HANDLING POTATOES INTO RED RIVER VALLEY STORAGES

METHODS AND EQUIPMENT

MARKETING RESEARCH REPORT NO. 471

TRANSPORTATION AND FACILITIES
RESEARCH DIVISION

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OTHER PUBLICATIONS ON HANDLING POTATOES

U.S. Department of Agriculture publications

An Improved Elevator For Deep Bin Potato Storages, Marketing Research Report No. 131, August, 1956.

Flume System for Handling Bulk Stored Potatoes. Marketing Research Report No. 177, June 1957.

Bin Pallets for Agricultural Products, USDA Forest Service Report No. 2115, June 1958.

A Light-Weight Conveyor for Filling Deep Bin Potato Storages. AMS–362, February 1960.

Pressures on Walls of Potato Storage Bins. AMS–401, August 1960.

State publications

Methods of Receiving Potatoes in Barrels at Maine Trackside Storages, Maine Agricultural Experiment Station Bulletin 560, June 1957. University of Maine, Orono, Maine.

Mechanized Methods of Receiving Potatoes at Maine Trackside Storages, Maine Agricultural Experiment Station Bulletin 585, September 1959, University of Maine, Orono, Maine.

PREFACE

The study described in this report was conducted at the Red River Valley Potato Research Center, East Grand Forks, Minn. It is part of a larger research project covering the development of more efficient work methods, equipment, and facilities for off-farm handling, sorting, cleaning, grading, sizing, and packing of fall-crop potatoes.

This study was conducted under the direction of Joseph F. Herrick, Jr., marketing research analyst, Handling and Facilities Research Branch, Transportation and Facilities Research Division, Agricultural Marketing Service.

This report is the first of a group of three to be published on potato handling in the Red River Valley. Subsequent reports will cover methods and equipment for handling potatoes from storage to packing line, and methods and equipment for packing and loading.

The cooperation of the storage operators, equipment manufacturers, and distributors is greatly appreciated.

Frederick C. Winter, Professor of Industrial Engineering, Columbia University, and consultant to the Division, and Alfred D. Edgar, agricultural engineer, supplied guidance and valuable suggestions.

CONTENTS

SUMMARY

Comparative requirements and costs of labor and equipment were developed for methods of handling potatoes into above- and below-ground storages with capacities of 42,000 cwt., 60,000 cwt., and 120,000 cwt.

The methods involve receiving and placing potatoes into storages of different types. The potatoes are received in a bulk hopper bottom truck or in sacks on a flat bed truck.

Costs per equivalent truckload (120 cwt.) for receiving and placing potatoes into various storages by the different methods and equipment, when receiving truckloads at the maximum rate the method can handle are as follows:

Storage and method	Storage capacity	Labor and equipment cost per truckload (120 cwt.)		
		Received in bulk, 3-man crew	Received in bulk, 4-man crew	Received in sacks, 5-man crew
	Cwt.	*Dollars*	*Dollars*	*Dollars*
Above-ground single door storage—cleated belt binloader.	42,000	2.19	----------	3.32
	60,000	1.96	----------	3.10
	120,000	2.00	----------	3.16
Above-ground multiple door storage—cleated belt binloader.	42,000	2.18	----------	3.30
	60,000	1.95	----------	3.09
	120,000	1.99	----------	3.15
Below-ground deep bin storage—flat conveyor, draper chain binloader, canvas chute.	42,000	1.81	----------	3.02
	60,000	1.65	----------	2.89
	120,000	1.70	----------	2.95
Below-ground deep bin storage—draper chain binloader, canvas chute.	42,000	1.79	----------	2.90
	60,000	1.68	----------	2.80
	120,000	1.71	----------	2.86
Above-ground one-ton pallet box storage—filling equipment, forklift truck.	42,000	6.04	6.25	----------
	60,000	5.54	5.75	----------
	120,000	----------	5.25	----------

These costs do not include cost of management, depreciation for the storage, and monetary losses resulting from injury to potatoes during handling.

The lowest cost method when receiving potatoes into a 42,000 cwt. storage without wait time between truckloads is the below-ground deep bin storage, using a draper chain binloader and a canvas chute with a 3-man crew, and receiving in a bulk hopper body truck. At volumes of 60,000 and 120,000 cwt., the lowest cost method is the below-ground deep bin storage using a flat belt conveyor, draper chain binloader, and a canvas chute with a 3-man crew and receiving in a bulk hopper body truck.

When receiving truckloads at less than the maximum receiving rates of the methods, the below-ground deep bin storage method without the flat belt conveyor is lowest in cost at volumes of 60,000 and 120,000 cwt. until it reaches its maximum receiving rate.

The equipment cost per truckload is considerably less for the 60,000 than the 42,000 cwt. storage due to the greater utilization of equipment. In filling the 120,000 cwt. storages all methods except the 4-man crew pallet box method required two sets of crews and equipment because the elapsed time of operation will not permit the storage to be filled in 24 days.

HANDLING POTATOES INTO RED RIVER VALLEY STORAGES—Methods and Equipment

By Leonard Pawski, industrial engineer
Transportation and Facilities Research Division, Agricultural Marketing Service

BACKGROUND

Placing the Nation's potato crop into storage for gradual packing and shipping during the months after harvest involves the handling of millions of hundredweights (cwt.) of potatoes each year.

Various types and combinations of equipment, crew sizes, and type of storages are used in these operations.

For many years, storage house operators have been increasingly interested in improving methods and reducing costs of handling potatoes. This study, therefore, was undertaken to: (1) Measure the relative efficiency of various work methods, including types or combination of types of handling equipment; (2) determine the kinds and amounts of equipment needed by storage house operators for efficient handling of different volumes of potatoes; (3) appraise comparative labor and equipment costs of moving various volumes of potatoes into storages of different sizes and designs with different methods and types of equipment; (4) develop and test improved methods of using various types and combinations of potato handling equipment; and (5) determine, with respect to potato handling operations, the comparative efficiency of various layouts and designs for potato storage houses.

