallet load was positioned on the floor, or in the second or third tier. While swinging about to begin his transport to the loading-out area, the operator adjusted the load to proper height for travel.

Conveyor.--There were many conveyor arrangements for removing cartons from the packing line or storage place to a loading-out point. In storage rooms short sections of gravity conveyor were sometimes used to span the distance between the workface and the main belt conveyor. These sections had to be moved and reassembled periodically, but they saved the time that would otherwise be spent carrying single cartons to the belt conveyor. Where conveyors were used, the break-out crew usually consisted of 2 workers. One man broke out cartons and handed them to the other worker to put on the conveyor.

Loading Trailers

There was a wide range in sizes and capacities of trucks and trailers into which packed apples were loaded. Trucks loaded with as few as 200 and as many as 650 cartons were observed. Usually one or two workers were in the trailer-loading crew. The actual number depended on how many men were available, how fast the trailer was to be loaded, and the number of workers assigned elsewhere in the loading-out operation.

Cartons brought into the trailer by clamp type 2-wheel handtruck were deposited in a position very near the one they were to occupy in the trailer. Where this equipment was used, there was need for only one loader.

Each carton delivered to the trailer by belt conveyor had to be lifted from the belt and stowed by hand in the trailer. One loader was able to perform this job if the end of the conveyor could be kept near the workface in the trailer; where the conveyor did not reach fully into the trailer, 2 workers were necessary. A short length of gravity conveyor extending from the end of the belt conveyor permitted a few cartons to accumulate. But even so, manual transportation within the trailer required 2 workers.

The forklift truck set loaded pallets down in the trailer as near as possible to the workface. The loader lifted cartons from the pallet and placed them in position in the trailer. When the pallet was empty he removed it to the platform to make room for the next pallet load. Where the width of the truck permitted, two pallets could be set down side by side, doing away with the time that was otherwise lost waiting for an empty pallet to be exchanged for a full one.

Cost of Loading-Out

To compute the cost of a loading-out operation, the cost of its individual work elements must be considered. These costs vary according to the equipment and methods used. In table 5 labor and equipment costs are combined to give a total cost for each method.

Table 5.--Labor and equipment costs for loading-out 1,000 containers of apples by 3 different methods--annual volume 46,750 containers 1/

Method	Crew size	Elapsed time	Labor required 2/	Cost		
				Labor 3/	Equipment 4/	Total
	Number	Hours	Man-hours	Dollars	Dollars	Dollars
Manual destacking, transportation by 6 clamp type 2-wheel handtrucks, and manual stowing	8	0.95	7.58	9.47	0.11	9.58
Manual destacking, transportation by 150-foot powered belt conveyor and 10-foot gravity conveyor, and manual stowing	5	1.66	8.32	10.40	3.12	13.52
1 forklift truck and 34 pallets, with manual stowing	2	3.33	4.22	5.28	3.72	9.00

1/ Includes 2,500 boxes of culls which were loaded out but not packed.
2/ Elemental labor requirements for each method are in table 43, appendix.
3/ Based on a labor cost of $1.25 per hour, and a transportation distance of 150 feet.
4/ Clamp type 2-wheel handtruck at $0.018 per hour each, 150-foot powered conveyor at $1.86, 10-foot gravity conveyor at $0.02, forklift truck at $1.62, and pallets at $0.07 each per hour.

Forklift trucks and pallets required 4.22 man-hours to load-out 1,000 cartons; clamp type 2-wheel handtrucks took 7.58 man-hours; and conveyors 8.32 man-hours. Where the transportation distance was 150 feet, only 2 men were used in the loading-out crew with the forklift truck, 5 men were used with the conveyor method, and 8 men with clamp type 2-wheel handtrucks. These are optimum crew sizes to reduce unproductive time to a minimum. The 8- and 5-man crews could be reduced, but the elapsed time, unproductive time, and total labor would all increase. Increasing by one or two the number of workers stowing from pallets would reduce elapsed time, with no increase in the total labor required. This may be desirable when there is urgency in getting out a load.

When these labor requirements were converted to dollars and added to the cost of the equipment required with each method, the forklift truck method had the smallest total cost, $9.00 per 1,000 cartons loaded. The conveyor method had the highest cost, $13.52 per 1,000 cartons, and the clamp type 2-wheel handtruck method cost $9.58 per 1,000 cartons.

The conveyor system, with the highest cost for both labor and equipment, required no labor in transporting cartons to the loading area. However, handling of individual cartons at each end of the conveyor overrode this advantage. Loading-out by conveyor cost half again as much as loading-out by forklift truck and pallets.

Costs of Combined Handling Operations

Five principal handling operations occur in apple packing plants: (1) Receiving, (2) bringing-up, (3) segregating, (4) putting packed apples into storage, and (5) loading-out. Each has been discussed in detail in preceding sections. However, in the final analysis of any materials handling system, it is necessary to combine individual operations into a plantwide handling system, and to compare the cost of this system with the cost of other plantwide handling systems.

Three different materials handling systems are considered: (1) Clamp type 2-wheel handtruck, (2) conveyors, and (3) forklift trucks and pallets. These are basic equipment types. Quite often there are variations of the equipment or auxiliary equipment is used. Identical handling systems were not found in this industry. In each plant the equipment and the method by which it was used had been adapted, adjusted, modified, or rearranged to suit the requirements of the plant in which it was installed. In some cases the handling system was made up of more than one equipment type.

The method presented for each equipment type is, in the main, representative of the method used in the Appalachian area. Elemental data in the appendix make it possible to compute labor and equipment costs for a number of different combinations and methods. But here, the cost is given for only one method with each equipment type. It is assumed in the calculations that 95 percent of the dumped fruit (41 pounds per crate) was packed in cartons (44 pounds per carton), and 5 percent was culls collected in crates (41 pounds per crate).

Clamp Type 2-Wheel Handtruck

This equipment required the smallest capital investment and had the lowest equipment cost of the three types studied, $5.03 per 1,000 crates handled (table 6). Its equipment cost was, in fact, only one-fifth that of the conveyor method, and one-third that of the forklift truck method. Labor cost for the clamp type 2-wheel handtruck was $45.94 per 1,000 crates. This was higher than for the forklift truck method but lower than for the conveyor method. The total cost of receiving, bringing-up, segregating, storing, and loading-out the equivalent of 1,000 crates was $50.97. Of this cost, 43 percent was for segregating and storing packed fruit, 24 percent for bringing-up apples to the dumper, 18 percent for loading-out, and only 15 percent for receiving.

Conveyors

Despite the fact that manual transportation was largely eliminated where conveyors were used, this method proved the most costly for both labor and equipment. Handling operations cost $62.62 per 1,000 crates for labor, and $26.96 for equipment, for a total of $89.58. This cost is 76 percent more than for clamp type 2-wheel handtrucks, and one and a half times greater than the cost of a forklift truck and pallet method. Labor accounted for 70 percent of the cost of the conveyor operation. This high labor cost is, in part, accounted for by manual high-piling and destacking assigned to this method. But even if a mechanical high-piler were used, little labor saving could be expected. Each container must be individually and manually placed down on the conveyor and removed in reverse manner. It is the high number of manual handlings that creates the high labor requirement.

Among the 4 handling operations, segregating and storing packed apples accounted for 35 percent of the total cost, bringing-up apples 34 percent, loading-out 15 percent, and receiving 16 percent.

Forklift Truck and Pallets

The cost of equipment for this method of handling was much greater than for the clamp type 2-wheel handtruck method, but was less than that for the conveyor method. The labor cost for using a forklift truck and pallets was only 40 percent of that of the clamp type 2-wheel handtruck method and 29 percent of the cost for labor that occurred with conveyors. The combined labor and equipment cost for the forklift truck method totaled 65 percent of the cost for the clamp type 2-wheel handtruck method and 38 percent of the cost of conveyors. A good part of the saving in labor resulted from the elimination of wait time that was inherent in the other methods.

Of the $33.93 combined labor and equipment cost for the 4 handling operations, 25 percent was for loading-out, 18 percent for bringing-up to the dumper, 19 percent was for receiving, and 38 percent for segregating and placing packed cartons in storage.

Maximum results with a forklift truck method are contingent on a skilled operator and optimum working conditions. These include good visibility to all

Table 6.--Combined labor and equipment costs per 1,000 crates dumped for plantwide handling systems based on 3 different equipment types. Annual volume 50,000 crates, with 95 percent of apples by weight packed out in cartons, and 5 percent culls collected in crates

Operation	Containers handled 4/	Clamp type 2-wheel handtrucks 1/						Conveyors 2/						Forklift trucks and pallets 3/					
		Crew size	Elapsed time	Labor required 5/	Cost: Labor 6/	Cost: Equipment	Cost: Total	Crew size	Elapsed time	Labor required 5/	Cost: Labor 6/	Cost: Equipment	Cost: Total	Crew size	Elapsed time	Labor required 5/	Cost: Labor 6/	Cost: Equipment	Cost: Total
	Number	Number	Hours	Man-hours	Dollars	Dollars	Dollars	Number	Hours	Man-hours	Dollars	Dollars	Dollars	Number	Hours	Man-hours	Dollars	Dollars	Dollars
Receiving 100 feet to storage	1,000	4	1.42	5.67	7.09	0.44	7.53	6	1.72	10.32	12.90	3.01	15.91	1	1.11	1.11	1.39	5.06	6.45
Bringing-up 100 feet to dumper	1,000	1	8.00	8.00	10.00	2.26	12.26	2	8.00	16.00	20.00	10.13	30.13	1	1.04	1.04	1.30	4.74	6.04
Segregating and putting in storage (100 feet)	885	2	8.00	16.00	20.00	2.23	22.23	2	8.00	16.00	20.00	10.90	30.90	2	8.00	8.52	10.65	2.34	12.99
Loading-out (150 feet)	7/ 935	8	0.89	7.08	8.85	0.10	8.95	5	1.55	7.78	9.72	2.92	12.64	2	3.11	3.98	4.97	3.48	8.45
Total		15	18.31	36.75	45.94	5.03	50.97	15	19.27	50.10	62.62	26.96	89.58	6	13.26	14.65	18.31	15.62	33.93

1/ Containers over 5-high were handled by a high-piler, except for breaking out cartons which was done manually.
2/ Clamp type 2-wheel handtrucks transported containers from powered conveyor to storage point, and bottom 4 containers from storage point to powered conveyors.
3/ Crates palletized before arrival at packing plant.
4/ Net weight of field crates 41 pounds; packed cartons 44 pounds.
5/ Includes time for unavoidable delays.
6/ Based on a cost of $1.25 per hour.
7/ Includes culls.

parts of the plant, sufficient room for maneuvering, clear aisles, smooth floors, wide doors, and a minimum of columns, duct work, and other obstructions.

APPLE PACKING LINE OPERATIONS

An apple packing line is the combination of several individual operations, closely synchronized, and usually performed simultaneously. It is, in effect, a production line which feeds in a raw product (orchard-run apples) at one end, and takes out a finished product (graded, sized, and packaged apples) at the other. The individual operations included in a packing line are: (1) Dumping, (2) sorting, (3) sizing, (4) packing, and (5) other operations (lidding, labeling, tallying, carton making, and boxing culls).

Dumping

In the dumping operation apples were tipped out of field crates onto a belt which moved them toward the sorters. This was the operation which fed all the other packing line operations, and set their performance rates. Dumping held a key position in the cycle of operations, making it imperative that a supply of orchard-run apples be always available at the dumping station, and that these apples be dumped at a steady, predetermined rate.

Apples were tipped out of field crates by both manual and mechanical means. Where done manually, two workers were employed; where performed mechanically, only the fractional time of one worker was required.

Manual Dumping

Nearly all packinghouses in the smaller volume range dumped manually, as did some larger volume houses. One worker kept a full field crate ready for the second worker who tipped apples out onto a spreader belt. The person performing the dumping disposed of empty crates, either by stacking them beside the dumping station, or by placing them on a conveyor. A typical 2-man dumping crew is shown in figure 11.

Two workers had the capacity to maintain a rate of 3.8 crates per minute, 228 per hour, or 1,824 per 8-hour day. This includes disposing of empty crates. At a dumping rate of 1,000 crates per day, these men were working at only 55 percent of their capacity. Yet, they could not be assigned other work.

Mechanical Dumping

Labor required to hand-dump can be reduced to a fraction by a mechanical dumper. There are different types of mechanical dumpers; one commonly used is shown in figure 12. This dumper has a capacity of 600 boxes per hour. Field crates were fed to it by a friction-drive conveyor, which could maintain a reservoir of 30 or more crates. One worker could fill this conveyor and then leave to perform other work. As the reservoir neared depletion he would take time to fill it again with crates of orchard-run apples. Except for this

BN-10016

Figure 11.--Two workers at a manual dumping station. One worker keeps a full crate in readiness for second worker who tips apples out onto spreader belt. Dumper disposes of empty crates on belt conveyor.

BN-10014

Figure 12.--Drum-type mechanical dumper. Note reservoir of field crates and gravity conveyor for carrying off empty crates.

occasional refilling of the friction-drive conveyor, the entire dumping operation was automatic. The desired dumping rate could be set into the machine and maintained without variation. Apples were tipped out with very little bruising, and the empty boxes were automatically carried away from the dumper by a conveyor.

One thousand crates could be placed on the friction-drive conveyor with only 1.67 man-hours of labor. The worker who did this spent most of his time doing other work within the area of the dumper, including stacking empty crates.

Cost of Dumping

Labor and equipment costs for dumping 1,000 crates daily for 50 days are shown in table 7. The cost for the manual method was $21.96 per 1,000 crates; for the mechanical method $10.78, or $11.18 less. The mechanical dumper added $6.73 per 1,000 crates to the equipment cost, but reduced labor by $17.91.

Table 7.--Labor and equipment costs for dumping 1,000 crates of apples by 2 different methods, at a rate of 1,000 crates dumped per day--annual volume 50,000 crates

Method	Crew size	Elapsed time	Labor required	Cost		
				Labor 1/	Equipment	Total
	Number	Hours	Man-hours	Dollars	Dollars	Dollars
Manual:						
One man maintains a supply of orchard-run crates for second worker who tips apples out of crates and sets empty crates aside	2	8	2/16.00	20.00	3/1.96	21.96
Mechanical:						
One man spends part time filling friction-chain conveyor with field crates, which are fed to and dumped by drum-type mechanical dumper; empty crates are carried away by conveyor	1	1.67	1.67	2.09	4/8.69	10.78

1/ Based on a labor cost of $1.25 per hour.
2/ Includes 6.45 man-hours of wait time.
3/ One spreader belt used 8 hours at $0.245 per hour.
4/ One 20-foot friction-chain conveyor 8 hours at $0.091 per hour. One rotary dumper 8 hours at $0.725 per hour. One spreader belt 8 hours at $0.245 per hour. One 10-foot gravity conveyor section 8 hours at $0.025 per hour.

Sorting

Sorting is the operation which separates apples into quality groups. It is an important operation to the packer. His reputation and the dollar return from his crop depend on how accurately this work is done. Grading down good quality fruit is tantamount to giving away apples; leaving poor quality fruit in with the high quality apples may, in the long run, cost even more. A fuller discussion of the sorting operation, including costs of different methods and types of sorting tables, was published in an earlier report. 1/

Each change in size or quality of apples can affect the productive capacity of the sorters. Workers can sort more fruit when apples are of large size and high quality than when they are small and of low quality. Because of this, it may become necessary to change the dumping rate--and thus the sorting rate--as the composition of field-run fruit changes. Or, to avoid slowing down other packing line operations, it may be necessary to temporarily add packers when lots difficult to sort are encountered.

Factors Which Influence the Sorting Operation

Both the rate at which apples are sorted and the caliber of the sorting job are affected by a number of factors, some of which are as variable as the makeup of a lot of orchard-run fruit. Factors which directly influence the sorting operation are: (1) Number of sorters, (2) quality in incoming fruit, (3) number of grades sorted out, (4) level of sorting performance, (5) type of sorting table, (6) capacity of the dumper, (7) prevalence of hard-to-detect injuries (like hail peck), and (8) arrangement of work stations.

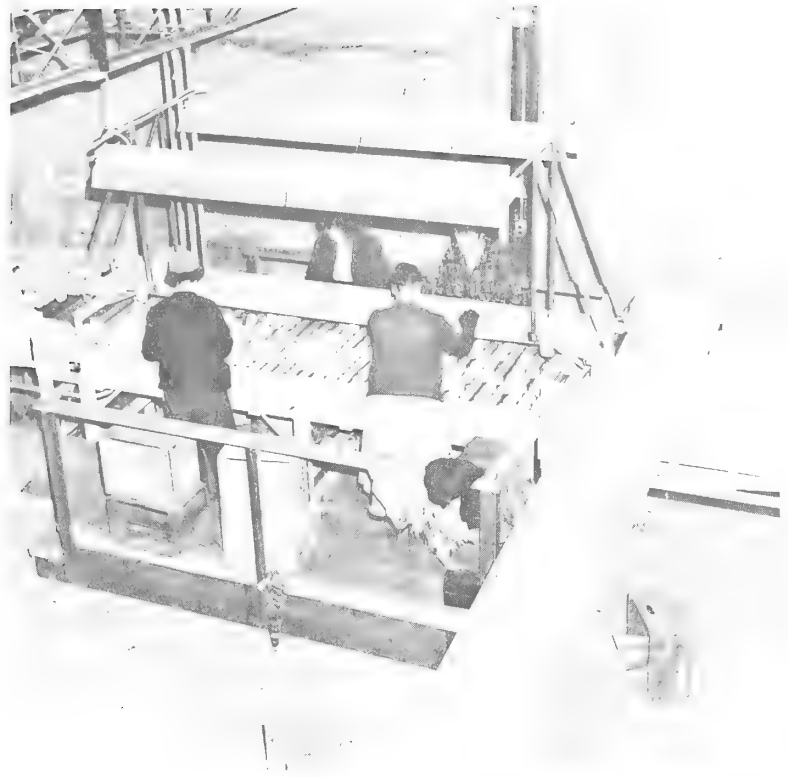
It has been found that the rates of translation and rotation of fruits and their direction of rotation bear directly on the capacity of the workers to properly perform the sorting function. 2/ Of these, the rotational rate and direction probably have the greatest influence on sorting efficiency. With spheroidal objects a forward rotation of 1.6 revolutions per foot of translation is most desirable. To achieve this rate of rotation the diameter of each apple would have to be 2.4 inches, which is about size 180, and considerably smaller than average. Since it is impossible to control the size of fruit being sorted, the rate of rotation must be adjusted by some other means.