Research methods and techniques

The research reported here was conducted in commercial potato storage houses selected to cover basic types of handling equipment used and significant variables that affect the use of the equipment. Such variables include: (1) The layout and design of the storage; (2) number of workers in the crews; and (3) volume of potatoes handled.

The principal methods involved receiving potatoes hauled in: (1) Bulk hopper body trucks; and (2) sacks on a flat bed truck.

The types of storages fell into two categories—above-ground and below-ground. The above-ground structures usually were of quonset type or vertical wall, with gable, flat and bow string truss roof construction with, or without, the inside partitioned into bins. The receiving door was of single or multiple type located on the side or end of the building. The type of above-ground structure selected for use in this report as representative of the whole was the vertical wall single and multiple door side entry storage with the inside partitioned into bins for storing potatoes in bulk. A vertical wall single-door side entry structure with a clear span roof was used for the pallet box handling method. The below-ground storages were predominantly of the drive-in, two-end entry, deep bin with arch, gable or gambrel roof construction.

The principal types of equipment used to place potatoes in storage were: (1) Cleated belt binloader for use in single and multiple door above-ground storages; (2) flat belt conveyor with a regular canvas chute and a draper chain binloader for topping the bins used in below-ground deep-bin storages; (3) draper chain binloader with a regular canvas chute used in below-ground deep bin storages; and (4) one-ton capacity pallet boxes filled at the storage with a trough belt conveyor and box tipper from a hopper body type truck and placed into an above-ground single door storage by use of a forklift truck.

In the plants using these methods and equipment, time studies of potato handling operations were made to: (1) Determine the elapsed time required; (2) determine total man-minutes of labor and total machine-minutes of equipment use required; (3) determine where delays, wait time, and other nonproductive times occurred during the performance of operations; and (4) provide a basis for developing improved methods.

Time studies were conducted in accordance with approved techniques by the use of a stopwatch. The actual time observed on elements of work were leveled by a performance rating to represent an average qualified person working at a normal rate. These actual times after being leveled are called base times. To these base times, additional times are added to compensate for fatigue and personal requirements. These times are then called productive times.

From these time study data, labor and equipment costs for performing handling operations by use of specified methods and types of equipment have been computed. These costs show the relative efficiency of

different methods and types of equipment. Labor costs are based on the productive labor required plus the amount of idle time inherent in the method.

Assumed wage rates used in computing labor costs

A wage rate of $1.25 per hour was used for all potato handling operations. This rate does not necessarily represent the average, but a rate commonly used in this area during the 1958 and 1959 harvest periods.

Costs of potato handling equipment

Purchase costs of handling equipment were supplied by dealers and manufacturers, and represent prices f.o.b. Grand Forks, N. Dak. Equipment costs were developed into two major categories: (1) Ownership and (2) operational. (See tables 16, 17, and 18 in the appendix.)

Ownership costs include depreciation, taxes, interest, and insurance, all considered to be fixed and are computed on an annual basis. Interest on the average investment is fixed at 5 percent and 4 percent is allowed for insurance and taxes.

Operational costs include maintenance, repairs, inspection and servicing, fuel, oil, and electricity. The cost for maintenance, repair, inspection, and servicing for all units except the forklift truck and one-ton capacity pallet boxes was set at 1½ percent of the replacement cost per 100 hours of operating time. (An annual cost of $0.0375 per pallet box was used. Of this cost, $0.0125 was allocated to the handling into storage operations and $0.0250 to the storage and removing from storage operations. A cost of $0.184 per hour of use was used for the forklift truck. Gasoline cost was considered at $0.20/gallon and oil at $0.40/quart.) Cost of electricity was considered at the following monthly rates:

For first 200 kw.-hrs	6.0¢ per kw.-hr.
For next 300 kw.-hrs	5.0¢ per kw.-hr.
For next 1500 kw.-hrs	4.0¢ per kw.-hr.
For all additional kw.-hrs	3.25¢ per kw.-hr.

Cost comparisons of handling operations

Total labor and equipment costs for all methods have been computed on an annual and per truckload basis when receiving truckloads at the maximum rate possible with the method. These cost comparisons do not include an allowance for wait time between truckloads. It was assumed another truckload was available as required.

Total labor and equipment costs for all methods were also computed on an annual and per truckload basis when receiving a specified number of truckloads per day. These cost comparisons include an allowance for wait time between truckloads.

Labor cost of the truck driver was included for only the portion of the time he participated in the operation.

The amount of equipment required for the storages of various capacities was determined on a basis of a 24-day receiving period, working 12 hours a day. The elapsed time of the operation was divided into the available minutes to determine the number of loads that could be handled. If this was less than the required number to fill the storage, another set of equipment and crew was added.

When the equipment is used for other operations, such as moving potatoes from storage to the packing line, the ownership cost was prorated to the separate operations according to the hours of use.

Costs are limited only to labor and equipment pertaining to the receiving operation at the storage.

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FIGURE 1.—Above-ground single door potato storage.

BN 11308-x

FIGURE 2.—Inside view of single door potato storage.

Costs of the bulk truck and flatbed truck are not included because they were considered part of the harvesting operation.

For comparative purposes, each storage used was designed as a typical model of its type of construction.

Costs for management, depreciation for the storage, and monetary losses resulting from injury to the potatoes during handling are not included.

Principal types of storages used for potatoes

Potato storages are either above or below ground. The above-ground single receiving door storage is one of the principal types used in the Valley (fig. 1). It has vertical walls; the inside is partitioned into bins and an alleyway (fig. 2).