Roller Sorting Table

In the Appalachian area the roller sorting table predominates (fig. 13). It was found in both small and large packinghouses, almost to the exclusion of other types of sorting tables. It featured a continuous series of wooden rollers which carried apples forward at a constant, predetermined rate. Apples rode between rollers and rotated in a backward direction as they progressed past the

1/ Hunter, D. L., Kafer, F., and Meyer, C. H. Apple Sorting Methods and Equipment. U. S. Dept. Agr. Mktg. Res. Rpt. 230, 24 pp. illus. Aug. 1958.

2/ Malcolm, D. G., and DeGarmo, E. P. Visual Inspection of Products for Surface Characteristics in Grading Operations. U.S. Dept. Agr. Mktg. Res. Rpt. 45, 57 pp. illus. June 1953.



BN-10000

Figure 13.--Roller sorting table, the type most frequently found in the Appalachian area.

sorters. Forward speed of the rollers could be adjusted, with the rate of rotation of the rollers (and consequently the turning rate of the apples), varying directly with the adjustment.

Individual roller sorting tables varied some in their dimensions, but centered around 4 feet in width and 8 feet in length, with the translation rate usually set at 25 to 35 feet per minute. The actual rate was adjustable over a much wider range than this.

The brusher removed loose dirt and polished the fruit. As apples left the brusher, they fell in place between two rollers of the sorting table. These rollers were hardwood, 2-1/4 inches in diameter, and 4 inches on center. Axles of these rollers were attached loosely to chain drives along each side of the table. These chains propelled the rollers forward. Rotation occurred as the rollers dragged over an apron along each side of the table. Their rate of rotation could not be regulated independently. Neither could the rollers be made to turn in a reverse direction.

At a forward rate of 30 feet per minute, a roller with a 2-1/4 inch diameter rotates 51 times per minute. Over an 8-foot length of table each roller would rotate 13.6 times. At this rate a 2-3/4 inch apple (size 120) would rotate 11.1 times in 8 feet, or make 1.4 revolutions per foot on its trip over the sorting table. These figures assume no slippage between the roller and side aprons, or

between roller and apple. In practice, the rotational rate would be somewhat less than that given, since some slippage is certain to occur. Smaller fruit would rotate faster; larger fruit more slowly.

Sorters stood (or sat) alongside the sorting table. As apples passed before them they inspected the fruit and decided the grade classification of each apple. The highest grade was left on the table to be carried off to the sizer. Lower grades were removed, and the sorter separated them into their classifications. Belt conveyors over the sorting table took away each classification of the lower grade fruit. Culls were usually collected in crates beside the sorters.

To move more apples across a roller sorting table, it was necessary to increase the translation rate, and consequently the rotational rate of the rollers. This also increased the revolutions per minute of apples (always in a reverse direction) being sorted. There was a point beyond which efforts to step up the capacity of a roller sorting table would result in a breakdown of the sorting function.

Spiral Sorting Table

Another type of sorting table used in the Appalachian area was the spiral sorting table (fig. 14). It consisted of 10 or more 8-foot rollers side-by-side and parallel to the length of the table. These rollers were padded with felt material. A cotton rope of the clothesline variety was wrapped around each roller in the manner of a spiral. All rollers on each side of the table rotated at the same rate and in the same direction. Apples, as they left the brusher, dropped between rollers and were carried forward through the spiral action of the ropes. As apples rolled forward they were inspected by the sorters. Undergrade fruit was removed and placed on one of two conveyors over the sorting table which carried it to an accumulation point. Culls were put in crates beside the sorters. Each over-the-table conveyor was for a designated grade of apples; these apples were of lower grade than those left on the sorting table.

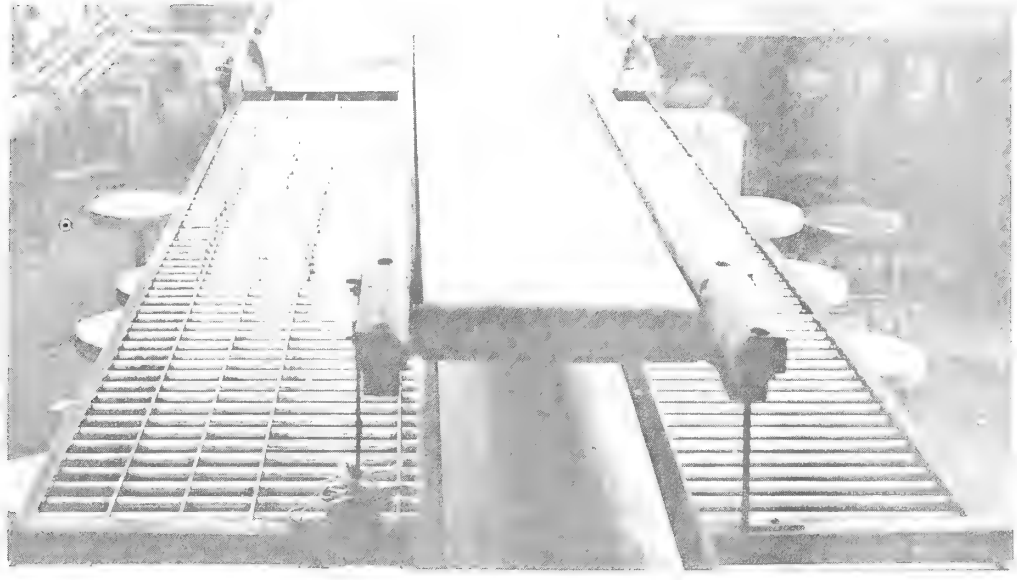
Float Roll Sorting Table

The float roll sorting table resulted from developmental work in the Pacific Northwest area under a contract administered by the United States Department of Agriculture. Deficiencies in sorting tables in current use were pointed up in an intensive study of sorting operations; suggestions were made for the improvement of sorting tables. The float roll sorting table (fig. 15) resulted from this study.

Independent control of both the rate of rotation and the rate of translation of the rollers is a requisite for optimum sorting performance; it was achieved with this table. These rates could be changed as the lots of apples changed, permitting sorters to do their best job at all times. This table was similar to the roller sorting table, except that aluminum rollers smaller in diameter were used. These rollers were spaced closer together, so that fruit rode on top of them, rather than between. This table could be divided into lanes, and each sorter could be given the responsibility for sorting apples in a lane assigned to her. There are a number of advantages to sorting from lanes: (1) The number of apples sorters can inspect is increased, (2) duplication of work

BN-10020

Figure 14.--Spiral sorting table. Apples move forward in lanes in the space between adjacent spiral rollers.



BN-10005

Figure 15.--Float roll sorting table. Independent control of rates of translation and rotation permits the sorting of more apples with greater accuracy.

is eliminated, (3) sorters develop a greater feeling of responsibility, (4) work is equalized among sorters, and (5) work of each sorter can be checked.

Cost of Sorting

Equipment represented less than 10 percent of the total cost of sorting. The remainder was the cost of labor to inspect the fruit and divide it into grades. While equipment cost was relatively fixed, the cost of labor was variable. The number of sorters needed for a given volume of apples varied with (1) type of sorting table used, (2) quality of incoming fruit, (3) number of grades being sorted, and (4) accuracy of sorting. As a general rule, with a roller type of sorting table (without lanes), 6 workers were able to sort 1,000 crates per day if the number of utility grade apples did not exceed 30 percent of the orchard-run fruit. Where lanes were used, productivity was somewhat greater.

At a dumping rate of 1,000 crates per day, and with a crew of 6 sorters, the cost of sorting 1,000 crates was $63.57 for the wooden roller type table; $64.30 for a spiral table; and $65.65 for a float roll table (table 8). There was no difference in the cost of labor, and only $2.08 per 1,000 crates in the cost of sorting tables when the dumping rate and crew size remained the same. The actual difference in sorting costs was determined by the capacity of the sorters which varied with the type of sorting table used. Six sorters had a greater sorting capacity when working from a float roll table than when working from either a spiral or roller type of table. By increasing the amount of fruit available to the sorters, unit cost for sorting could be reduced, as well as the cost of all those packing line operations whose rates were determined by the rate at which apples were sorted.

Table 8.--Labor and equipment costs for sorting 1,000 crates of apples with 3 different types of sorting tables--50,000 crates dumped per year at a rate of 1,000 crates per day

Type of sorting table	Crew size	Elapsed time	Labor required	Cost		
				Labor 1/	Equipment 2/	Total
	Number	Hours	Man-hours	Dollars	Dollars	Dollars
Wooden roller	6	8	48	60.00	3.57	63.57
Spiral	6	8	48	60.00	4.30	64.30
Float roll	6	8	48	60.00	5.65	65.65

1/ At $1.25 per hour.
2/ Table 26, appendix.

Sizing

Apples are marketed on the basis of both their grade and size. After grading, they are further divided into size groups. Under the U. S. Standards for apples, minimum size is determined by the greatest diameter along the stem-calyx axis. Size is often stated as the number of apples that would be packed into a wooden box or fiberboard carton. In the Appalachian area the sizes most commonly packed were: 64, 72, 80, 88, 100, 113, 125, 138, 150, and 163. Although both larger and smaller sizes were put up, these account for the great volume of packed fruit. Apples that were smaller than size 163 were usually bagged and packed in master cartons.

Sizing required no labor as the entire operation was performed mechanically. Since cost of labor was not a factor, considerations in evaluating this operation were: (1) Cost of owning and operating the sizer, (2) capacity of the sizer, (3) its accuracy, and (4) the amount and severity of bruising that it caused. Three different types of sizers were studied: (1) Chain, (2) weight, and (3) dimension. Chain sizers (which sized according to an apple's diameter) were found in more packinghouses than were the other types, and practically all smaller volume houses sized with this equipment.

Chain Sizers

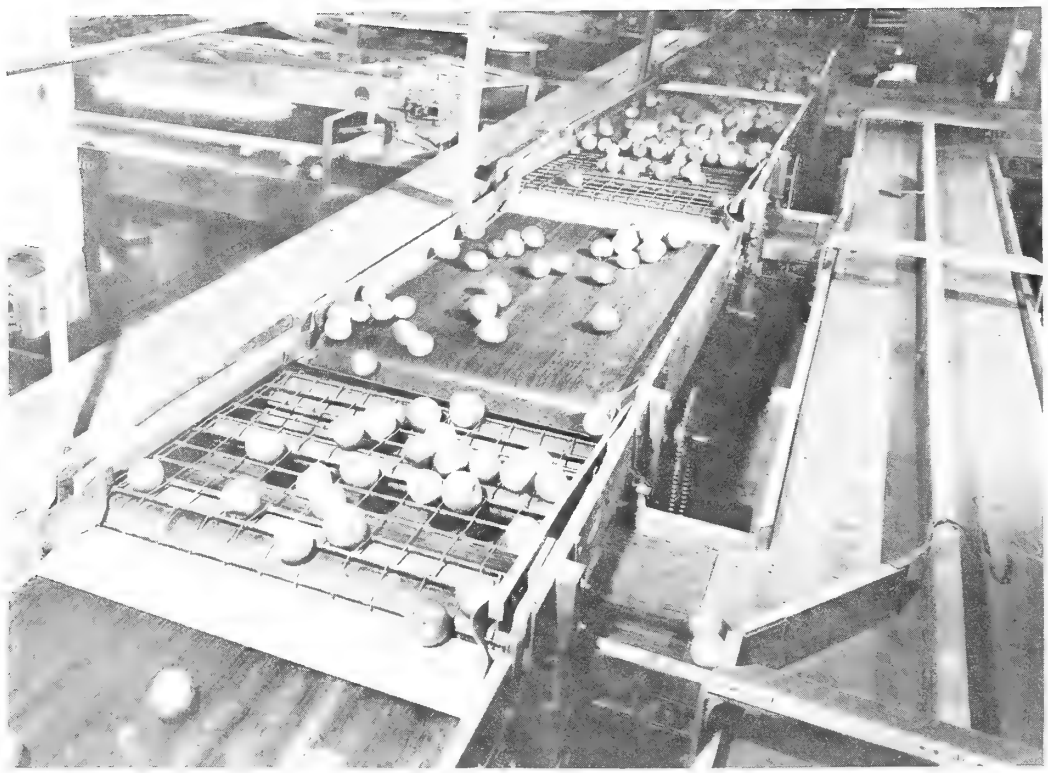
This equipment consisted of a series of sizing chains connected by short spreader belts (fig. 16). Each chain of the series was designed so that apples larger than a specified size would ride over it, and those under that size would fall through. Apples which rode over spilled off onto a spreader belt and were delivered to the next size of chain. Apples which fell through dropped onto a belt conveyor and were delivered to a packing station.

Accuracy of sizing by this method was approximately the same as for the other two sizing methods, but the chain sizer had a smaller capacity. The least amount of crowding caused bruising to mount rapidly. It was important that distances apples dropped onto and from the chain be minimized, and that padding material be applied wherever needed.

Where most chain sizing systems removed the smallest apples at the first chain, and the largest at the last chain, there were some that reversed this and removed the largest fruit first, and the smallest last. Under this system all apples below the largest size would fall through onto a belt conveyor which delivered them to another chain. The fruit that rode over the chain was carried off to a packer. All fruit below the second largest size fell through the second chain, only to go over still other chain sizers. With this method of sizing the large fruit rode over fewer chains, and it was this fruit that was most easily bruised. However, this advantage was cancelled by the fact that the great majority of apples dropped through several chains before coming to rest. All these extra drops added bruises to the apples.

Weight Sizers

Size measurement by weight was possible because of the close correlation



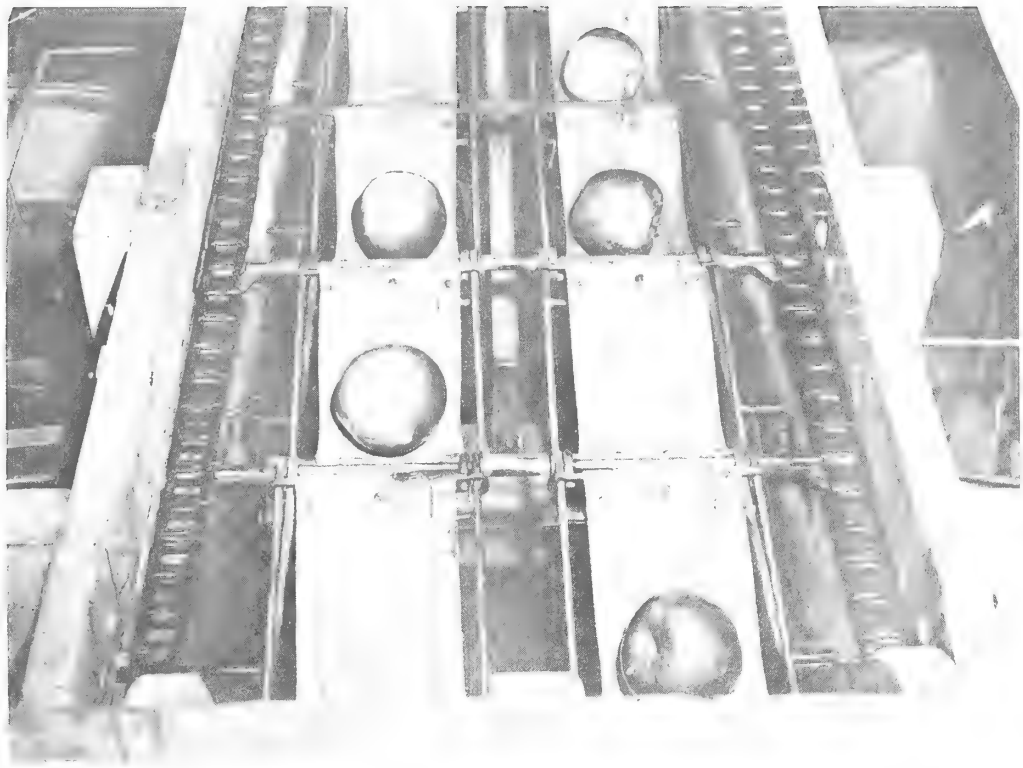
BN-10010

Figure 16.--Chain sizer. Apples too large to drop through are carried over to the next larger chain where they either fall through or are again carried over to a still larger chain.

between an apple's weight and its diameter. Weight sizing was always associated with tub accumulators, from which apples were lifted manually when they were packed.

The equipment consisted of sets of canvas cups linked together to form an endless chain. Two such chains, parallel to each other, were in each sizing machine (fig. 17). Apples from the sorting table dropped into the canvas cups, one apple to a cup. As they moved forward each was tested by a succession of spring scales. When the weight of the apple in a cup corresponded with the setting of a scale, an activating arrangement tripped the cup so that the apple spilled out, and was delivered to the proper accumulating tub. Large apples were taken out first, and small apples last.

Each scale could be adjusted independently and over a wide range of weights. Accuracy of sizing with this machine was dependent on: (1) All apples having the same specific gravity, (2) the center of gravity of the apple resting in the center of the cup, and (3) the scales being properly set and kept that way. Weight sizing was as accurate as chain or dimension sizing, and no more damaging to the fruit when proper care was taken.



BN-10007

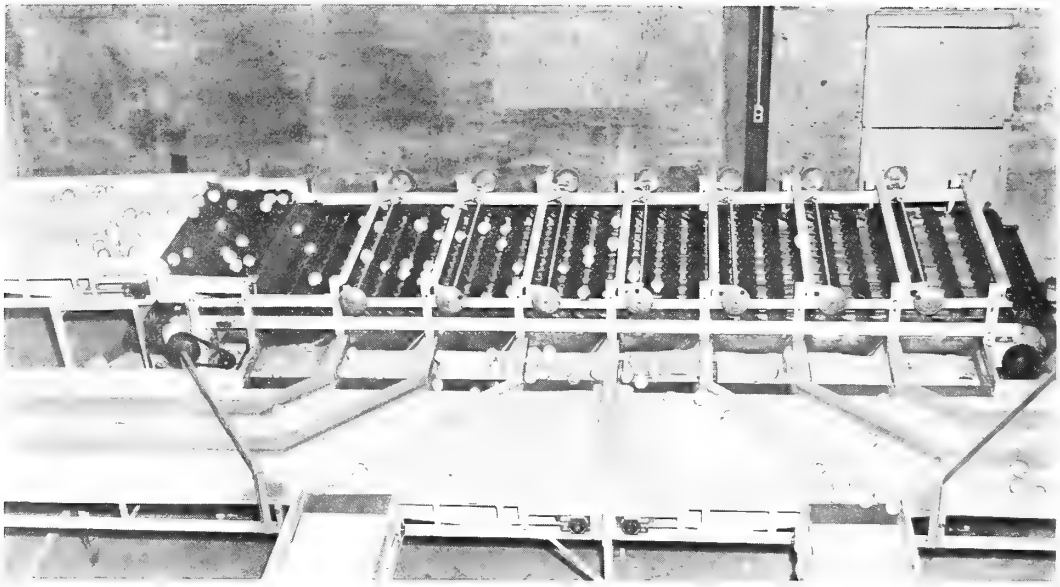
Figure 17.--Canvas cups of a weight-type sizer used in packinghouses in the Appalachian area.

Dimension Sizers

Dimension sizers are not to be confused with chain sizers, which also size apples according to their dimensions. Rather, a dimension sizer, as used here, refers to a single machine designed to test an apple for its greatest diameter along the stem-calyx axis, and having determined that diameter, to deliver the fruit to an accumulator for apples of that size.

A dimension sizer used by some packinghouses in the Appalachian area had several sets of plastic cups made up of two parts. These separated as they moved forward (fig. 18). Apples dropped through at the point where the opening in the cup equaled the diameter of the apple. Take-away belts delivered the apples to designated sections of a return flow-belt, from which they were packed out.

Because of the random manner in which apples came to rest in the cups, it was impossible to achieve a high degree of uniformity. Still, the accuracy of sizing with this equipment was about the same as with the chain and weight sizers.



BN-10006

Figure 18.--A dimension sizer. Plastic cups move apart as they travel forward and apples drop through, according to their size, onto take-away belts.

Cost of Sizing

The only cost in apple sizing was for equipment as no labor was used. Initial cost, annual cost, and cost per 1,000 crates dumped for each of three sizers are given in table 9. Chain sizers cost $19.40 per 1,000 crates dumped. This includes 6 chain units and 7 spreader belts which separate the chain units. The weight sizer cost $15.84 per 1,000 crates, and the dimension sizer with spreading cups $20.15. Only one-half of the cost of the weight sizer has been charged to the sizing operation; the other half to packing.

Packing

Placing apples of uniform size and quality into shipping containers culminated all the handling and packing line operations so far discussed. Receiving, storing, sorting, sizing, and all the other operations were for the final purpose of putting up an attractive pack that would appeal to buyers. With this as their goal, packers have been quick to accept improvements in containers and packing materials. In a few years the industry shifted from baskets to boxes, and then to cartons as the principal containers of apples for the fresh market. Retail-size bags were introduced along with cell and tray packs for separating and protecting apples within the container.

Apples were packed in bushel baskets, wooden boxes, and fiberboard cartons, with most of them going into fiberboard cartons. The amount of fruit bagged was variable; with some plants it was a considerable part of their production, while others did not bag at all. U. S. No. 1 and Utility grade apples were

Table 9.--Cost of 3 different types of sizing equipment, based on 50,000 crates dumped annually

Type of sizer	Initial cost	Annual cost	Cost per 1,000 crates dumped
	Dollars	Dollars	Dollars
6-unit chain sizer 1/	4,775	969.82	19.40
20-tub weight sizer 2/	4,975	792.08	15.84
6-unit expanding cup dimension sizer 3/	5,400	1,007.45	20.15

1/ Includes 7 spreader belts to separate the chain sizers.
2/ The weight sizer is a combined weighing and accumulating device. Since apples are packed from tubs which are a part of this equipment, only half the cost has been charged to sizing and the other half to packing.
3/ Includes one spreader belt.

either packed, bagged, or jumble-filled, depending upon market conditions and packinghouse policy. To permit comparisons between methods, it is assumed that these apples were handled and packed in the same manner and by the same methods as the higher grade fruit.

Bushel Baskets

Although fewer baskets were packed each year, a significant number of bushel baskets was used in small-volume houses and for early variety apples. These baskets averaged 47 pounds net weight, and except for the top layer (face), were jumble packed. Packing of bushel baskets occurred in two parts: (1) Facing, and (2) filling. These two jobs were performed by different workers, but were closely coordinated and performed simultaneously.

Facing.--This was done to make the pack more attractive by putting a symmetrical layer of eye-catching apples across the top of a jumble-filled bushel basket. Facing apples were selected from the orchard-run fruit for their appealing color and conformation.

Facers arranged apples in rings in concave metal plates slightly larger than the top of a bushel basket. The most attractive side of each apple was put down (it was this side that would show in the packed basket). When all the rings were formed in a faceplate, it was removed from the stand and delivered to the filler.

Filling.--Bushel baskets were filled by a worker who set a prepared faceplate on a stand and covered it with a paper liner. This liner, which was the shape and size of a bushel basket, was filled rather than the basket itself. A metal shell of the same size was placed over the liner to add rigidity.

The facing ring together with its liner and shell was positioned under a gate in the side of a return flow belt. The worker filling baskets directed apples through the gate and into the liner. He would stop filling periodically and sprinkle oil-impregnated shredded paper over the apples. He shut the gate and placed the last 8 or 10 apples manually.

When the liner was full, the entire unit (faceplate, liner, and shell) was transferred to a belt conveyor. The shell was removed so that it could be used in filling the next liner. At the lidding station a bushel basket was slipped over the full liner, the basket inverted, and the faceplate lifted off.

Cost of packing bushel baskets.--In this analysis only the costs of labor and equipment are considered; containers and packing supplies are not included. At $1.25 per hour, labor cost $83.04, and equipment only $0.10 per 1,000 baskets packed (table 10). This is a combined cost of $83.14, or 8.3¢ per basket. Six facers and three fillers were the optimum crew to face and fill 1,000 baskets in an 8-hour day. Because of the imbalance of work involved, fillers waited 1.96 man-hours, which is included in the cost of labor.

Table 10.--Labor and equipment cost for packing 1,000 bushel baskets of apples at an annual volume of 50,000 and a daily volume of 1,000 baskets

Operation	Crew size	Elapsed time	Labor required 1/	Cost		
				Labor 2/	Equipment	Total
	Number	Hours	Man-hours	Dollars	Dollars	Dollars
Prepare face rings	6	7.38	44.29	55.36	3/0.08	55.44
Fill baskets	3	7.38	4/22.14	27.68	5/0.02	27.70
Total	9	7.38	66.43	83.04	0.10	83.14

1/ Labor requirements are given in table 45, appendix.
2/ At $1.25 per hour.
3/ Twelve faceplates at $0.007.
4/ Includes 1.96 man-hours of wait time.
5/ Three filling shells at $0.007.

Fiberboard Cartons

More apples were packed out in fiberboard cartons than in any other type of container. With the exception of those first put into bags, all apples packed in fiberboard cartons were also tray packed. Forty-five percent of all fruit

packed in the Appalachian area was tray-packed, 25 percent was bagged in master cartons, 20 percent was place-packed in wooden boxes, and 10 percent was packed in bushel baskets.

There were three ways in which apples were tray packed: (1) Manually from tubs, (2) manually from a return flow belt, and (3) by semiautomatic tray packers. Each method had its own labor and equipment requirements, and productive capacity. Data for each method are based on size 113 apples.

Packing manually from tubs.--Tray packing from tubs was always associated with sizing by weight. Different tubs were used for different sizes of apples. Tubs rotated slowly, and fruit within them remained evenly distributed during packing. A "floating" bottom in each tub was meant to keep the top layer of apples at a fixed height so that packers would not have to reach very far into the tub for apples. However, when only a few apples were in the tub, it was necessary for the packer to reach down into the tub for them.

After placing an empty carton on the stand and a tray in the carton, the packer lifted apples from the tub and placed them in tray pockets (fig. 19). A common method was to remove apples with one hand, tranfer them to the other hand, and then set them in place in the carton. When the carton was full, it was lifted from the stand and carried to a conveyor. By this method a worker was able to pack 17.2 cartons per hour or 138 cartons per 8-hour day.

BN-10018

Figure 19.--Packing trays by hand from a rotating tub. A "floating" bottom holds apples at a fixed height for ease of packing.

Packing manually from a return-flow belt.--Packing apples from a return-flow belt was much like packing them from a tub. The packer stood beside the belt, removed apples as they came by her, and packed them into cartons on a stand alongside the belt (fig. 20).

A return-flow belt consisted of 2 belt conveyors adjacent to each other, but traveling in opposite directions. Apples accumulated behind retarders, forming reservoirs from which the packers worked. Moveable shunts divided the belt into sections for different sizes of fruit. Because these shunts were moveable, the portion of the return-flow belt given to each size could be adjusted as necessary. The return-flow belt provided the packer with a clear view of the fruit; this together with a shorter reach enabled him to pack 22.6 cartons per hour, or 181 cartons per day.

BN-10019

Figure 20.--Worker manually packing apples from a return-flow belt.

Packing with semiautomatic tray packers.--A semiautomatic tray packer is a device which fills trays, releases them to a carton, and then sends the filled carton to a conveyor (fig. 21).

The semiautomatic tray packer was always in position at a gate in the side panel of the return-flow belt. From the belt apples were guided by a retarding bar onto a pan which held the approximate number of apples to fill one tray. After setting a tray in place, the worker released the apples to roll from the

BN-10011

Figure 21.--Worker packing apples with semiautomatic tray packer.

pan into the tray pockets. With an apple in each pocket the tray was released to settle--on an air cushion--into place in the carton. At the same time the pan refilled with apples. When the last tray was in the carton the packer released the full carton to a gravity conveyor. Full cartons were never picked up or carried by the packer. In 1 hour a worker could tray pack 42.6 cartons. This was equivalent to 341 cartons in an 8-hour working day.

Because apples rolled into tray pockets in a random fashion, the packer spent a little more time with the top layer. She aligned these apples and turned their most attractive sides up. When finished, the pack was as attractive as those packed by hand.

Cost of packing fiberboard cartons.--The cost for each of three methods is shown in table 11. In each case the cost of labor far exceeded the cost of equipment. This was true even when the most mechanized method (using semiautomatic tray packers) was used although labor became a much smaller part of the total cost.

The method utilizing semiautomatic tray packers had the highest equipment cost, but the smallest combined labor and equipment cost. With this method apples were tray packed at a cost of $48.44 per 1,000 cartons. When apples were packed manually from a return-flow belt this cost was $66.70; packing from tubs cost $89.62 per 1,000 cartons. These costs assume an annual volume of

Table 11.--Labor and equipment costs for tray packing 1,000 cartons of size 113 apples by 3 different methods at an annual volume of 50,000 and a daily volume of 1,000 cartons

Packing method	Crew size	Elapsed time	Labor required	Cost		
				Labor 1/	Equipment	Total
	Number	Hours	Man-hours	Dollars	Dollars	Dollars
Position carton, pack manually from tubs, and manually remove filled carton..	8	7.25	57.97	72.46	2/17.16	89.62
Position carton, pack manually from return-flow belt, and manually remove filled carton.....	6	7.36	44.13	55.16	3/11.54	66.70
Position carton, pack with semiautomatic tray packer, and release filled carton to conveyor.....	3	7.83	23.48	29.35	4/19.09	48.44

1/ Based on a labor cost of $1.25 per hour
2/ One-half the annual cost of a 20-tub weight-type sizer ($15.84), charged to packing (the other half charged to sizing), and 12 packing stands at $0.11 each.
3/ One 40-foot return-flow belt $10.87, and 6 packing stands at $0.11 each.
4/ One 40-foot return-flow belt $10.87, and 3 semiautomatic tray packers at $2.74 each.

50,000 packed cartons, and a labor cost of $1.25 per hour. Should these assumptions change, the relative costs would also change. It would, however, take a considerable change to alter the positions on the cost scale of these three methods of packing. For example, reducing the labor cost to $1.00 per hour would decrease the present $41.18 advantage of the semiautomatic tray packer method over the highest cost method to an advantage of only $32.60 per 1,000 cartons. Still, the method using semiautomatic tray packers would continue to be the least costly.

Northwest Box

Once a container of major importance, the wooden northwest box has given way to the fiberboard carton. Although it declined in popularity the northwest box was still in use for some varieties and grades. Its use was virtually confined to "C" grade apples, with very few used for fancy fruit.

Apples packed in wooden boxes were individually wrapped in oil-impregnated paper, which protected them from scald and enhanced their appearance (fig. 22). All apples observed being packing into these containers were taken from rotating tubs, although they could have been taken from return-flow belts as well. The

BN-10003

Figure 22.--Apples being individually wrapped and place-packed in a northwest box.

same type of packing stand was used as in filling fiberboard cartons. In one motion the packer removed an apple from the tub, wrapped it, and set it in place in the box. Northwest boxes of size 113 apples were packed at the rate of 18.9 boxes every hour, or 151 boxes per day. Packing included positioning empty boxes and removing full ones; trays were not used when apples were wrapped. The total cost for labor was $66.13 per 1,000 boxes (table 12). An equipment cost of $17.16 made the total cost for wrapping and place-packing size 113 apples into northwest boxes $83.29 per 1,000 boxes. This was $16.59 more than for manually tray packing apples into cartons from a return-flow belt. Because no time was taken to position trays between each layer it cost $6.33 less per thousand northwest boxes than to manually tray pack into cartons from tubs.

Consumer Bags

A packer could bag small fruit and find a market for it, where there would be fewer calls for the same fruit packed another way. While some small apples

Table 12.--Labor and equipment costs for wrapping and packing 1,000 northwest boxes of size 113 apples from rotating tubs at an annual volume of 50,000 and a daily volume of 1,000 boxes

Time item	Crew size	Elapsed time	Labor required	Cost		
				Labor 1/	Equipment	Total
	Number	Hours	Man-hours	Dollars	Dollars	Dollars
Position empty box on packing stand	7	--	2.17	2.71	--	--
Wrap and pack apples from tub to northwest box	7	--	47.22	59.02	--	--
Manually remove packed box from stand to conveyor	7	--	3.52	4.40	--	--
Total	7	7.56	52.91	66.13	2/17.16	83.29

1/ Based on a labor cost of $1.25 per hour.
2/ One-half the annual cost of a 20-tub weight-type sizer ($15.84) charged to packing (the other half charged to sizing), and 12 packing stands at $0.11 each.

(size 163 and smaller) were tray packed--particularly for the export market--the majority that went for fresh consumption were in consumer bags. Bagged apples probably accounted for 25 percent of the fruit packed in the Appalachian area. Most consumer bags were plastic and held 4 or 5 pounds of apples. However, mesh bags and other weight units were also used.

Some differences in filling, closing, and cartoning were observed. Usually equipment was used. Despite variations in bagging methods, elements of the bagging operation were (1) attaching bag to holder, (2) filling bag with apples from automatic weigher, (3) removing full bag from holder and attaching closer, and (4) placing full bag in cell of carton. Figure 23 shows a station where this work was performed.

The number of apples placed in each bag did not affect the cost of bagging if a bagging machine was used. In some cases one worker in addition to the bagger closed bags while another placed them in cartons. These additional workers increased the cost of bagging. It took a worker 3.64 man-minutes to position an empty carton, attach nine plastic bags to an automatic weigher, fill the bags to 5 pounds each, place them in a carton, and remove the full carton.

BN-10009

Figure 23.--A bagging station where one worker performs a complete work cycle.

	Man-minutes
Position empty carton on packing stand.....	0.14
Attach 9 bags to automatic weigher.....	.72
Fill bags with apples.....	1.21
Remove full bags and attach closers.....	1.05
Place full bags in cells of cartons.....	.31
Manually remove filled carton.....	.21
Total.....	3.64

At this rate in an 8-hour day one worker could bag, seal, and cell pack 132 cartons. At $1.25 per hour this amounted to a labor cost of 7.6 cents per carton.