The above-ground multiple door storage (fig. 3) has a door for each bin (fig. 4). This is a design

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FIGURE 3.—An above-ground multiple door potato storage.

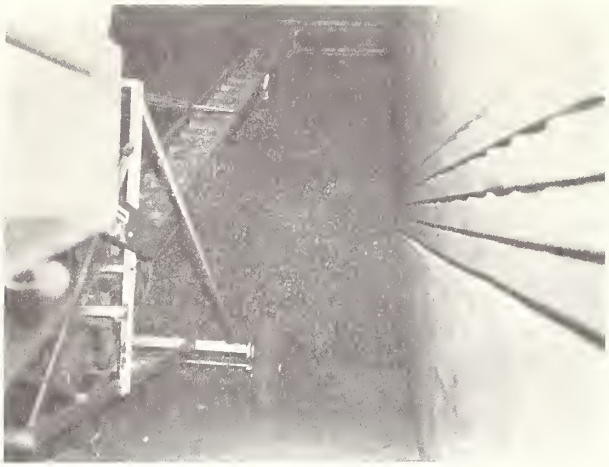

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FIGURE 4.—Inside view of bin of a multiple door potato storage.

usually used to provide immediate access to any bin when an owner rents bins to growers.

The below-ground deep bin storage (fig. 5) has a drive-in entrance from both ends of the building. The inside is partitioned off into bins having a depth usually of 14 feet below the drive floor and 6 feet above (fig. 6).

Principal types of equipment used for receiving potatoes

Bulk hopper body truck

The bulk hopper body truck (fig. 7) is loaded in the field direct from the harvester. The average load of potatoes carried in it is 120 cwt. To unload the potatoes from the truck a ¾-hp. gear reduction motor or a ¾-hp. motor with a jack shaft drive is used to drive the draper chain conveyor in the bottom of the hopper body. The conveyor carries the potatoes out of the truck.

A bulk hopper body truck is shown in figure 7.

For comparative purposes, the ownership and operating cost of a common ¾-hp. motor is used. Neither the extra cost of a gear reduction motor or jack shaft reduction is included.

BN 11310-x

FIGURE 5.— Below-ground deep bin potato storage.

BN 11315-x

FIGURE 6.—View of the drive floor of a deep bin potato storage.

As potatoes are being unloaded, boards that support the load over the chain are pulled out to permit the potatoes to flow on the draper chain and be carried out. Dirt from the potatoes falls through the chain and onto the floor. The unloading capacity of this equipment is 1,032 cwt. per hour.

Flat bed truck

Potatoes are also received in sacks on flat bed trucks as shown in figure 8. Potatoes are hand picked in the fields, placed in burlap sacks, and loaded on the truck. The 100-pound capacity sacks contain approximately 67 pounds of potatoes. There are about 180 of these sacks on each truckload. A truckload was considered as 120 cwt. After the truck is positioned at the storage for unloading, usually three workers carry and empty the sacks onto a conveyor. The conveyor then moves the potatoes to bulk storage bins.

Cleated belt binloader

The cleated belt binloader is used for filling the above-ground storages (fig. 9). A chain conveyor

BN 11309-x

FIGURE 7.—Bulk hopper body truck.

takes the potatoes from the hopper onto the cleated belt conveyor in the boom to elevate them onto the pile. The boom swings in a wide arc, so potatoes can be placed in a wide area without moving the binloader. The boom is raised and lowered as required to minimize the drop of the potatoes from the conveyor onto the pile. As the truck is being unloaded, the hopper of the binloader is raised to minimize the drop of the potatoes. The capacity of the machine is 600 cwt. per hour.

BN 11313-x

FIGURE 8.—A flat bed truck loaded with 120 cwt. of potatoes in sacks.

Flat belt conveyor and canvas chute

A flat belt conveyor with vertical sides and a canvas chute are used in filling a deep bin of a below-ground storage (figs. 10 and 11). The chute is attached to the end of the conveyor, and as a cone of potatoes is built up, sections of the chute are removed. After the cone has reached the conveyor, the potatoes are carried from the conveyor onto the pile and slide as a mass to the far parts of the bin. The conveyor has an 18-inch-wide belt and a capacity of 900 cwt. per hour.

BN 11314-x

FIGURE 9.—Cleated belt binloader.

Draper chain binloader, canvas chute

A draper chain binloader is used for topping, or leveling off, the pile of potatoes in a deep bin after a flat conveyor was used to fill the bin to the conveyor level. It is also used to fill a bin completely. A chute is attached to the end of the conveyor, and as a cone of potatoes is built up, sections of the chute are removed. After the cone has reached the conveyor, the potatoes are carried from the conveyor onto the pile, and slide as a mass to the far parts of the bin. The conveyor section of the binloader is quite flexible, all angles of the conveyor can be changed while the machine is in operation. The boom section and elevating hopper section are raised and lowered by a hand operated hydraulic pump and valves. The capacity of the machine is 600 cwt. per hour. Figure 12 shows potatoes from a bulk hopper body truck being unloaded into the hopper of a draper chain binloader. Figure 13 shows the binloader used in filling the bin.