Where the work elements for bagging were divided among two or more packers, labor requirements rose. Bagging apples is a highly repetitive operation, and it would be impossible to synchronize the efforts of separate workers to bag, close, and carton the fruit. Such a crew arrangement would increase the capacity of a bagging machine, but at an increased labor cost. The most efficient bagging method resulted when one worker performed all the elements in their sequence, with no assistance. Attaching bags to the weigher, filling the bags, and removing them from the holder had to be done by the same worker and accounted for the bulk of the labor required in the bagging operation.

One worker to perform all elements was still the least costly method when both labor and equipment were considered. At $1.25 per hour for labor, the cost for both labor and equipment to bag, close, and carton 1,000 cartons of nine 5-pound bags was $78.98, or 7.9 cents per carton.

Labor	$75.91
Equipment	3.07
	$78.98

The equipment in this tabulation consisted of 2 single-head bagging machines. Cost of supplies (bags, cartons, closers) was not included. Adding a second worker to close and carton bags increased the productivity of the equipment by about one-third, but added greatly to the labor cost.

Other Packing Line Operations

Dumping, sorting, sizing, and packing are the principal packing line operations and account for a large share of the labor and equipment used to pack apples. They are not, however, the only operations. Others include (1) lidding, (2) labeling, (3) tallying, (4) carton making, and (5) crating of culls.

Usually one person was assigned to one or more of these operations. They were normally flexible enough that workers assigned to them could, within limits, move about within the plant helping each other as workloads changed.

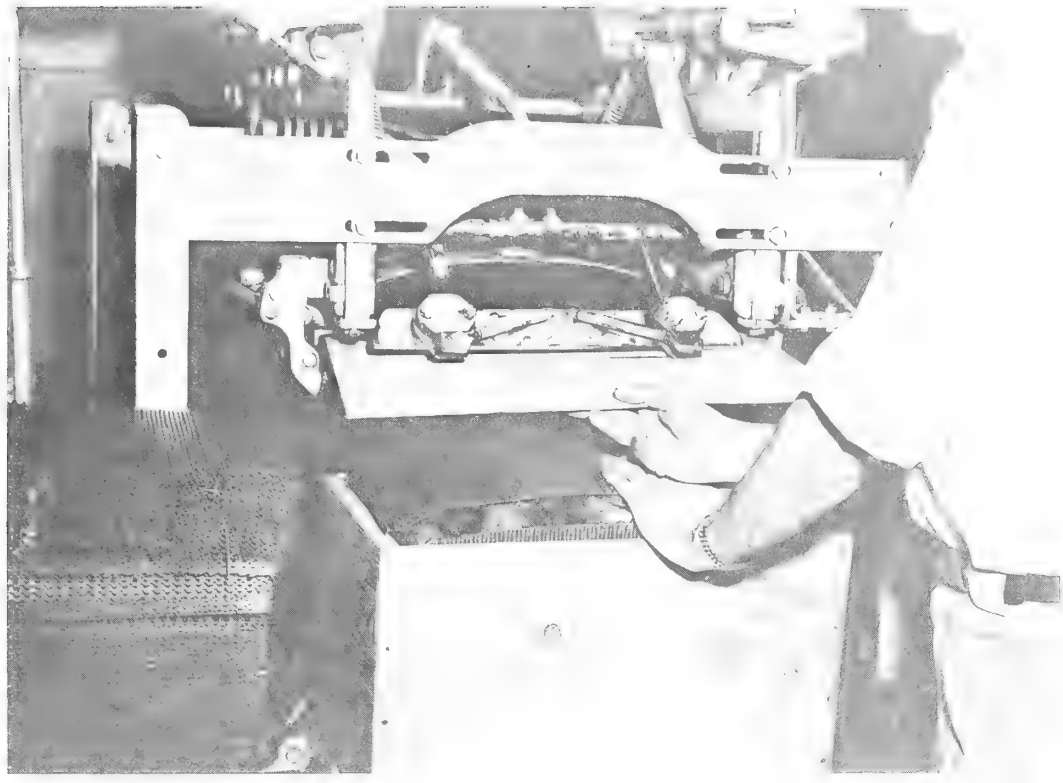
Lidding

Filled containers were removed to a conveyor which delivered them to a lidding station. This was true for bushel baskets, northwest boxes, and fiberboard cartons, although each was lidded in a different manner.

Bushel baskets.--Apples to be shipped in bushel baskets arrived at the lidding station face down, with only a faceplate and paper liner holding the fruit to the shape of a basket. The lidder set a basket over the liner and the apples it contained, and pulled it forward to a turning device in the conveyor line. The basket was turned face up, and the faceplate removed. Shredded paper was sprinkled over the apples and a lid set in place and fastened.

Northwest boxes.--Lids were fastened to northwest boxes by a nailing machine. The lidder laid a paper pad across the top layer of apples and set a lid in the nailing machine (fig. 24). The lid consisted of three pieces of shook joined by a crosspiece at each end. If the nailing machine was set into, and made a part of the conveyor, the box was pushed straight into the nailer; otherwise, the box was lifted from the conveyor and carried to the nailing machine. With the box in position, the lid was adjusted to set squarely on the box, and the nailing machine was activated by a foot pedal. The machine automatically ejected the box onto another conveyor.

Fiberboard cartons.--These containers did not have lids in the sense that bushel baskets and wooden boxes had. Some had flaps which were part of the carton. These flaps, when fastened together, formed a cover for the container.



BN-10008

Figure 24.--Worker placing lid in nailing machine which will attach it to northwest box of apples.

Other cartons were covered with a telescoping lid which enclosed the filled container, but was not sealed to it. Flaps were nearly always sealed with staples. Both manual and pneumatic staplers were used, with the latter most often found in larger volume houses.

Cartons were delivered to the lidding station by conveyor. Where stapling was done with a hand-operated stapling machine, the lidder could work ahead on the filled-carton conveyor. This was an advantage over pneumatic staplers which were fixed in place.

To staple a carton closed, the lidder first placed a paper pad over the apples (unless the packer had already done so), and then fastened the flaps together with two staples. The worker then pushed it ahead on the conveyor to the segregating area.

Telescoping lids made closing even simpler. The worker set a paper pad over the fruit (if necessary), and slipped a lid from a nearby supply over the filled carton. However, this lid had to be formed and stapled in the same manner as the carton holding the apples. The cost of doing this is chargeable to the lidding operation.

Cost of lidding.--For each lidding method, only one worker was needed where

the volume packed did not exceed 1,000 containers per day. Table 13 gives the cost of lidding bushel baskets, northwest boxes, and fiberboard cartons. Lidding fiberboard cartons with telescoping lids showed the greatest cost--$14.50 per 1,000 containers. The additional labor and equipment required to form and staple the lid amounted to two-thirds of the total cost.

Table 13.--Labor and equipment costs to lid 1,000 containers of packed apples, 50,000 containers lidded per year at 1,000 per day

Container	Crew size	Elapsed time	Labor required	Cost		
				Labor 1/	Equipment	Total
	Number	Hours	Man-hours	Dollars	Dollars	Dollars
Bushel basket	1	8.00	8.00	10.00	2/0.68	10.68
Northwest box	1	2.62	2.62	3.26	3/7.75	11.01
Fiberboard carton:						
Sealed by hand stapler	1	4.17	4.17	5.21	4/3.13	8.34
Sealed by pneumatic stapler	1	4.17	4.17	5.21	5/3.59	8.80
Covered with telescoping lid	2	3.80	6/8.18	10.22	7/4.28	14.50

1/ At $1.25 per hour.
2/ 1 basket turner at $0.085 per hour.
3/ 1 nailing machine at $0.970 per hour.
4/ 1 hand stapler at $0.029 per hour, plus $2.90 for preformed staples (5/8" staples 2 per carton).
5/ 1 pneumatic stapler at $0.086 per hour, plus $2.90 for preformed staples (5/8" staples 2 per carton).
6/ 1 worker 4.38 man-hours forming lid, and second worker 3.80 man-hours lidding.
7/ Includes one-half the cost of motorized bottom stitcher, plus $2.16 for wire staples (12 per lid).

Sealing cartons by hand and by pneumatic stapler had almost identical total costs since the same amount of labor was required. The cost of staples was the largest equipment cost item for this method of sealing.

Labeling

A paper label bearing the packer's trade name was pasted on each box, carton, and basket, and a rubber stamp was used to mark information concerning the contents on the containers. Packers customarily carried two or more trade names, with each reserved for a particular grade of fruit.

The labeler's station was along the conveyor which delivered apples from

the packing line, either before or after the lidding station. When a container reached him, the labeler brushed glue across it, placed a label over the area, and then set the label by rubbing it lightly with a damp cloth or sponge. If containers were palletized at each packing station, labels were applied there. In either case, one worker was able to apply up to 2,000 labels per day.

The variety, grade, and size was stamped on containers manually either by packers before releasing the containers, or by the labeler. Stamping required 2.47 man-hours per 1,000 containers. One worker was able to both label and stamp well over 1,000 containers per day.

Tallying

Keeping a record of each grade, size, and variety packed was the responsibility of the tally clerk. This job often rested with the segregator, labeler, or lidder. Some houses did not keep a running tally, but totaled up at the end of each day; others assigned a person full time to keep the tally. This work required only a small amount of time, but had to be done by someone in a position to see each packed container.

A simple tally sheet consisted of a page for each grade of apple. The page was divided into columns, one column for each size packed. As a container of apples passed by the tally clerk, he placed a mark in the appropriate column. At the end of the day, the marks were totaled, revealing the number of each grade and size packed.

Carton Making

A packinghouse operator had to stock 2 or more types of cartons to meet his customers' needs. These cartons were received flat and in bundles, and were assembled by a carton maker using a stapling machine.

Cartons were formed by stapling the bottom flaps together, with 12 staples (fig. 25). The following were the basic elements of carton making: (1) Lift flat carton from bundle and shape into carton by pushing ends together, (2) fold down bottom flaps and set carton over stapler head, (3) staple flaps 6 times at each end of carton, and (4) lift carton from stapler head and place in pile, drop down chute, or hang on overhead monorail.

Sometimes two workers were used in the carton-making operation. One worker removed flat cartons from the bundles and shaped them, and the other worker folded the flaps, stapled them, and removed the cartons. Two workers produced more cartons than one, but at a higher cost per carton (table 14).

One worker could make 1,000 cartons in 4.38 hours. For this production, labor cost $5.48, and equipment $4.24. Two workers, working together, could make 1,000 cartons in 3.22 hours at a labor cost of $8.04 and an equipment cost of $4.24. If one or two men were assigned full time to carton making considerable wait time would occur. However, it was common practice for the carton maker to utilize what would otherwise be wait time by stapling telescoping lids and supplying packing material to the packing line.

BN-10001

Figure 25.--Worker stapling carton together with a motorized stapling machine.

Crating Culls

Cull apples were those removed by sorters as not qualified for U. S. Utility grade or better, and those taken out at the eliminator because of their small size (under 2-1/4 inches). On an average, they represented about 5 percent of the orchard-run fruit. Although cull apples were of little commercial value, they had to be crated and disposed of, since cull apples were never packed for the fresh trade. Cull apples were collected in orchard crates from both the sorting table and eliminator. When a crate was full it was removed and stacked, and an empty set in its place.

Little time was required to change an empty crate for a full one--about half an hour a day for 50 crates. When fruit was running heavier to culls, more time was required. For an average run of fruit, at a dumping rate of 1,000 crates per day, the person supplying the dumper would have time to take care of the cull fruit as well.

Table 14.--Labor and equipment costs for forming and stapling 1,000 fiberboard cartons on motorized bottom stitcher by 2 different method

Method	Crew size	Elapsed time	Labor required	Cost		
				Labor 1/	Equipment	Total
	Number	Hours	Man-hours	Dollars	Dollars	Dollars
1 worker performed all work elements	1	4.38	4.38	5.48	2/4.24	9.72
1 worker removed flat carton from bundle, formed it into carton, and handed it to 2d worker who stitched bottom flaps and removed carton	2	3.22	6.43	8.04	2/4.24	12.28

1/ Based on a cost of $1.25 per hour.
2/ Includes $2.16 for wire staples (12 per carton).

Costs of Combined Packing Line Operations

Labor and equipment costs presented for each packing line operation are on the basis of 50,000 containers annually, at a daily volume of 1,000 containers. A great many combinations of packing line methods can be synthesized from the data in this report and in the appendix. A packer can vary the conditions given to fit his own situation and still arrive at a reasonable estimate of what the cost would be in his own plant.

An example is developed to show how individual operations can be fitted together into a complete packing line. To do this, it is necessary to compute costs on the actual number of containers that would be involved in each of the different operations. Using as a base a dumping rate of 50,000 crates annually and 1,000 crates daily, the number of containers that might be expected to pass through each of the packing line operations is given in table 15. Crew arrangement and labor and equipment costs for the selected combination of methods are given in table 16. Packing the equivalent of 1,000 dumped crates would cost $180.95. Of this, $120 would be for labor and $60.95 for equipment. Twelve workers would be productively engaged 92 percent of their time, and waiting only 8 percent. Most of this waiting accrues to one worker--the one supplying the dumper--and could be eliminated by having him work in the bring-up operation.

Comparable costs can be determined for a large number of different packing methods by using the data in this report and the same method of analyses. An operator can compute the cost of a given method in his own plant by substituting his own data for labor rates, annual volumes, daily volumes, and other variables.

Table 15.--Assumed distribution of orchard-run apples in the Appalachian area, and number of containers in each packing line operation 1/

Operation	Type of container	Number of containers	
		Annually	Daily
Dumping	Crate	50,000	1,000
Sorting	Crate	50,000	1,000
Sizing	Crate	47,500	950
Packing	Carton	44,250	885
Lidding	Carton	44,250	885
Labeling	Carton	44,250	885
Tallying	All	46,750	935
Carton making	Carton	44,250	885
Boxing culls	Crate	2,500	50

1/ Based on crates holding 41 pounds of apples, and cartons 44 pounds.

HANDLING AND PACKING BY DIFFERENT COMBINATIONS OF METHODS AT DIFFERENT VOLUMES

Throughout this report handling and packing operations have been considered separately. They were treated this way since entirely different equipment, methods, and crews were used in each. But to arrive at plantwide costs it is necessary to combine all the operations that occur in a packinghouse--both handling and packing--into one overall method. Three different combinations of methods are analyzed here: (1) Handling by clamp type 2-wheel handtrucks with manual packing from a return-flow belt, (2) handling by conveyors with manual packing from tubs, and (3) handling by forklift truck and pallets with packing by semiautomatic tray packers. None of these methods was observed in its entirety in one packinghouse; instead, they have been synthesized from data taken in many plants. This illustrates how the costs of different combinations of methods can be predicted without actually installing and testing them.

Handling and packing costs are affected by the volume of apples handled and packed. When the volume changes, the cost for performing each of the operations also changes. Such a change occurs in both the total cost, and in the unit cost. Further, the comparative costs are likely to change. For each method, costs are shown for annual volumes of 50,000, 100,000, and 200,000 crates. These costs are developed from data in the statistical supplement, beginning on page 70, and are exclusive of packing materials, overhead, and

Table 16.--Labor and equipment costs for packing apples by a selected combination of methods. Annual volume 50,000 crates dumped, with 1,000 crates dumped daily

Operation	Containers 1/		Workers	Labor required		Cost		
	Type	Number		Productive time	Wait time	Labor 2/	Equipment	Total
			Number	Man-hours	Man-hours	Dollars	Dollars	Dollars
Dumping--A mechanical dumper with one worker to keep it supplied. He also removes culls and stacks empty field crates	Crate	1,000	1	3.64	4.36	10.00	8.69	18.69
Sorting--Six workers using a float roll table	Crate	1,000	6	48.00	-	60.00	5.65	65.65
Sizing--A dimension type sizer	Crate	950	0	-	-	-	20.15	20.15
Packing--Three workers tray pack cartons with semiautomatic tray packers	Carton	885	3	20.78	3.22	30.00	19.09	49.09
Lidding--One worker hand-staples carton lids, and also tallies and labels	Carton	885	1	8.00	-	10.00	3.13	13.13
Carton making--One worker makes cartons and also supplies packing materials	Carton	885	1	8.00	-	10.00	4.24	14.24
Total			12	88.42	7.58	120.00	60.95	180.95

1/ Based on crates holding 41 pounds of apples, and cartons 44 pounds.
2/ Based on $1.25 per hour.

management costs. Only the cost of labor and equipment used directly in the handling and packing line operations are included.

Handling by Clamp Type 2-Wheel Handtrucks with Manual Packing from Return-Flow Belt

Clamp type 2-wheel handtrucks have the lowest equipment cost, but require the greatest number of workers. Where large volumes must be handled over short periods of time, or over great distances, labor cost could become prohibitive if clamp type 2-wheel handtrucks are used. A worker can handle only 5 containers at one time with this equipment, and such limited capacity can be compensated for only by increasing the number of trucks and operators. As workers are added, costs mount.

In this example, the packing line operation includes mechanical dumping, sorting from a wooden roller table, dimension sizing, and manual packing from a return-flow belt. The costs for this method at three different volumes are presented in tables 17, 18, and 19.

At an annual volume of 50,000 crates, handling cost $0.051 and packing $0.196 per crate. For handling, equipment amounted to only 10 percent of the cost, and for packing it was 24 percent.

To handle and pack fruit at a volume of 100,000 crates dumped annually would require 2 additional clamp type 2-wheel handtrucks, one additional high-piler, and 2 more packing stands. Still the total cost would be reduced from $0.247 to $0.213 per crate.

Raising the annual volume from 100,000 to 200,000 crates would require the addition of 3 clamp type 2-wheel handtrucks, one roller sorting table, and 3 packing stands. The unit cost for handling and packing at this volume would be $0.203, or 1.0 cent less per crate than at 100,000 crates annually.

Handling by Conveyors with Manual Packing from Tubs

Conveyors represent the most costly handling method of the three studied. At 50,000 boxes annually, they have the highest labor and equipment costs. However, as volume increases smaller increments of labor need be added than with the clamp type 2-wheel handtruck method. At the three volumes studied, this advantage never became great enough to overcome the high equipment cost associated with conveyors. Conveyors eliminated the need for workers to transport apples between points, but this did not compensate for a high initial equipment cost, nor the extra handling that occurred at each end of the conveyor.

Tables 20, 21, and 22 present these handling costs for annual volumes of 50,000, 100,000, and 200,000 boxes, together with the costs of dumping manually, sorting from a wooden roller table, sizing by weight, and packing manually from tubs. This combination proved to be the most costly, requiring the greatest number of workers. Handling and packing line costs combined total $0.316 per crate for an annual volume of 50,000 crates dumped, $0.245 for 100,000 crates,

Table 17.--Labor and equipment costs for handling 50,000 crates of apples annually by clamp type 2-wheel handtruck and packing manually from a return-flow belt

(1,000 crates a day for 50 days)

Operation	Containers handled annually 1/	Crew size	Labor required 2/	Cost				
				Labor 3/	Equipment	Total annual	Total daily	Per dumped crate
	Number	Number	Man-hours	Dollars	Dollars	Dollars	Dollars	Dollars
Handling:								
Receiving	50,000	4/	283	354.00	22.00	376.00	7.53	0.008
Bringing-up	50,000	1	400	500.00	113.00	613.00	12.26	.012
Segregating and storing packed cartons	44,250	2	800	1,000.00	111.50	1,111.50	22.23	.022
Loading-out	46,750	4/	354	442.50	5.00	447.50	8.95	.009
Total handling			1,837	2,296.50	251.50	2,548.00	50.97	.051
Packing line:								
Dumping mechanically	50,000	1	400	500.00	434.50	934.50	18.69	.019
Sorting from roller table	50,000	6	2,400	3,000.00	178.53	3,178.53	63.57	.064
Dimension sizing	47,500	-	-	-	1,007.45	1,007.45	20.15	.020
Packing manually from belt	44,250	6	2,200	2,750.00	584.95	3,334.95	66.70	.066
Other packing line operations 5/		2	800	1,000.00	368.50	1,368.50	27.37	.027
Total packing line		15	5,800	7,250.00	2,573.93	9,823.93	196.48	.196
Total handling and packing line			7,637	9,546.50	2,825.43	12,371.93	247.45	.247

1/ Crates weigh 41 pounds, and cartons 44 pounds.
2/ Includes wait time incidental to the method.
3/ At $1.25 per hour.
4/ Workers were not assigned full time to this operation.
5/ Includes lidding, labeling, tallying, carton making, crating culls, and supplying packing material.

Table 18.--Labor and equipment costs for handling 100,000 crates of apples annually by clamp type 2-wheel handtruck and packing manually from a return-flow belt

(1,500 crates a day for 67 working days)

Operation	Containers handled annually 1/	Crew size	Labor required 2/	Cost				
				Labor 3/	Equipment	Total annual	Total daily	Per dumped crate
	Number	Number	Man-hours	Dollars	Dollars	Dollars	Dollars	Dollars
Handling:								
Receiving	100,000	4/	567	709.00	32.66	741.66	11.07	0.007
Bringing-up	100,000	2	1,072	1,675.00	123.28	1,798.28	26.84	.018
Segregating and storing packed cartons	88,500	3	1,608	2,010.00	132.39	2,142.39	31.98	.021
Loading-out	93,500	4/	714	892.50	28.35	920.85	13.75	.009
Total handling			3,961	5,286.50	316.68	5,603.18	83.63	.055
Packing line:								
Dumping mechanically	100,000	1	536	670.00	496.46	1,166.46	17.41	.012
Sorting from roller table	100,000	6	3,216	4,020.00	205.25	4,225.25	63.06	.042
Dimension sizing	95,000	-	-	-	1,140.15	1,140.15	17.02	.011
Packing manually from belt	88,500	8	4,288	5,360.00	659.26	6,019.26	89.84	.061
Other packing line operations 5/		4	2,144	2,680.00	572.30	3,252.30	48.54	.032
Total packing line		19	10,184	12,730.00	3,073.42	15,803.42	235.87	.158
Total handling and packing line			14,145	18,016.50	3,390.10	21,406.60	319.50	.213

1/ Crates weigh 41 pounds, and cartons weigh 44 pounds.
2/ Includes wait time incidental to the method.
3/ At $1.25 per hour.
4/ Workers were not assigned full time to this operation.
5/ Includes lidding, labeling, tallying, carton making, crating culls, and supplying packing material.

Table 19.--Labor and equipment costs for handling 200,000 crates of apples annually by clamp type 2-wheel handtruck and packing manually from a return-flow belt

(2,000 crates a day for 100 working days)

Operation	Containers handled annually 1/	Crew size	Labor required 2/	Cost				
				Labor 3/	Equipment	Total annual	Total daily	Per dumped crate
	Number	Number	Man-hours	Dollars	Dollars	Dollars	Dollars	Dollars
Handling:								
Receiving	200,000	4/	1,134	1,418.00	62.48	1,480.48	14.80	0.008
Bringing-up	200,000	2	1,600	2,000.00	165.60	2,165.60	21.66	.011
Segregating and storing packed cartons	177,000	4	3,200	4,000.00	165.60	4,165.60	41.66	.021
Loading-out	187,000	4/	1,429	1,786.00	46.62	1,832.62	18.32	.009
Total handling			7,363	9,204.00	440.30	9,644.30	96.44	.049
Packing line:								
Dumping mechanically	200,000	1	800	1,000.00	545.14	1,545.14	15.45	.008
Sorting from roller table	200,000	10	8,000	10,000.00	463.02	10,463.02	104.63	.052
Dimension sizing	190,000	-	-	-	1,233.83	1,233.83	12.34	.006
Packing manually from belt	177,000	11	8,800	11,000.00	729.28	11,729.28	117.29	.059
Other packing line operations 5/		5	4,000	5,000.00	772.39	5,772.39	57.72	.029
Total packing line		27	21,600	27,000.00	3,743.66	30,743.66	307.43	.154
Total handling and packing line			28,963	36,204.00	4,183.96	40,387.96	403.87	.203

1/ Crates weigh 41 pounds, and cartons weigh 44 pounds.
2/ Includes wait time incidental to the method.
3/ At $1.25 per hour.
4/ Workers were not assigned full time to this operation.
5/ Includes lidding, labeling, tallying, carton making, crating culls, and supplying packing material.

Table 20.--Labor and equipment costs for handling 50,000 crates of apples annually by conveyor and packing manually from tubs

(1,000 crates a day for 50 working days)

Operation	Containers handled annually 1/	Crew size	Labor required 2/	Cost				
				Labor 3/	Equipment	Total annual	Total daily	Per dumped crate
	Number	Number	Man-hours	Dollars	Dollars	Dollars	Dollars	Dollars
Handling:								
Receiving	50,000	4/	566	708.00	150.50	858.50	17.16	0.017
Bringing-up	50,000	2	800	1,000.00	506.50	1,506.50	30.13	.030
Segregating and storing packed cartons	44,250	2	800	1,000.00	545.00	1,545.00	30.90	.031
Loading-out	46,750	4/	389	486.00	146.00	632.00	12.64	.013
Total handling			2,555	3,194.00	1,348.00	4,542.00	90.83	.091
Packing line:								
Dumping manually	50,000	2	800	1,000.00	98.20	1,098.20	21.96	.022
Sorting from roller table	50,000	6	2,400	3,000.00	178.53	3,178.53	63.57	.063
Weight sizing	47,500	-	-	-	792.08	792.08	15.84	.016
Packing manually from tubs	44,250	7	2,800	3,500.00	831.07	4,331.07	86.62	.087
Other packing line operations 5/		3	1,200	1,500.00	368.50	1,868.50	37.37	.037
Total packing line		18	7,200	9,000.00	2,268.38	11,268.38	225.36	.225
Total handling and packing line			9,755	12,194.00	3,616.38	15,810.38	316.19	.316

1/ Crates weigh 41 pounds, and cartons 44 pounds.
2/ Includes wait time incidental to the method.
3/ At $1.25 per hour.
4/ Workers were not assigned full time to this operation.
5/ Includes lidding, labeling, tallying, carton making, crating culls, and supplying packing material.

Table 21.--Labor and equipment costs for handling 100,000 crates of apples annually by conveyor and packing manually from tubs

(1,500 crates a day for 67 working days)

Operation	Containers handled annually 1/	Crew size	Labor required 2/	Cost				
				Labor 3/	Equipment	Total		
						Annual	Daily	Per dumped crate
	Number	Number	Man-hours	Dollars	Dollars	Dollars	Dollars	Dollars
Handling:								
Receiving	100,000	4/	1,132	1,415.00	195.36	1,610.36	24.04	0.016
Bringing-up	100,000	2	1,072	1,340.00	901.56	2,241.56	33.46	.022
Segregating and storing packed cartons	88,500	2	1,072	1,340.00	587.46	1,927.46	28.77	.019
Loading-out	93,500	4/	832	1,040.00	261.56	1,301.56	19.43	.013
Total handling			4,108	5,135.00	1,945.94	7,080.94	105.70	.071
Packing line:								
Dumping manually	100,000	2	1,072	1,340.00	114.85	1,454.85	21.71	.014
Sorting from roller table	100,000	6	3,216	4,020.00	205.25	4,225.25	63.06	.042
Weight sizing	95,000	-	-	-	888.02	888.02	13.25	.009
Packing manually from tubs	88,500	10	5,360	6,700.00	947.22	7,647.22	114.13	.076
Other packing line operations 5/		4	2,144	2,680.00	572.30	3,252.30	48.54	.033
Total packing line		22	11,792	14,740.00	2,727.64	17,467.64	260.69	.174
Total handling and packing line			15,900	19,875.00	4,673.58	24,548.58	366.39	.245

1/ Crates weigh 41 pounds, and cartons weigh 44 pounds.
2/ Includes wait time incidental to the method.
3/ At $1.25 per hour.
4/ Workers were not assigned full time to this operation.
5/ Includes lidding, labeling, tallying, carton making, crating culls, and supplying packing material.

Table 22.--Labor and equipment costs for handling 200,000 crates of apples annually by conveyor and packing manually from tubs

(2,000 crates a day for 100 working days)

Operation	Containers handled annually 1/	Crew size	Labor required 2/	Cost				
				Labor 3/	Equipment	Total		
						Annual	Daily	Per dumped crate
	Number	Number	Man-hours	Dollars	Dollars	Dollars	Dollars	Dollars
Handling:								
Receiving	200,000	4/	2,264	2,830.00	259.20	3,089.20	30.89	0.015
Bringing-up	200,000	2	1,600	2,000.00	962.40	2,962.40	29.62	.015
Segregating and storing packed cartons	177,000	2	1,600	2,000.00	695.20	2,695.20	26.95	.013
Loading-out	187,000	4/	1,664	2,080.00	416.81	2,496.81	24.97	.012
Total handling			7,128	8,910.00	2,333.61	11,243.61	112.43	.055
Packing line:								
Dumping manually	200,000	3	2,400	3,000.00	126.30	3,126.30	31.26	.016
Sorting from roller table	200,000	10	8,000	10,000.00	463.02	10,463.02	104.63	.052
Weight sizing	190,000	-	-	-	954.40	954.40	9.54	.005
Packing manually from tubs	177,000	13	10,400	13,000.00	1,037.34	14,037.34	140.37	.070
Other packing line operations 5/		5	4,000	5,000.00	772.39	5,772.39	57.72	.029
Total packing line		31	24,800	31,000.00	3,353.45	34,353.45	343.53	.172
Total handling and packing line			31,928	39,910.00	5,687.06	45,597.06	455.96	.227

1/ Crates weigh 41 pounds, and cartons weigh 44 pounds.
2/ Includes wait time incidental to the method.
3/ At $1.25 per hour.
4/ Workers were not assigned full time to this operation.
5/ Includes lidding, labeling, tallying, carton making, crating culls, and supplying packing material.

and $0.227 for 200,000 crates. Equipment costs are 23 percent of the combined labor and equipment costs for an annual volume of 50,000 crates, 19 percent for a volume of 100,000 crates, and 13 percent for 200,000 crates. About three-fourths of all the costs are in the packing line operations, and only one-fourth in handling.

To increase the annual volume from 50,000 to 100,000 crates dumped the only additional equipment needed is 3 packing stands. To increase from 100,000 to 200,000 crates annually only 3 more packing stands and 1 roller sorting table need to be added.

Handling by Forklift Truck and Pallets and Packing by Semiautomatic Tray Packers

This operation incorporated the most highly mechanized methods and equipment that were available for handling and packing apples in the Appalachian area. Integration of these advanced types of equipment into one complete packinghouse operation permitted a significant reduction in the number of workers required and reduced the dollar cost of handling and packing apples.

All apples were received, transported, and stored on pallets. For this method of handling, apples were dumped mechanically, sorted on a float roll table, sized by a dimension sizer, and packed by semiautomatic tray packers. Detailed costs for such a combined method of handling and packing are given for different volumes in tables 23, 24, and 25.

Although this is a highly mechanized operation, labor is the predominant cost. Labor costs were 67 percent of the combined labor and equipment cost for a volume of 50,000 crates dumped annually, 69 percent for 100,000 crates, and 78 percent for 200,000 crates. There was no difference in the combined unit cost between volumes of 100,000 and 200,000 annually. The costs did shift between individual operations, but the aggregate remained the same. The cost to handle and pack the equivalent of one dumped crate was $0.214 at an annual volume of 50,000, $0.166 at 100,000, and $0.165 at 200,000 crates annually. At all volumes tested, handling by forklift truck and packing by semiautomatic tray packers released enough workers to make this combination the least costly of all those studied.

To raise the volume from 50,000 to 100,000 crates annually with this method, it is necessary to add 42 pallets and one semiautomatic tray packer; to increase to 200,000 crates annually, additional equipment is needed: 84 pallets, one forklift truck, and two semiautomatic tray packers.

Conclusions

In comparing costs for different methods at different volumes, these facts stand out: (1) At $1.25 per hour, the cost of labor was in all cases much greater than the cost of equipment, (2) the cost of packing was much greater than the cost of handling, and (3) the economies of scale dropped off rapidly (fig. 26).

Table 23.--Labor and equipment costs for handling 50,000 crates of apples annually by forklift truck and pallets and packing by semiautomatic tray packers

(1,000 crates a day for 50 working days)

Operation	Containers handled annually 1/	Crew size	Labor required 2/	Cost				
				Labor 3/	Equipment	Total		
						Annual	Daily	Per dumped crate
	Number	Number	Man-hours	Dollars	Dollars	Dollars	Dollars	Dollars
Handling:								
Receiving	50,000	-	56	70.00	253.00	323.00	6.45	0.006
Bringing-up	50,000	-	52	65.00	237.00	302.00	6.04	.006
Segregating and storing packed cartons	44,250	-	426	532.50	117.00	649.50	12.99	.013
Loading-out	46,750	-	199	248.75	174.00	422.75	8.45	.008
Total handling		4/	733	916.25	781.00	1,697.25	33.93	.033
Packing line:								
Dumping mechanically	50,000	1	400	500.00	434.50	934.50	18.69	.019
Sorting from float roll table	50,000	6	2,400	3,000.00	282.36	3,828.36	65.65	.066
Dimension sizing	47,500	-	-	-	1,007.45	1,007.45	20.15	.020
Packing with semiautomatic packers	44,250	3	1,200	1,500.00	954.62	2,454.62	49.09	.049
Other packing line operations 5/		2	800	1,000.00	368.50	1,368.50	27.37	.027
Total packing line		12	4,800	6,000.00	3,047.43	9,047.43	180.95	.181
Total handling and packing line			5,533	6,916.25	3,828.43	10,744.68	214.88	.214

1/ Crates weigh 41 pounds, and cartons weigh 44 pounds.
2/ Includes wait time incidental to the method.
3/ At $1.25 per hour.
4/ Fork truck operator divided his time among all 4 handling operations; another man worked in last 2 operations for time he was needed, then returned to packing line.
5/ Includes lidding, labeling, tallying, carton making, crating culls, and supplying packing material.

Table 24.--Labor and equipment costs for handling 100,000 crates of apples annually by forklift truck and pallets and packing by semiautomatic tray packers

(1,500 crates a day for 67 working days)

Operation	Containers handled annually 1/	Crew size	Labor required 2/	Cost				
				Labor 3/	Equipment	Total annual	Total daily	Per dumped crate
	Number	Number	Man-hours	Dollars	Dollars	Dollars	Dollars	Dollars
Handling:								
Receiving	100,000	-	111	138.75	404.36	543.11	8.10	0.005
Bringing-up	100,000	-	111	138.75	404.36	543.11	8.10	.005
Segregating and storing packed cartons	88,500	-	595	743.75	312.02	1,055.77	15.76	.010
Loading-out	93,500	-	401	501.85	367.96	869.81	12.98	.009
Total handling		4/	1,218	1,523.10	1,488.70	3,011.80	44.94	.029
Packing line:								
Dumping mechanically	100,000	1	536	670.00	496.46	1,166.46	17.41	.012
Sorting from float roll table	100,000	6	3,216	4,020.00	320.75	4,340.75	64.79	.043
Dimension sizing	95,000	-	-	-	1,140.15	1,140.15	17.02	.011
Packing with semiautomatic tray packers	88,500	4	2,144	2,680.00	1,224.70	3,904.70	58.28	.039
Other packing line operations 5/		4	2,144	2,680.00	572.30	3,252.30	48.54	.032
Total packing line		15	8,040	10,050.00	3,754.36	13,804.36	206.04	.137
Total handling and packing line			9,258	11,573.10	5,243.06	16,816.16	250.98	.166

1/ Crates weigh 41 pounds, and cartons 44 pounds.
2/ Includes wait time incidental to the method.
3/ At $1.25 per hour.
4/ One full time and one part time worker in total handling operation.
5/ Includes lidding, labeling, tallying, earton making, crating culls, and supplying packing material.