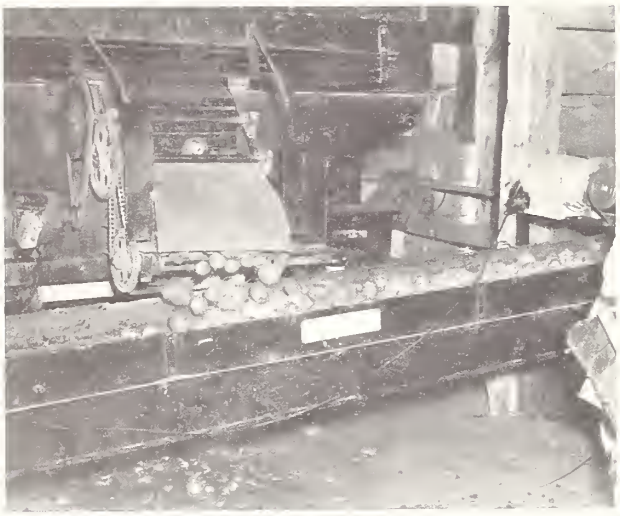

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FIGURE 10.—Potatoes being unloaded from a bulk hopper body truck onto a flat belt conveyor.

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FIGURE 11.—Canvas chute attached to a flat belt conveyor used to lower potatoes into a below-ground bin.

Pallet box, trough belt conveyor, box tipper, roller conveyor, forklift truck

One-ton capacity pallet boxes are filled at the storage. The potatoes are conveyed from the bulk hopper body truck onto a trough belt conveyor and into the pallet box tilted by the box tipper (fig. 14). The box is lowered to an upright position as it is filled, thereby reducing the fall of the potatoes to minimize the injury. After the pallet box has been filled, it is moved aside on roller conveyors, an empty pallet box is raised and the filling operation is repeated (fig. 15).

The worker operating the pallet box tipper controls the operation of the bulk truck and the trough belt conveyor along with the tipper by means of switches and valves mounted on the box tipper. The box tipper and two sections of roller conveyors also are used for emptying boxes when removing potatoes from storage.

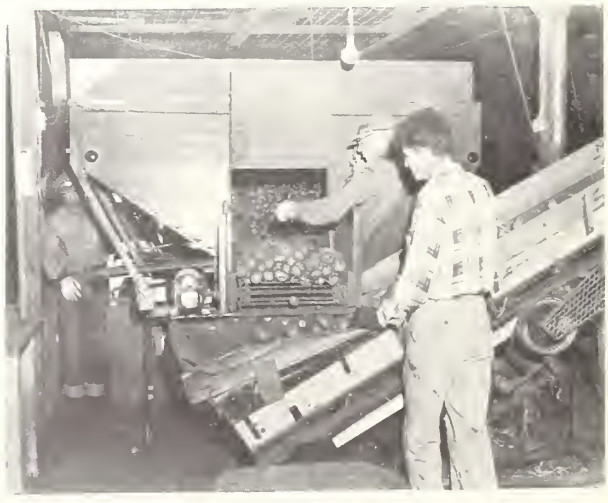

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FIGURE 12.—Bulk hopper body truck being unloaded into hopper of draper chain binloader.

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FIGURE 13.—Draper chain binloader being used to fill a bin.

"B" size potatoes and culls can be removed prior to filling the pallet boxes by installing a draper chain conveyor, sizer and sorting table ahead of the belt conveyor as shown in figure 15.

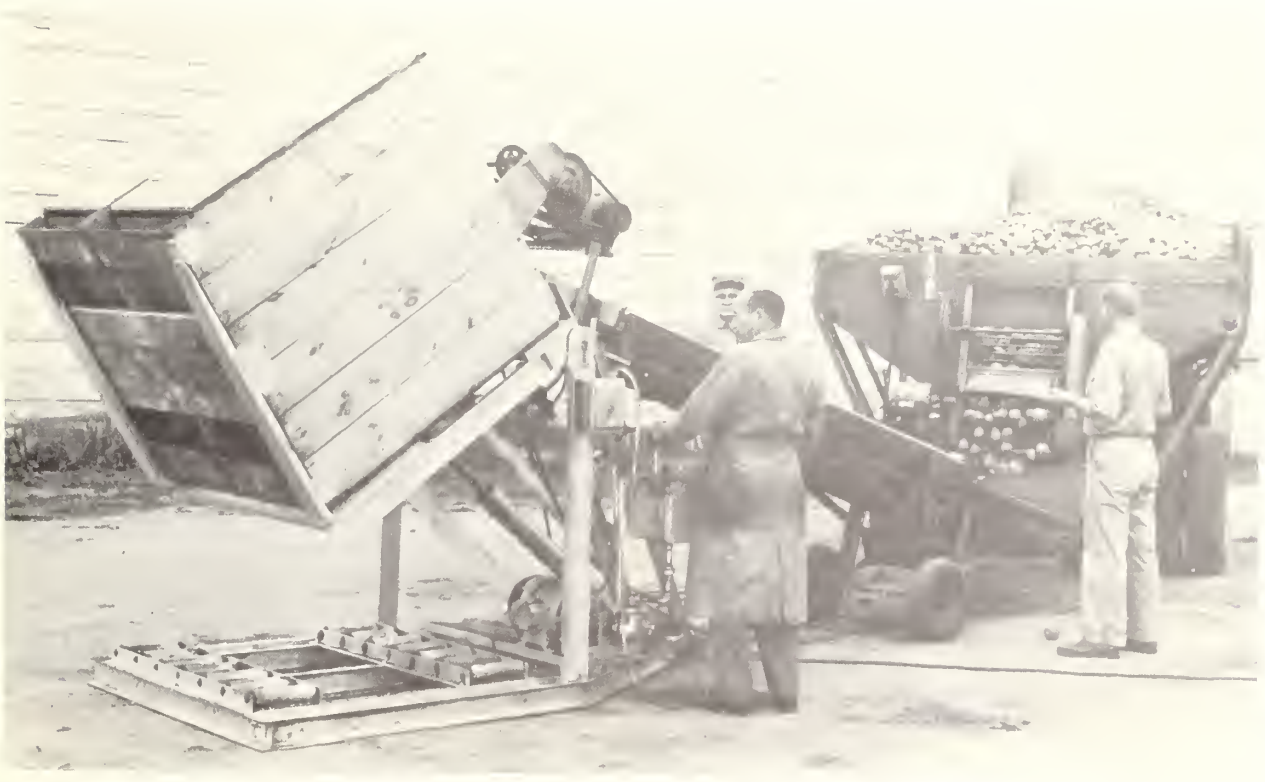

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FIGURE 14.—Bulk hopper body truck, trough belt conveyor, and pallet box on box tipper (from right to left).