Table 25.--Labor and equipment costs for handling 200,000 crates of apples annually by forklift truck and pallets and packing by semiautomatic tray packers

(2,000 crates a day for 100 working days)

Operation	Containers handled annually 1/	Crew size	Labor required 2/	Cost				
				Labor 3/	Equipment	Total		
						Annual	Daily	Per dumped crate
	Number	Number	Man-hours	Dollars	Dollars	Dollars	Dollars	Dollars
Handling:								
Receiving	200,000	-	222	280.00	736.26	1,016.26	10.17	0.005
Bringing-up	200,000	-	222	280.00	736.26	1,016.26	10.17	.005
Segregating and storing packed cartons	177,000	-	1,718	2,147.50	595.83	2,743.33	27.43	.014
Loading-out	187,000	-	803	1,003.75	693.83	1,697.58	16.97	.008
Total handling		4/	2,965	3,711.25	2,762.18	6,473.43	64.74	.032
Packing line:								
Dumping mechanically	200,000	1	800	1,000.00	545.14	1,545.14	15.45	.008
Sorting from float roll table	200,000	10	8,000	10,000.00	354.79	10,354.79	103.55	.052
Dimension sizing	190,000	-	-	-	1,233.83	1,233.83	12.34	.006
Packing with semiautomatic tray packers	177,000	6	4,800	6,000.00	1,643.48	7,643.48	76.43	.038
Other packing line operations 5/		5	4,000	5,000.00	772.39	5,772.39	57.72	.029
Total packing line		22	17,600	22,000.00	4,549.63	26,549.63	265.49	.133
Total handling and packing line			20,565	25,711.25	7,311.81	33,023.06	330.23	.165

1/ Crates weigh 41 pounds, and cartons 44 pounds.
2/ Includes wait time incidental to the method.
3/ At $1.25 per hour.
4/ One full time and one part time worker in total handling operation.
5/ Includes lidding, labeling, tallying, carton making, crating culls, and supplying packing material.

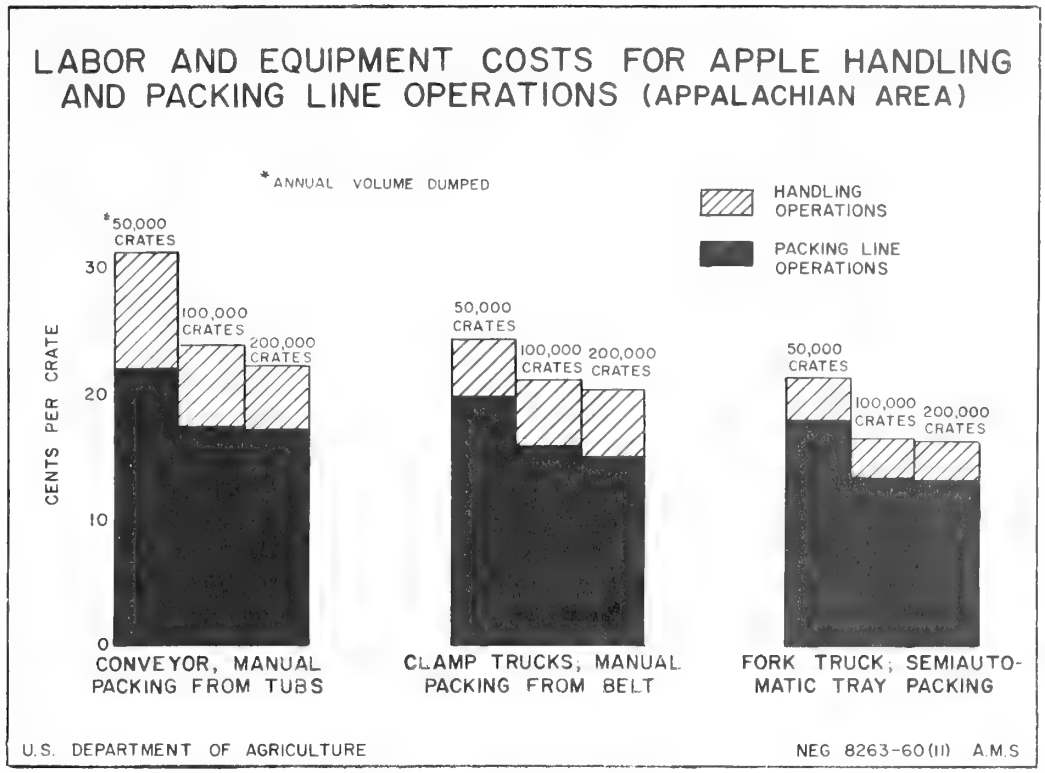


Figure 26

Apple packing plants are still labor intensive, despite labor saving devices which have been introduced in recent years. As handling and packing technology improves, workers will become more productive, and the per bushel cost for labor will decrease. Investment in equipment--even with a relatively high initial cost--is a sound investment if it will increase productivity of the labor force. Nor should high-cost equipment be eliminated from consideration solely on the basis of small volumes handled and packed out. Rather, it--as any equipment type--should be evaluated in terms of potential savings over existing and alternative methods.

In attacking high packinghouse costs the logical place to begin is with packing line operations. Here is where the majority of both labor and equipment costs are incurred, and where the greatest savings can be made.

The amount of equipment needed for a packinghouse handling 50,000 crates per year will nearly suffice for 100,000 crates. Thus, by adding only a small increment of equipment, it is possible to increase a plant's volume from 50,000 to 100,000 crates per year and to reduce the unit cost of handling and packing apples. At the same time labor can be more fully utilized at this higher volume. For the clamp type 2-wheel handtruck method the saving which results from such an increase in scale of operation is 3.4 cents per crate; for the conveyor method it is 7.1 cents, and 4.8 cents for the forklift truck method.

Raising the volume from 100,000 to 200,000 crates annually results in a small additional saving per crate: 1.0 cent for the clamp type 2-wheel handtruck

method, 1.8 cents for the conveyor method, and 0.1 cent for the forklift truck method. This relationship suggests that the greatest economy is achieved where the volumes received are in increments of 100,000 crates, for it is at such volumes that maximum productivity is achieved with the labor and equipment inputs.

Beyond 100,000 crates annual volume there is very little economy of scale where labor and equipment are the consideration. There are, however, other costs which have not been considered in this analysis. These include the cost of management, buildings, refrigeration, maintenance, and other "overhead" costs. Greater economies than are shown for just labor and equipment may be achieved at higher volumes when management, buildings, refrigeration, maintenance, and other "overhead" costs are considered.

APPENDIX

Development of the Study

This study is an extension of a research program carried out in the Pacific Northwest area. From that work have emerged new items of equipment for handling and packing apples. Some are now found in the Appalachian area, but their introduction has been slow. A piece of equipment, specifically designed to meet the needs of one area, cannot always be installed directly in another area with the same results. In transferring fruits of research from one area of the country to another, it is necessary first to consider the different conditions that exist. The purpose of this study was to determine the criteria for economic use of this new equipment under conditions existing in the Appalachian area. Among the items of equipment under consideration were the following:

1. Float roll sorting table. By rotating apples in a forward direction while independently controlling the speeds of rotation and translation, a large number of apples can be sorted, and the quality of sorting work improved. The addition of cull chutes and sorting lanes to the table is a further improvement.

2. Return-flow belt system for accumulating fruit. With this system, apples pass continuously before the packer, and reaching into tubs is eliminated.

3. Automatic box filler. This equipment requires virtually no attending; yet it jumble-fills boxes to a predetermined weight and automatically releases the full boxes and replaces them with empties.

4. High-piler. Manual stacking of boxes above 5 high is eliminated; 5 and 10 boxes at a time are placed in high storage position mechanically.

5. Semiautomatic tray packer. A product of private development, this equipment fills all the cups of a tray simultaneously and releases the full tray into a carton.

6. Rotary dumper. This equipment dumps field crates at a constant, preset rate with only a fraction of the labor required for manual dumping.

The first step in this study was a survey of selected packinghouses in the Appalachian area. Its purpose was to collect information on types of equipment in use, volumes packed, types of packages used, varieties of apples packed, length of packing season, and other variables. From these data, eight packinghouses were selected for further study. In these eight packinghouses were found all the significant variables indicated in the survey.

How Labor and Equipment Requirements Were Determined

Time studies were made of operations as they occurred. It was possible to determine from these studies the portion of each worker's time spent in productive work. A worker's productive time was divided into the elements that made up the operation he was performing, and time values were determined for these elements. The labor requirements thus derived were adjusted to a set of standardized conditions, including worker effort, transportation distances, and number of packages handled. Thus, a complete analysis of the work requirements of each operation was possible, and could be compared with other operations adjusted to the same bases. Unproductive time was also recorded, and the causes of delays were noted.

Sorting operations were studied by work sampling. This technique permitted all the sorters to be observed simultaneously, so that the interrelationship of sorters, as well as the job of sorting, might be evaluated. Labor and equipment costs are shown separately for the different handling and packing methods. It should be noted that the combinations of methods presented are not in all cases those which were actually observed. Some are synthesized by combining work elements observed in widely separated packinghouses. Using this analytical technique, the best performance for each method and each type of equipment could be determined. Comparisons are based on this level of performance.

Labor requirements for each handling and packing operation are presented as both man-hours and elapsed times. Equipment costs were computed using current replacement cost, with straight line depreciation over the estimated life of the equipment, and an interest rate of 5 percent on the average investment. Equipment lifetime is based on hours of annual use, with consideration given to obsolescence. The cost of labor is expressed in dollars by applying a rate of $1.25 per hour to the man-hours for performing the operation. This rate is meant to include all the costs of labor--wages, bonuses, unemployment insurance, and similar costs.

Handling Operations

In an apple packing plant handling takes place during (1) receiving, (2) bringing-up, (3) segregating, (4) putting packed cartons into storage, and (5) loading-out.

Receiving is the unloading of full crates from the orchard, and their transportation to and placement in storage, or their delivery to the dumper.

Bringing-up is the removal of field crates from storage and their transportation to and placement in the vicinity of the dumper.

Segregating is the sorting out of packed containers according to the grade and size of fruit they contain.

Putting packed cartons into storage is the delivery and placement of packed apples in a cold storage room. Sometimes this operation and segregating are performed simultaneously.

Loading-out is the removal of apples from storage or the packing line and their delivery to and stowing in a road truck or trailer for shipment from the packing plant.

Setup and cleanup are part of receiving. Setup is the preparation of truck for unloading; it includes untying the load, removing endgate or V-boards, placing bridge plate, and assembling the receiving equipment. Cleanup is the preparation of a truck for its return to the orchard; it includes removing bridge plate, and placing tailgate, V-boards, and tie ropes on truck bed.

The types of handling equipment in most common use in the Appalachian area and included in this study, are the following:

1. Clamp type 2-wheel handtruck.
2. Gravity and powered conveyor.
3. Forklift truck and pallets.

Packing Line Operations

A packing line incorporates all those operations that contribute directly toward converting field-run apples into a graded and packed product. There are four such operations: (1) Dumping, (2) sorting, (3) sizing, and (4) packing. Other operations associated with these are (1) lidding, (2) labeling, (3) tallying, (4) carton making, and (5) crating culls.

Dumping is the operation in which apples are emptied from field crates onto a spreader belt either manually or mechanically.

Sorting is the separation of apples into grades according to quality groupings.

Sizing is the grouping of apples according to their greatest diameters along the stem-calyx axis, and is done after sorting. Apple size may be determined by measuring either the weight or dimension of the apple.

Packing is the placement of apples in a container. They may be placed in any of several container types, by any of several methods.

Statistical Supplement

Equipment Cost Data

The three tables immediately following (26, 27, and 28) present basic cost data for all types of equipment described in this report. Each table is based

Table 26.--Cost of equipment for handling and packing 50,000 bushels of apples a year in the Appalachian area 1/

Equipment	Initial cost per unit	Expected life	Annual ownership cost				Annual operating cost			Total annual cost
			Depreciation	Interest at 5 percent	Insurance and taxes at 4 percent	Total	Power 2/	Maintenance 3/	Total	
	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
2-wheel clamp truck	45	17	2.65	1.12	1.80	5.57	-	3.50	3.50	9.07
Belt conveyor (16" x 20')	850	17	50.00	21.25	34.00	105.25	6.65	12.00	18.65	123.90
Forklift truck	4,275	10	427.50	106.88	171.00	705.38	12.15	90.00	102.15	807.53
Pallet (40" x 48")	3	10	.30	.08	.12	.50	-	.10	.10	4/ .60
Gravity conveyor (10' section)	95	18	5.28	2.38	3.80	11.46	-	1.00	1.00	12.46
20' chain conveyor	170	12	14.17	4.25	6.80	25.22	6.10	5.00	11.10	36.32
High-piler	800	12	66.67	20.00	32.00	118.67	5.00	8.00	13.00	131.67
Destacker	2,900	12	241.67	72.50	116.00	430.17	14.00	50.00	64.00	494.17
Drum dumper	1,690	12	140.83	42.25	67.60	250.68	9.30	30.00	39.30	289.98
Manual stapler	65	12	5.42	1.62	2.60	9.64	-	2.00	2.00	11.64
Spreader belt	515	12	42.92	12.88	20.60	76.40	9.30	12.50	21.80	98.20
Pneumatic stapler	130	12	10.83	3.25	5.20	19.28	10.00	5.00	15.00	34.28
Eliminator	530	12	44.16	13.25	21.20	78.61	9.30	6.50	15.80	94.41
Bottom stitcher	500	12	41.67	12.50	20.00	74.17	10.00	20.00	30.00	104.17
Brusher	715	12	59.58	17.88	28.60	106.06	9.30	8.00	17.30	123.36
Sorting table:										
Wooden roller	1,000	12	83.33	25.00	40.00	148.33	15.20	15.00	30.20	178.53
Spiral type	1,245	12	103.75	31.12	49.80	184.67	15.20	15.00	30.20	214.87
Float roll	1,700	12	141.66	42.50	68.00	252.16	15.20	15.00	30.20	282.36
Sizer:										
Dimension	5,400	12	450.00	135.00	216.00	801.00	18.25	90.00	108.25	909.25
Weight (with 20 tubs)	9,950	12	829.17	248.75	398.00	1,475.92	18.25	90.00	108.25	1,584.17
Chain	195	12	16.33	4.90	7.84	29.07	14.00	4.00	18.00	47.07
Nailer	2,500	12	208.33	62.50	100.00	370.83	5.00	12.00	17.00	387.83
40' return-flow belt	3,340	12	278.33	83.50	133.60	495.43	8.10	40.00	48.10	543.53
Power shunt	225	12	18.75	5.62	9.00	33.37	2.70	2.50	5.20	38.57
Packing stand	45	17	2.65	1.12	1.80	5.57	-	-	-	5.57
Faceplate	3	20	.15	.08	.12	.35	-	-	-	.35
Filling shell	3	20	.15	.08	.12	.35	-	-	-	.35
Semiautomatic tray packer	880	12	73.33	22.00	35.20	130.53	-	6.50	6.50	137.03
Bagging machine	450	12	37.50	11.25	18.00	66.75	5.00	5.00	10.00	76.75
Box filler	1,080	12	90.00	27.00	43.20	160.20	5.00	13.00	18.00	178.20
Basket turner	250	17	14.71	6.25	10.00	30.96	-	3.00	3.00	33.96

1/ Handling equipment based on 500 hours annual use; packing equipment 400 hours annual use.
2/ Based on 2.7 cents per kilowatt hour.
3/ Because maintenance programs vary so greatly among packing plants, these figures should be considered only as approximations.
4/ Each pallet used 3.40 hours per year, excluding storage time.