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FIGURE 15.—Draper chain conveyor, sizer and sorting table; trough belt conveyor; box tipper; roller conveyor; and forklift truck (from right to left).

A gasoline powered industrial forklift truck of 3,000-pound capacity is used for removing the pallet box from the roller conveyor, transporting and stacking it in the storage (fig. 16). Boxes are stacked 4-high in storage. Empty pallet boxes are picked up, transported, and placed on the roller conveyor. The forklift truck is also used for removing the full boxes from storage during the packing and shipping season.

The pallet box shown in figure 17 is a one-ton capacity box of a high strength hardwood construction and is the type of box considered in the pallet-box handling method. The outside dimensions of the pallet box are 46 inches long x 48 inches wide x 48 inches high. The sides of the box and the top and bottom facing of the pallet are made of 1-inch boards of random width, the four corner posts of 3- by 3-inch lumber, and the stringers of the pallet of 2- by 4-inch lumber. The tare weight of the pallet box is 260 pounds and it holds 2,000 pounds of potatoes.

Figure 14 shows another type of box construction. The sides of the box and the top and bottom facing of the pallet are of nominal 1-inch pine of random

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FIGURE 16.—A gasoline powered industrial forklift truck.

BN 11307-x

FIGURE 17.—A 1-ton capacity pallet box with spaced sides and bottom.

width. The four corner posts and the stringers of the pallet are of 2- by 4-inch lumber with cross member bracing of 1- by 4-inch boards on the inside. This box has a tare weight of 200 lbs.

METHODS AND EQUIPMENT FOR RECEIVING AND PLACING POTATOES INTO STORAGE

Potato harvesting in the Red River Valley usually is most active from about September 6 to October 15. Harvesting a crop into storage is made up of 3 functions:

1. Removing the potatoes from the ground and placing them in a bulk truck or in sacks on a flat bed truck.
2. Transporting the truckload to the storage.
3. Removing them from the truck and placing them in storage.

A crew is assigned to each function. The truck driver assists in removing the potatoes from the truck and placing them into storage. As soon as the truck is empty, the truck driver closes up the truck and leaves for the field. The crew at the storage removes the dirt and trash (vines, clods, and culls) brought with the potatoes from the field and prepares for the next truckload.

Above-ground single-door storage—cleated belt binloader

A cut away illustration and typical layout of a 42,000 cwt. storage is given in figures 18 and 19. This storage is filled with a cleated belt binloader.

The bins are filled to a height of 14 feet. The loads are placed in tiers to reduce the roll down of the potatoes to a minimum. A backboard is used to prevent roll down on the floor as the bins are being filled. When the pile reaches the end of the bin, binboards are installed. Cables are attached to the binboards to help support the load. After the bins are filled, the alleyway is filled to within 10 feet of the door.

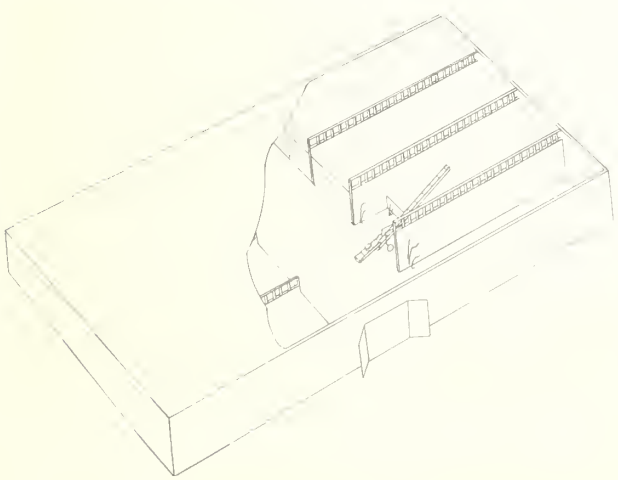

FIGURE 18.—Above-ground single-door potato storage.

Bulk hopper body truck—3-man crew

Table 1 shows the labor requirements to receive a truckload of potatoes from a bulk hopper body truck using a 3-man crew.

This operation begins as the truck starts to back into the storage. After the truck is positioned, the driver hooks up the motor which drives the draper chain, while the trash picker opens the gate of the truck and the binloader operator makes necessary adjustments. Other elements of work such as moving and adjusting the binloader and backboard, and installing binboards are performed by the trash picker and binloader operator on certain loads while the truck is backing in and setting up.

During the time the binloader is operating (fill storage), the truck driver pulls boards from the truck, pushes the potatoes that are stuck to the sides of the truck body and picks trash such as vines, clods, and culls from the potatoes. He controls the operation of the conveyor in the truck except when he is pushing potatoes.

The trash picker picks trash, assists the binloader operator in moving the backboard, and controls the operation of the conveyor in the truck when the driver is pushing potatoes.

The binloader operator controls the piling of the potatoes by moving the boom up, down, or sideways to keep the drop of potatoes to a minimum. He also assists in moving the backboard and hooking up the cables to the binboard. The remainder of his time is used in picking trash.

Occasionally the binloader must be stopped to reposition the boom or the binloader. This is called unavoidable delay (U.D.).

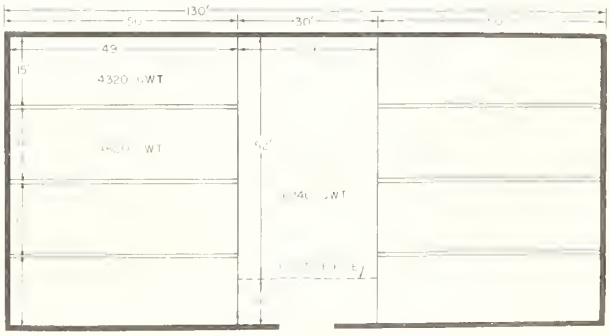

FIGURE 19.—Layout of above-ground single-door storage.

TABLE 1.—*Labor required by a 3-man crew to receive a 120 cwt. truckload equivalent of potatoes when filling an above-ground single door storage of 42,000 cwt. using a bulk hopper body truck and cleated belt binloader*

Time item	Truck driver	Trash picker	Binloader operator	Total
	Man-minutes	*Man-minutes*	*Man-minutes*	*Man-minutes*
Set up and miscellaneous:				
Set up and miscellaneous	1.63	0.51	0.85	
Wait	.22	1.34	1.00	
Total	1.85	1.85	1.85	5.55
Fill storage (unload truck):				
Pull boards and push potatoes	3.27			
Adjust equipment		.11	2.81	
Pick trash	9.93	13.09	10.39	
Total	13.20	13.20	13.20	39.60
Unavoidable delay:				
Adjust binloader	.18	.18	.19	
Wait	.01	.01		
Total	.19	.19	.19	.57
Clean up and miscellaneous:				
Close up truck and drive truck out	1.47	.83		
Adjust equipment	.06	1.19	1.39	
Wait		.41	1.08	
Remove dirt		4.44	4.40	
Total	1.53	6.87	6.87	15.27
Total productive labor	16.54	20.35	20.03	56.92
Total unproductive labor	.23	1.76	2.08	4.07
Total labor	16.77	22.11	22.11	60.99
Elapsed time	16.77	22.11	22.11	

After the potatoes are emptied from the truck and piled, the driver and trash picker push the boards back in the truck, unhook the motor, and close the gate while the operator adjusts the equipment. On certain loads the driver assists in installing binboards. After closing up the truck, the driver leaves for the field and the trash picker and binloader operator remove the dirt, move the binloader, install binboards, and adjust the equipment when required.

Sacks—5-man crew

Table 2 shows the labor requirements to receive a truckload of potatoes from sacks on a flat bed truck, using a 5-man crew. This operation begins as the truck starts to back into the storage. Other elements of work such as moving and adjusting the binloader and backboard and installing binboards are performed by the rest of the crew on certain loads while the truck is backing and setting up. After the truck is positioned, the driver and two men of the storage crew unload and empty sacks into the conveyor. The trash picker picks trash and the binloader operator operates the binloader and both move the backboard as in the 3-man crew bulk method.

After the potatoes have been emptied from the truck, the driver and one unloader assemble and tie down the empty sacks on the truck while the rest of the crew adjusts the equipment and installs binboards on certain loads. After the sacks are tied down, the driver leaves for the field, and the rest of the crew remove the dirt, move the binloader, install binboards, and adjust equipment when required.

Above-ground multiple-door storage—cleated belt binloader

An illustration and typical layout of a 42,000 cwt. storage is given in figures 20 and 21. Potatoes are piled 14 feet high and bins are filled in the same manner as in the single-door storage.

Bulk hopper body truck—3-man crew

Table 3 shows the labor requirements to receive a truckload of potatoes from a bulk hopper body truck, using a 3-man crew. The operation of the crew for filling the storage is relatively the same as in the filling of bins in the single-door storage.

Sacks—5-man crew

Table 4 shows the labor requirements to receive a truckload of potatoes from sacks on a flat bed truck using a 5-man crew. The operation of the crew for filling the storage is relatively the same as for filling of bins in the single-door storage.

TABLE 2.—*Labor required by a 5-man crew to receive a 120 cwt. truckload equivalent of potatoes when filling an above ground single door storage of 42,000 cwt. receiving in sacks on a flat bed truck and using a cleated belt binloader*

Time item	Truck driver	Unloader	Unloader	Trash picker	Binloader operator	Total
	Man-minutes	*Man-minutes*	*Man-minutes*	*Man-minutes*	*Man-minutes*	*Man-minutes*
Set up and miscellaneous:						
Set up and miscellaneous	1.16	0.08	0.23	0.23	0.76	
Wait	.20	1.28	1.13	1.13	.60	
Total	1.36	1.36	1.36	1.36	.136	6.80
Fill storage (unload truck):						
Unload and empty sacks in hopper of binloader.	17.28	17.28	17.28			
Adjust equipment				.12	2.82	
Pick trash				17.16	14.46	
Total	17.28	17.28	17.28	17.28	17.28	86.40
Unavoidable delay:						
Adjust binloader		.05	.18	.18	.19	
Wait	.19	.14	.01	.01		
Total	.19	.19	.19	.19	.19	.95
Clean up and miscellaneous:						
Assemble and tie down sacks	1.21	1.21				
Close up truck and drive truck out	.51					
Adjust equipment		.62	.80	.80	.97	
Wait		.38	1.41	1.41	1.32	
Remove dirt		2.64	2.64	2.64	2.56	
Total	1.72	4.85	4.85	4.85	4.85	21.12
Total productive labor	20.16	21.89	21.13	12.13	21.76	106.07
Total unproductive labor	.39	1.79	2.55	2.55	1.92	9.20
Total labor	20.55	23.68	23.68	23.68	23.68	115.27
Elapsed time	20.55	23.68	23.68	23.68	23.68	