Table 27.--Cost of equipment for handling and packing 100,000 bushels of apples a year in the Appalachian area 1/

Equipment	Initial cost per unit	Expected life	Annual ownership cost				Annual operating cost			Total annual cost
			Depreciation	Interest at 5 percent	Insurance and taxes at 4 percent	Total	Power 2/	Maintenance 3/	Total	
	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
2-wheel clamp truck	45	15	3.00	1.12	1.80	5.92	-	4.50	4.50	10.42
Belt conveyor (16" x 20')	850	15	56.67	21.25	34.00	111 92	10.00	15.00	25.00	136.92
Forklift truck	4,275	8	534.37	106.88	171.00	812.25	18.25	115.00	133.25	945.50
Pallet (40" x 48")	3	10	.30	.08	.12	.50	-	.10	.10	4/ .60
Gravity conveyor (10' section)	95	15	6.33	2.38	3.80	12.51	-	1.35	1.35	13.86
20' chain conveyor	170	10	17.00	4.25	6.80	28.05	8.10	5.35	13.45	41.50
High-piler	800	10	80.00	20.00	32.00	132.00	7.50	10.00	17.50	149.50
Destacker	2,900	10	290.00	72.50	116.00	478.50	18.65	80.00	98.65	577.15
Basket turner	250	15	16.67	6.25	10.00	32.92	-	4.00	4.00	36.92
Drum dumper	1,690	10	169.00	42.25	67.60	278.85	12.40	35.00	47.40	326.25
Manual stapler	65	10	6.50	1.62	2.60	10.72	-	3.00	3.00	13.72
Spreader belt	515	10	51.50	12.88	20.60	84.98	12.40	15.00	27.40	112.38
Pneumatic stapler	130	10	13.00	3.25	5.20	21.45	14.00	7.00	21.00	42.45
Eliminator	530	10	53.00	13.25	21.20	87.45	12.40	8.00	20.40	107.85
Bottom stitcher	500	10	50.00	12.50	20.00	82.50	14.00	25.00	39.00	121.50
Brusher	715	10	71.50	17.88	28.60	117.98	12.40	10.00	22.40	140.38
Sorting table:										
Wooden roller	1,000	10	100.00	25.00	40.00	165.00	20.25	20.00	40.25	205.25
Spiral type	1,245	10	124.50	31.12	49.80	205.42	20.25	20.00	40.25	245.67
Float roll	1,700	10	170.00	42.50	68.00	280.50	20.25	20.00	40.25	320.75
Sizer:										
Dimension	5,400	10	540.00	135.00	216.00	891.00	24.30	110.00	134.30	1,025.30
Weight (with 20 tubs)	9,950	10	995.00	248.75	398.00	1,641.75	24.30	110.00	134.30	1,776.05
Chain	195	10	19.50	4.88	7.80	32.18	18.65	5.00	23.65	55.83
40' return-flow belt	3,340	10	334.00	83.50	133.60	551.10	10.80	50.00	60.80	611.90
Power shunt	225	10	22.50	5.62	9.00	37.12	3.60	3.40	7.00	44.12
Nailer	2,500	10	250.00	62.50	100.00	412.50	10.00	15.00	25.00	437.50
Packing stand	45	15	3.00	1.12	1.80	5.92	-	-	-	5.92
Filling shell	3	15	.20	.08	.12	.40	-	-	-	.40
Semiautomatic tray packer	880	10	88.00	22.00	35.20	145.20	-	8.00	8.00	153.20
Faceplate	3	15	.20	.08	.12	.40	-	-	-	.40
Box filler	1,080	10	108.00	27.00	43.20	178.20	6.65	16.65	23.30	201.50
Bagging machine	450	10	45.00	11.25	18.00	74.25	10.00	8.00	18.00	92.25

1/ Handling equipment based on 625 hours annual use; packing equipment 536 hours annual use.
2/ Based on 2.7 cents per kilowatt hour.
3/ Because maintenance programs vary so greatly among packing plants, these figures should be considered only as approximations.
4/ Each pallet used 3.40 hours per year excluding storage time.

Table 28.--Cost of equipment for handling and packing 200,000 bushels of apples a year in the Appalachian area 1/

Equipment	Initial cost per unit	Expected life	Annual ownership cost				Annual operating cost			Total annual cost
			Depreciation	Interest at 5 percent	Insurance and taxes at 4 percent	Total	Power 2/	Maintenance 3/	Total	
	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
2-wheel clamp truck	45	12	3.75	1.12	1.80	6.67	-	5.00	5.00	11.67
Belt conveyor (16" x 20')	850	12	70.83	21.25	34.00	126.08	13.30	17.00	30.30	156.38
Forklift truck	4,275	6	712.50	106.88	171.00	990.38	24.30	130.00	154.30	1,144.68
Pallet (40" x 48")	3	10	.30	.08	.12	.50	-	.10	.10	4/ .60
Gravity conveyor (10' section)	95	13	7.31	2.38	3.80	13.49	-	1.50	1.50	14.99
20' chain conveyor	170	9	18.88	4.25	6.80	29.93	12.20	5.50	17.70	47.63
High-piler	800	9	88.89	20.00	32.00	140.89	10.00	12.00	22.00	162.89
Destacker	2,900	9	322.22	72.50	116.00	510.72	28.00	90.00	118.00	628.72
Drum dumper	1,690	9	187.77	42.25	67.60	297.62	18.60	40.00	58.60	356.22
Spreader belt	515	9	57.22	12.88	20.60	90.70	18.60	17.00	35.60	126.30
Eliminator	530	9	58.89	13.25	21.20	93.34	18.60	9.00	27.60	120.94
Brusher	715	9	79.44	17.88	28.60	125.92	18.60	11.00	29.60	155.52
Sorting table:										
Wooden roller	1,000	9	111.11	25.00	40.00	176.11	30.40	25.00	55.40	231.51
Spiral type	1,245	9	138.33	31.12	49.80	219.25	30.40	25.00	55.40	274.65
Float roll	1,700	9	188.89	42.50	68.00	299.39	30.40	25.00	55.40	354.79
Sizer:										
Dimension	5,400	9	600.00	135.00	216.00	951.00	36.50	120.00	156.50	1,107.50
Weight (with 20 tubs)	9,950	9	1,105.55	248.75	398.00	1,752.30	36.50	120.00	156.50	1,908.80
Chain	195	9	21.67	4.88	7.80	34.35	28.00	6.00	34.00	68.35
40' return-flow belt	3,340	9	371.10	83.50	133.60	588.20	16.20	55.00	71.20	659.40
Power shunt	225	9	25.00	5.62	9.00	39.62	5.40	4.00	9.40	49.02
Packing stand	45	13	3.46	1.12	1.80	6.38	-	-	-	6.38
Semiautomatic tray packer	880	9	97.78	22.00	35.20	154.98	-	9.00	9.00	163.98
Box filler	1,080	9	120.00	27.00	43.20	190.20	10.00	18.00	28.00	218.20
Bagging machine	450	9	50.00	11.25	18.00	79.25	10.00	10.00	20.00	99.25
Filling shell	3	13	.23	.08	.12	.43	-	-	-	.43
Faceplate	3	13	.23	.08	.12	.43	-	-	-	.43
Basket turner	250	13	19.23	6.25	10.00	35.48	-	5.00	5.00	40.48
Manual stapler	65	9	7.22	1.62	2.60	11.44	-	4.00	4.00	15.44
Pneumatic stapler	130	9	14.44	3.25	5.20	22.89	20.00	8.00	28.00	50.89
Bottom stitcher	500	9	55.56	12.50	20.00	88.06	20.00	30.00	50.00	138.06
Nailer	2,500	9	277.78	62.50	100.00	440.28	10.00	17.00	27.00	467.28

1/ Handling equipment based on 900 hours annual use; packing equipment 800 hours annual use.
2/ Based on 2.7 cents per kilowatt hour.
3/ Because maintenance programs vary so greatly among packing plants, these figures should be considered only as approximations.
4/ Each pallet used 3.40 hours per year excluding storage time.

on a different annual volume. These costs are representative for the Appalachian area. However, there could be considerable variation in individual cases. Any packer can substitute his own cost figures for those given and carry out an analysis as it would pertain to his own plant.

Handling Data

Labor data for each handling operation are given in tables 29 through 44. In some, labor and equipment costs are also shown. Using these data, a packer can determine where--within a handling operation--the labor requirements are greatest, and where they are the least. He can also use these data in tracing down the causes of delays and determining the reasons for wait time.

Labor Requirements for Handling and Packing Operations

Tables 45 through 52 and figure 27 give the detailed labor requirements of the handling and packing operations.

Base time is that amount of labor which would be required to perform an element if the worker doing it were trained in his job, and not affected by fatigue. In practice, workers do become slower as they become tired. Also, in the course of a day's work they spend some time away from their work station for personal reasons. In consideration of this, an allowance is added to the base time. Base time plus the allowance gives productive time, which is the amount of labor that can reasonably be expected to be expended in performing an element of work. Productive time is used in establishing labor requirements for complete operations.

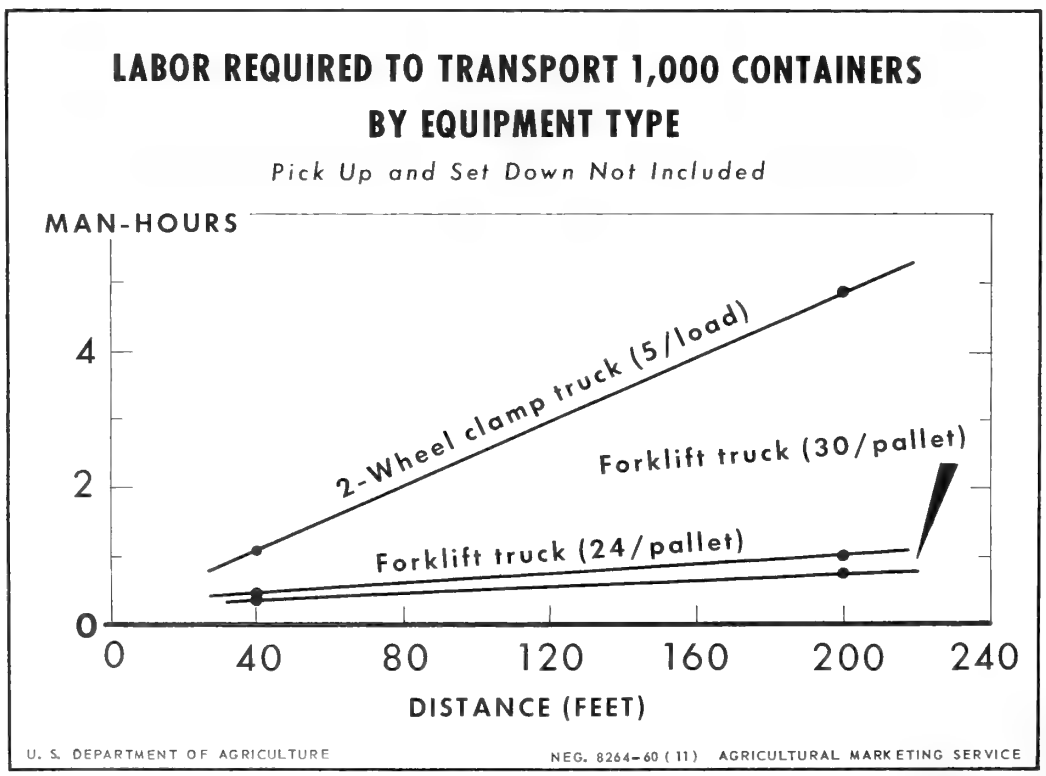


Figure 27

Table 29.--Labor required by 3- and 4-man crews to receive 1,000 field crates of apples using clamp type 2-wheel handtrucks

Time item	3-man crew receiving apples and moving them directly to dumper		4-man crew receiving apples and placing them in storage	
	Workers	Labor required 1/	Workers	Labor required 2/
	Number	Man-hours	Number	Man-hours
Productive labor:				
Setup	1	0.07	1	0.07
Unload	3	.91	3	.91
Transport	3	2.51	3	2.51
Stack	3	.32	3	.48
High-pile mechanically	-	-	1	1.29
Cleanup	1	.05	1	.05
Total productive labor		3.86		5.31
Unproductive labor:				
Wait for setup and cleanup	2	.24	3	.36
Total labor	3	4.10	4	5.67
		Hours		Hours
Elapsed time		1.37		1.42

1/ One man sets up while others wait; then 3 men pick up stacks of crates, transport them to dumper, and deposit crates in position. On completion one man cleans up while others wait.

2/ One man sets up while others wait; then 3 men pick up stacks of crates, transport them to storage, and deposit crates in position; one man high-piles alternate stacks with high-piler. On completion one man cleans up while others wait.

Table 30.--Labor and equipment costs for receiving and placing in storage 1,000 field crates of apples by use of clamp type 2-wheel handtrucks and mechanical high-piler--annual volume 50,000 crates

Time item	Labor 1/	Equipment	Total
	Dollars	Dollars	Dollars
Productive labor:			
Setup and cleanup	0.15	2/0.03	0.18
Unload, transport 100 feet, and deposit load	4.88	3/ .07	4.95
High-pile top 5 crates	1.61	4/ .34	1.95
Total	6.64	.44	7.08
Unproductive labor:			
3 men wait during setup and cleanup	.45	-	.45
Total	7.09	.44	7.53

1/ Based on an assumed labor cost of $1.25 per hour.
2/ Three clamp type 2-wheel handtrucks at $0.018 each per hour, and 1 high-piler at $0.263 per hour.
3/ Three clamp type 2-wheel handtrucks at $0.018 each per hour.
4/ One high-piler at $0.263 per hour.

Table 31.--Labor required by 6-man crew, using conveyors, clamp type 2-wheel handtrucks, and a high-piler, to receive and stack 1,000 field crates of apples 1/

Time item	Labor	
		Man-hours
Productive labor:		
Setup		0.09
Unload truck:		
Manually unload crate to conveyor at workface	1.50	
Position short conveyor section in truck (twice per truck)	.06	
Total unload		1.56
Build 5-high stacks along conveyor		1.98
Transport with clamp type 2-wheel hand truck		
Pick up 5-crate loads	.91	
Transport 5-crate loads 20 feet	.62	
Deposit 5-crate loads	.48	
Total transport		2.01
High-pile top 5 crates with high-piler		1.29
Cleanup		.07
Total productive labor		7.00
Unproductive labor:		
5 men wait while 1 man sets up		.45
2 transporters wait on unloader		1.11
2 stack builders wait on unloader		1.14
1 high-piler wait on unloader		.27
5 men wait while 1 man cleans up		.35
Total unproductive time		3.32
Total		10.32
		Hours
Elapsed time		1.72

1/ Crew organization: One man sets up while 5 men wait; then one man picks up crates and sets them down on conveyor. Twice per truckload he positions short conveyor section. In the storage room two men build stacks along conveyor, two men pick up stacks, transport them to storage point, and deposit stacks, and one man high-piles alternate stacks. On completion one man cleans up while five men wait.

Table 32.--Labor and equipment costs for receiving and placing in storage 1,000 field crates of apples using conveyors, clamp type 2-wheel handtrucks, and a high-piler--annual volume 50,000 crates

Time item	Labor 1/	Equipment	Total
	Dollars	Dollars	Dollars
Setup and cleanup	0.20	0.26	0.46
Unload truck	1.95	2/1.94	3.89
Build stack at conveyor	2.48	3/ .04	2.52
Pick up, transport, and deposit 5-crate loads	2.51	3/ .04	2.55
High-pile top 5 crates with high-piler	1.61	4/ .34	1.95
Wait time	2.35	.39	2.74
Total	11.10	3.01	14.11

1/ Based on an assumed labor cost of $1.25 per hour.
2/ 10-foot gravity conveyor section at $0.024 per hour; 100-foot powered conveyor at $1.24 per hour.
3/ Two clamp type 2-wheel handtrucks at $0.018 each per hour.
4/ One high-piler at $0.263 per hour.

Table 33.--Labor required to receive 1,000 field crates of apples by use of forklift truck and pallets when crates are palletized before and after arrival at packing plant

Time item	Crates palletized before arrival at packing plant 1/		Crates palletized after arrival at packing plant 2/	
	Workers	Labor	Workers	Labor
	Number	Man-hours	Number	Man-hours
Productive labor:				
Setup		0.08	1	0.08
Unload truck:				
Position empty pallet			1	.26
Load pallet			2	2.50
Total unload				2.76
Transport:				
Pick up 24-crate pallet loads		.15		.15
Move 100 feet		.64		.64
Deposit load		.19		.19
Total transport		.98	1	.98
Cleanup		.05	1	.05
Total productive labor	1	1.11		3.87
Unproductive labor:				
2 men wait while 1 man sets up				.16
1 man waits while 1 man positions empty pallet				.26
Transporter waits while 2 men unload truck				.55
2 men wait while 1 man cleans up				.10
Total unproductive labor				1.07
Total	1	1.11	3	4.94
	Hours		Hours	
Elapsed time	1.11		1.65	

1/ Crew organization: 1 man sets up, then removes loaded pallets to storage. On completion same man cleans up. With 1-man crew there is no wait time.

2/ Crew organization: 1 man sets up while 2 men wait; then 1 man positions empty pallet which 2 men load with 24 crates. Transporter removes loaded pallet to storage. On completion 1 man cleans up while 2 men wait.

Table 34.--Labor and equipment costs for receiving 1,000 field crates of apples by use of forklift truck and pallets when crates are palletized before and after arrival at packing plant--annual volume 50,000 crates

Time item	Crates palletized before arrival at packing plant			Crates palletized after arrival at packing plant		
	Labor 1/	Equipment	Total	Labor 1/	Equipment	Total
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Unloading	-	-	-	3.45	-	-
Transporting	1.23	-	-	1.23	-	-
Setup and cleanup	.16	-	-	.16	-	-
Wait	-	-	-	1.34	-	-
Total	1.39	2/5.06	6.45	6.18	3/7.52	13.70

1/ Based on an assumed labor cost of $1.25 per hour.
2/ One forklift truck used 1.11 hours at $1.62 per hour; 42 pallets used 1.11 hours at $0.07 per pallet per hour.
3/ One forklift truck used 1.65 hours at $1.62 per hour; 42 pallets used 1.65 hours at $0.07 per pallet per hour.

Table 35.--Labor required to bring-up 1,000 field crates of apples by use of clamp type 2-wheel handtrucks--destacking top 5 crates done manually and by mechanical destacker

Time item	Destacking performed manually 1/		Destacking performed mechanically 2/	
	Man-hours		Man-hours	
Productive labor:				
Break out top 500 crates		2.29		0.89
Transport apples to the area of the dumper:				
Pick up 5-crate loads	.91		.91	
Transport 100 feet	2.51		2.51	
Set down loads	.33		.33	
Total transport		3.75		3.75
Total productive labor		6.04		4.64
Unproductive labor: 3/				
Breakout man waits for dumper	5.71			
Transporter waits for dumper	4.25		3.36	
Total unproductive labor		9.96		3.36
Total		16.00		8.00
	Hours		Hours	
Elapsed time	8.00		8.00	

1/ Crew organization: 1 man removes top 5 crates from 10-high stack; he hands crates to second transporter who builds 5-high stack on floor, then transports load to area of dumper and deposits it.
2/ Crew organization: 1 man performs all bring-up elements. He destacks top 5 crates of 10-crate stack, then transports them to area of dumper and deposits load.
3/ Rate of the bring-up operation is set by the dumping rate of 1,000 crates per 8-hour day.