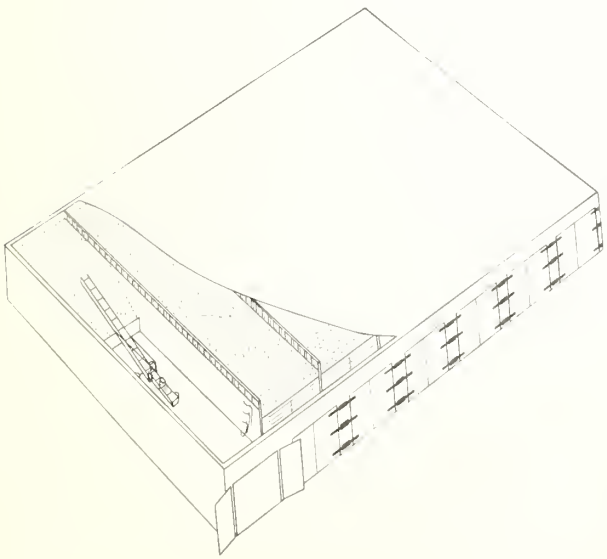

FIGURE 20.—Above-ground multiple-door storage.

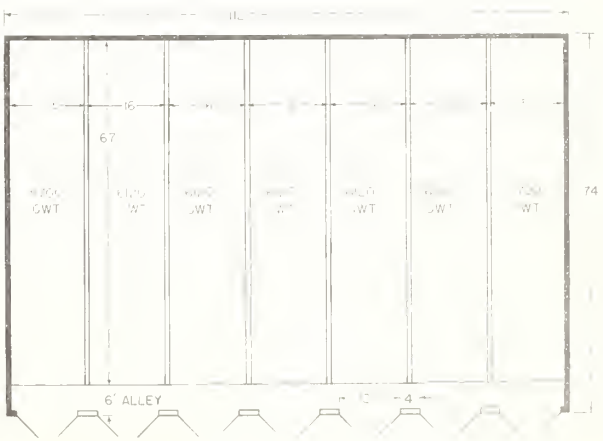

FIGURE 21.—Layout of above ground multiple-door storage.

TABLE 3.—*Labor required by 3-man crew to receive a 120 cwt. truckload equivalent of potatoes when filling an above ground multiple-door storage of 42,000 cwt. using a bulk hopper body truck and cleated belt binloader*

Time item	Truck driver	Trash picker	Binloader operator	Total
	Man-minutes	*Man-minutes*	*Man-minutes*	*Man-minutes*
Set up and miscellaneous:				
Set up and miscellaneous	1.62	0.42	0.76	
Wait	.15	1.35	1.01	
Total	1.77	1.77	1.77	5.31
Fill storage (unload truck):				
Pull boards and push potatoes	3.27			
Adjust equipment		.12	2.69	
Pick trash	9.93	13.08	10.51	
Total	13.20	13.20	13.20	39.60
Unavoidable delay:				
Adjust binloader	.10	.10	.11	
Wait	.01	.01		
Total	.11	.11	.11	.33
Clean up and miscellaneous:				
Close up truck and drive truck out	1.47	.83		
Adjust equipment	.03	1.12	1.21	
Wait		.41	1.15	
Remove dirt		4.41	4.41	
Total	1.50	6.77	6.77	15.04
Total productive labor	16.42	20.08	19.69	56.19
Total unproductive labor	.16	1.77	2.16	4.09
Total labor	16.58	21.85	21.85	60.28
Elapsed time	16.58	21.85	21.85	

Deep bin below ground storage—flat belt conveyor and draper chain binloader

Illustrations and a typical layout for a 42,000 cwt. deep bin below-ground storage are given in figures 22–26. The bins are filled by the use of a flat belt conveyor with a canvas chute attached to it (fig. 22). As a cone is built up at the control of a worker who operates the chute, sections are removed from the chute until the cone reaches the conveyor. After the cone reaches the conveyor, the bin is filled to conveyor level and the potatoes slide as a mass to the far corners of the bin. Occasionally the potatoes must be pushed to start the slide. After the potatoes reach the level of the flat belt conveyor, the con-

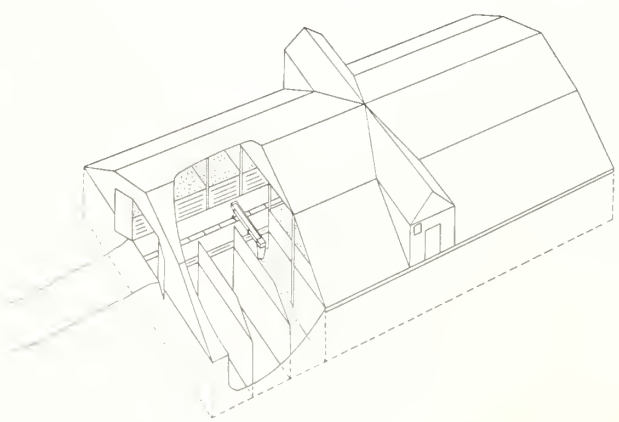

FIGURE 22.—Flat belt conveyor and canvas chute filling bin.

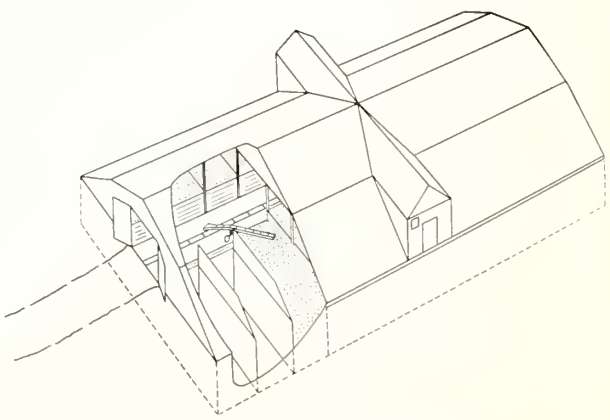

FIGURE 23.—Draper chain binloader used to complete filling of bin.