Table 36.--Labor and equipment costs for bringing-up 1,000 field crates of apples by clamp type 2-wheel handtruck --destacking top 5 crates done manually and by a mechanicaly destacker--annual volume 50,000 crates dumped

Time item	Destacking performed manually			Destacking performed mechanically		
	Labor	Equipment	Total	Labor	Equipment	Total
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Productive time:						
Break out top 500 crates	2.86	-	-	1.11	-	-
Transport apples 100 feet to area of dumper	4.69	-	-	4.69	-	-
Unproductive time:						
Break-out man waits for dumper	7.14	-	-	4.20	-	-
Transporter waits for dumper	5.31	-	-	-	-	-
Total	20.00	1/0.14	20.14	10.00	2/2.26	12.26

1/ One clamp type 2-wheel handtruck 8 hours at $0.018 per hour.
2/ One high-piler 8 hours at $0.263 per hour, and one clamp type 2-wheel handtruck 8 hours at $0.018 per hour.

Table 37.--Labor required for 2-man crew to bring up 1,000 field crates of apples by use of gravity and powered conveyors

Time item	Crates handled	Labor 1/
	Number	Man-hours
Productive labor:		
Break out crates and place on roller conveyor	600	0.67
Transfer crates to belt conveyor	600	.67
Move 4-high stacks 12 feet by handtruck to belt conveyor	400	.57
Place boxes from 4-high stacks on belt conveyor	400	.58
Total productive labor		2.49
Unproductive time:		
Break-out man waits for dumper		6.76
Transfer man waits for dumper		6.75
Total unproductive time		13.51
Total		16.00

1/ Crew organization: 1 man destacks top 6 crates of 10-crate stacks and sets them down on gravity conveyor laid across crates of 4th layer; 2d worker removes crates from end of gravity conveyor and transfers them to powered conveyor which supplies dumper. Bring-up rate determined by dumping rate of 1,000 crates per 8-hour day.

Table 38.--Labor and equipment costs for bringing up 1,000 crates of apples by use of combination gravity and powered conveyors

Time item	Labor	Equipment	Total
	Dollars	Dollars	Dollars
Productive time:			
Break out crates and place on gravity conveyor	0.84	-	-
Transfer crates to belt conveyor	.85	-	-
Move stacks by handtruck to belt conveyor	.71	-	-
Place boxes on belt conveyor	.71	-	-
Unproductive time:			
Break-out man waits for dumper	8.45	-	-
Transfer man waits for dumper	8.44	-	-
Total	20.00	1/10.13	30.13

1/ One 10-foot gravity conveyor at $0.024 per hour, one clamp type 2-wheel handtruck at $0.018 per hour, and 100 feet of powered belt conveyor at $1.24 per hour, used 8 hours each.

Table 39.--Labor required for 1 worker to bring up 1,000 field crates of apples by use of a forklift truck and pallets 1/

Time item	24 crates per pallet	30 crates per pallet
	Man-hours	Man-hours
Productive labor:		
Pick up pallet loads in storage	0.20	0.15
Transport loads 100 feet	.65	.54
Set down loads	.19	.15
Total productive labor	1.04	.84
Unproductive time	-	-
Total	1.04	.84

1/ 1 man performs bring-up operation--breaking out crates, transporting them to dumper, and setting pallet loads down near dumper.

Table 40.--Labor and equipment costs for bringing up 1,000 crates of apples by use of forklift truck and pallets

Time item	24 crates per pallet			30 crates per pallet		
	Labor	Equipment	Total	Labor	Equipment	Total
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Pick up pallet loads in storage	0.25	-	-	0.19	-	-
Transport loads 100 feet	.81	-	-	.75	-	-
Set down loads	.24	-	-	.18	-	-
Total	1.30	1/4.74	6.04	1.12	2/3.30	4.42

1/ 42 pallets used 1.04 hours at $0.07 per hour, and 1 forklift used 1.04 hours at $1.62 per hour.

2/ 33 pallets used 0.84 hour at $0.07 per hour, and 1 forklift truck used 0.84 hour at $1.62 per hour.

Table 41.--Labor required to put 1,000 cartons of apples into storage by use of 3 different types of equipment at a packing rate of 885 cartons per day

Time item	Clamp type 2-wheel handtruck and high-piler 1/		Powered conveyor and manual high-piling 2/		Forklift truck and pallets 3/	
	Man-hours		Man-hours		Man-hours	
Productive labor:						
Build stacks	-	1.98	-	-	-	2.85
Transport:						
Pick up loads	0.91	-	-	-	0.12	-
Transport 100 feet	2.51	-	-	-	.54	-
Deposit loads	.48	-	-	-	.15	-
Total transport		3.90	-	-		.81
High-pile mechanically	-	1.29	-	-	-	-
Stack all cartons manually	-	-	-	7.90	-	-
Total productive labor		7.17		7.90		3.66
Unproductive time:						
Workers wait for cartons from packing line	-	10.77	-	10.04	-	5.97
Total		17.94		17.94		9.63
	Hours		Hours		Hours	
Elapsed time	8.97		8.97		8.97	

1/ One man segregates cartons into stacks, 2d worker picks up cartons, transports them to storage, either sets the bottom 5 cartons in storage position or top 5 cartons in front of stack they are to rest on, and returns for another load; he also high-piles alternate stacks with high-piler.

2/ Two men remove cartons from powered conveyor, carry them to storage position, and manually place them in storage position. For high-piled cartons, one worker hands cartons up to 2d worker who places them in storage.

3/ One worker picks up pallet loads, transports them to storage, and sets pallets in storage position; worker then returns for another pallet load, or goes to other work so that he does not wait for cartons from packing line. Second worker is assigned full time to this operation; he builds pallet loads 30 cartons per pallet.

Table 42.--Labor and equipment costs to put 1,000 cartons of apples into storage by use of 3 different types of equipment, based on 44,250 cartons annually.

Time item	Clamp type 2-wheel handtruck			Powered conveyor			Forklift truck and pallets		
	Labor	Equipment	Total	Labor	Equipment	Total	Labor	Equipment	Total
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Productive time:									
Build stacks	2.48	-	-	-	-	-	3.56	-	-
Transport	4.88	-	-	-	-	-	1.01	-	-
High-pile	1.61	-	-	-	-	-	-	-	-
Stack manually	-	-	-	9.88	-	-	-	-	-
Total productive time	8.97			9.88			4.57		
Unproductive time:									
Workers wait for cartons from packing line	13.46	-	-	12.55	-	-	7.46	-	-
Total	22.43	1/2.52	24.95	22.43	2/11.64	34.07	12.03	3/2.64	14.67

1/ One clamp type 2-wheel handtruck at $0.018 per hour and 1 high-piler used 8.97 hours at $0.263 per hour.
2/ 100 feet of powered belt conveyor used 8.97 hours at $1.24 per hour.
3/ 34 pallets at $0.07 per pallet per hour and 1 forklift truck used 0.66 hour at $1.62 per hour.

Table 43.--Labor required to load 1,000 cartons of apples when delivered to a trailer by 3 different types of equipment

Time item	Clamp type 2-wheel handtruck 1/		Powered conveyor 2/	Forklift truck and pallets 3/	
	Man-hours		Man-hours	Man-hours	
Productive labor:					
Destack	-	1.37	4.57	-	-
Transport:					
Pick up loads	0.91	-	-	0.15	-
Transport 150 feet	3.69	-	-	.59	-
Deposit loads	.48	-	-	.15	-
Total transport		5.08	-		0.89
Stow cartons manually	-	.95	3.33		3.33
Total productive labor	-	7.40	7.90	-	4.22
Unproductive time:					
Destacker waits on transporters	-	.18	-	-	-
Destackers wait on stowers	-	-	.42	-	-
Total		7.58	8.32		4.22
	Hours		Hours	Hours	
Elapsed time	0.95		1.66	3.33	

1/ One man removes high-piled cartons from storage and hands to transporter. Transporter picks up stack (or one from storage), transports it to trailer, and deposits it to be put in place by the loader.

2/ Two workers remove cartons from storage and place on feeder conveyor. Third worker transfers cartons to belt conveyor, and 2 workers stow cartons.

3/ One worker performs destacking and transport, and second worker stows cartons in trailer, 30 cartons per pallet.

Table 44.--Labor and equipment costs for loading out 1,000 containers of apples by 3 different methods, based on 46,750 containers annually

Time item	Clamp type 2-wheel handtruck			Conveyor			Forklift truck and pallets		
	Labor	Equipment	Total	Labor	Equipment	Total	Labor	Equipment	Total
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Productive labor:									
Destack	1.11	-	-	5.71	-	-	-	-	-
Transport	6.35	-	-	-	-	-	1.12	-	-
Stow	1.19	-	-	4.16	-	-	4.16	-	-
Unproductive time	.82	-	-	.53	-	-	-	-	-
Total	9.47	1/0.35	9.82	10.40	2/3.12	13.52	5.28	3/3.72	9.00

1/ Includes cost of 1 high-piler at $0.263 per hour and six clamp type 2-wheel handtrucks used 0.95 hour at $0.018 per hour.

2/ Includes 150 feet of powered belt conveyor at $1.86 per hour plus 10-foot gravity conveyor used 1.66 hours at $0.02 per hour.

3/ Includes 34 pallets used 0.94 hour at $0.07 per hour, plus 1 forklift truck used 0.94 hour at $1.62 per hour.

Table 45.--Labor required for a crew of 9 workers to manually face and fill 1,000 bushel baskets of apples 1/

Time item	Workers	Labor required	
	Number	Man-hours	
Productive labor:			
Facing:			
Position empty faceplate...	-	2.12	-
Fill faceplate.....	-	40.60	-
Remove full faceplate.....	-	1.57	-
Total facing.....	6		44.29
Filling:			
Position faceplate, liner, and shell.....	-	1.95	-
Fill liner from return-flow belt 2/.....	-	16.30	-
Manually remove filled liner.....	-	1.93	
Total filling.....	3		20.18
Total productive labor.....		-	64.47
Unproductive labor:			
Fillers wait on facers.....	-	-	1.96
Total.....	9		66.43
		Hours	
Elapsed time.....		7.38	

1/ Crew organization: Six workers place fruit in faceplates and deliver to fillers; 3 workers perform filling operation.

2/ Includes spreading oiled paper through pack.

Table 46.--Labor required to perform each part of the receiving operation

Time item	Workers	Base time	Fatigue and personal allowances	Productive time
	Number	Man-minutes	Man-minutes	Man-minutes
Manually unload crate from truck to conveyor at workface	1	0.072	0.018	0.090
Add short conveyor section in truck	1	.248	.024	.272
Extend conveyor into truck	1	.250	.024	.274
Manually unload crate from truck to conveyor at platform	1	.173	.032	.205
Pick up 5-crate load with clamp type 2-wheel handtruck	1	.237	.039	.276
Deposit 5-crate load in congested area with clamp type 2-wheel handtruck	1	.126	.019	.145
Manually position pallet on orchard truck	1	.310	.062	.372
Manually load crate on pallet at tailgate	1	.143	.028	.171
	2	.125	.025	.150
Pick up loaded pallet from tailgate	1	.192	.020	.212
Deposit loaded pallet	1	.249	.024	.273
Stack crates to 5-high manually	1	.476	.119	.595
Stack top 5 of 10-high stack with high-piler	1	.673	.101	.774

Table 47.--Labor required to perform each part of the bringing-up operation

Time item	Workers	Base time	Fatigue and personal allowances	Productive time
	Number	Man-minutes	Man-minutes	Man-minutes
Break out 5 high-piled crates with destacker	1	0.462	0.069	0.531
Pick up 5-crate load with clamp type 2-wheel handtruck	1	.237	.039	.276
Deposit 5-crate load in open area	1	.086	.013	.099
Manually load low-stacked carton from storage position to feeder conveyor	1	.072	.015	.087
Manually break out high-piled crate and build load	2	.219	.055	.274
Pick up loaded pallet from storage position	1	.257	.026	.283
Deposit loaded pallet in open area	1	.249	.024	.273
Break out one of six top crates from 10-high stack and place on on roller conveyor	2	.111	.023	.134

Table 48.--Labor required for each part of the operation of storing packed cartons of apples

Time item	Workers	Base time	Fatigue and personal allowances	Productive time
	Number	Man-minutes	Man-minutes	Man-minutes
Place carton on pallet alongside conveyor	1	0.143	0.028	0.171
Pick up loaded pallet from floor-uncongested area	1	.192	.020	.212
Pick up 5-carton load with clamp type 2-wheel handtruck	1	.237	.039	.276
Deposit loaded pallet in uncongested area	1	.249	.024	.273
Deposit 5-carton load in congested area with clamp type 2-wheel handtruck	1	.126	.019	.145
Stack carton manually from conveyor - 1st to 5th layers	1	.095	.024	.119
Manually high-pile carton in 6th to 10th layers	2	.245	.073	.318
Manually stack 1 carton in 10-high stack from conveyor	2	.365	.109	.474
Stack top 5 of 10-high stack with high-piler	1	.673	.101	.774

Table 49.--Elemental labor requirements per occurrence for performing loading-out operation

Time item	Workers	Base time	Fatigue and personal allowances	Productive time
	Number	Man-minutes	Man-minutes	Man-minutes
Break out high-piled crate manually	2	0.219	0.055	0.274
Pick up loaded pallet from storage	1	.257	.026	.283
Deposit loaded pallet	1	.249	.024	.273
Stow carton manually from pallet	2	.160	.040	.200
Pick up 5-crate load with clamp type 2-wheel handtruck	1	.237	.039	.276
Deposit 5-crate load in congested area with clamp type 2-wheel handtruck	1	.126	.019	.145
Break out crates from 10 high to 4 high by use of roller conveyor	2	.111	.023	.134

Table 50.--Elemental labor requirements per occurrence for performing dumping operation

Time item	Workers	Base time	Fatigue and personal allowances	Productive time
	Number	Man-minutes	Man-minutes	Man-minutes
Manually dump apples and set aside empty crate	2	0.458	0.115	0.573
Supplying automatic dumper by refilling friction-drive conveyor for each crate	1	.080	.020	.100

Table 51.--Labor required for each part of the packing operation in apple packing plants

Method of packing and individual time item	Workers	Base time	Fatigue and personal allowances	Productive time
	Number	Man-minutes	Man-minutes	Man-minutes
Face and fill bushel baskets:				
Position empty faceplate on stand..	1	0.111	0.016	0.127
Fill faceplate.....	1	2.118	.318	2.436
Remove full faceplate from stand...	1	.078	.016	.094
Position faceplate, liner, and shell for filling.....	1	.102	.015	.117
Fill basket manually by diverting apples from return-flow belt.....	1	.851	.127	.978
Manually remove filled basket to conveyor.....	1	.097	.019	.116
Wrap and pack size 113 apples in Northwest boxes from rotating tub:				
Remove empty box from monorail and position on packing stand.....	1	.113	.017	.130
Wrap and place-pack apples in box..	1	2.463	.370	2.833
Manually move filled box to conveyor.....	1	.128	.083	.211
Tray-pack 1 carton of size 113 apples:				
Position empty carton on packing stand.....	1	.118	.018	.136
Position empty carton in automatic tray packer.....	1	.198	.030	.228
Place 5 trays in carton and manually fill them from tub.....	1	2.723	.408	3.131
Place 5 trays in carton and manually fill them from return-flow belt.....	1	1.438	.863	2.301
Place 5 trays in carton and fill them by semiautomatic tray packer.	1	.928	.139	1.067
Manually remove filled carton to conveyor.....	1	.128	.083	.211
Release filled carton from tray packer to conveyor.....	1	.070	.042	.112
Bag and cell-pack nine 5-lb. bags of apples with automatic bagging machine:				
Position 1 empty carton on packing stand.....	1	.118	.018	.136
Attach 9 bags to automatic weigher.	1	.627	.094	.721
Fill 9 bags with apples.....	1	1.052	.158	1.210
Remove 9 full bags and attach closers.....	1	.915	.138	1.053
Place 9 full bags in cells of carton.....	1	.272	.041	.313
Manually move 1 filled carton to conveyor.....	1	.128	.083	.211

Table 52.--Labor required for each part of the operations of making cartons, lidding or sealing containers, and labeling packed containers in apple packing plants

Time item	Workers	Base time	Fatigue and personal allowances	Productive time
	Number	Man-minutes	Man-minutes	Man-minutes
Form, staple, and set aside 1 fiberboard carton	1	0.219	0.044	0.263
	2	.322	.064	.386
Lid or seal containers:				
Place bushel basket over filled liner, place basket in basket turner, rotate 180°, sprinkle oiled paper over apples, and place lid on basket and attach through handles	1	.417	.063	.480
Insert lid in nailer, position northwest box in nailer, and nail lid by pressing foot control	1	.136	.021	.157
Seal carton by placing 2 staples by hand or with pneumatic stapler	1	.217	.033	.250
Place telescoping lid over packed carton	1	.198	.030	.228
Mark grade, size, and variety on container with a rubber stamp	1	.129	.019	.148

☆U. S. GOVERNMENT PRINTING OFFICE : 1961 O - 597032

Growth Through Agricultural Progress