TABLE 4.—*Labor required by a 5-man crew to receive a 120 cwt. truckload equivalent of potatoes when filling an above ground multiple-door storage of 42,000 cwt. receiving in sacks on a flat bed truck and using a cleated belt binloader*

Time item	Truck driver	Unloader	Unloader	Trash picker	Binloader operator	Total
	Man-minutes	*Man-minutes*	*Man-minutes*	*Man-minutes*	*Man-minutes*	*Man-minutes*
Set up and miscellaneous:						
Set up and miscellaneous	1.16	0.05	0.15	0.15	0.70	
Wait	.14	1.25	1.15	1.15	.60	
Total	1.30	1.30	1.30	1.30	1.30	6.50
Fill storage (unload truck):						
Unload and empty sacks in hopper of binloader.	17.28	17.28	17.28			
Adjust equipment				.13	2.69	
Pick trash				17.15	14.59	
Total	17.28	17.28	17.28	17.28	17.28	86.40
Unavoidable delay:						
Adjust binloader		.02	.10	.10	.09	
Wait	.11	.09	.01	.01	.02	
Total	.11	.11	.11	.11	.11	.55
Clean up and miscellaneous:						
Assemble and tie down sacks	1.21	1.21				
Close up truck and drive truck out	.51					
Adjust equipment		.65	.74	.74	.81	
Wait		.32	1.44	1.44	1.40	
Remove dirt		2.64	2.64	2.64	2.61	
Total	1.72	4.82	4.82	4.82	4.82	21.00
Total productive labor	20.16	21.85	20.91	20.91	21.49	105.32
Total unproductive labor	.25	1.66	2.60	2.60	2.02	9.13
Total labor	20.41	23.51	23.51	23.51	23.51	114.45
Elapsed time	20.41	23.51	23.51	23.51	23.51	

veyor is moved to the next bin and the binloader installed over the bin. The binloader finishes filling the bin to 6 feet above the drive floor (fig. 23).

After all the bins are filled, binboards are installed in the upper drive floor and basement alleyway (fig. 6) to provide a wall for the potatoes. The center floor board is removed from the driveway. A canvas chute is attached to the binloader. A worker, operating the chute, builds up a cone of potatoes in the basement. When the cone reaches the slot in the floor, the potatoes are piled on the upper drive floor

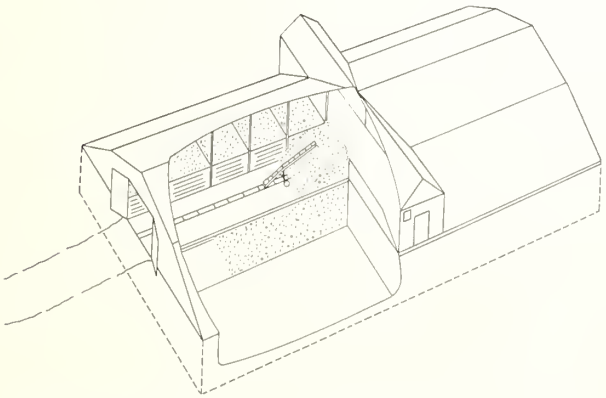

FIGURE 24.—Draper chain binloader filling upper drive floor and basement alleyway.

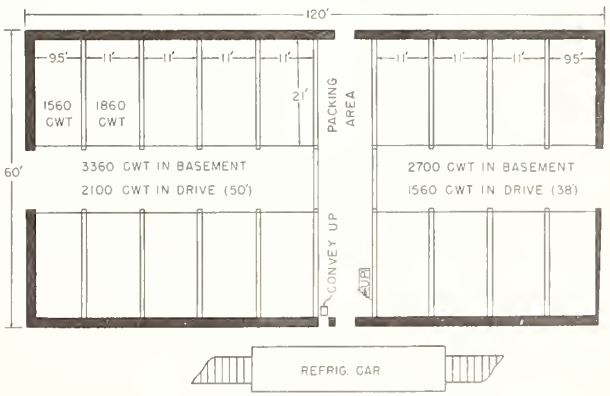

FIGURE 25.—Layout of deep bin below ground storage.

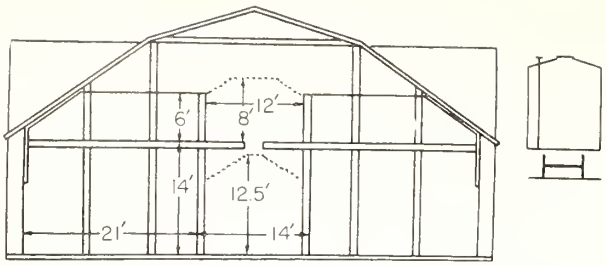

FIGURE 26.—Cross sectional illustration of deep bin storage.

(fig. 6). As the potatoes are piled on the upper drive floor, the binloader operator will remove a board that is used to block the flow to the basement, and let the potatoes slide to the basement below, to minimize injury to the potatoes instead of an individual roll-down method. After the slide, the slot is blocked again until another pile is built up for another slide. In this manner both the upper drive and basement alleyway can be filled simultaneously (fig. 24).

A section indicated in figure 25 as the packing area is located on the drive floor level and is used for washing and packing the potatoes. A small washing and packing line is installed in this area. The doorway opposite the trackside is for receiving loads directly from the truck to the packing line. The trackside doorway is for loading potatoes in cars.

Bulk hopper body truck—3-man crew

Table 5 shows the labor requirements to receive a truckload of potatoes from a bulk hopper body truck using a 3-man crew. This operation begins as the truck starts to back into the storage. After the truck is positioned, the driver hooks up the motor while the equipment operator opens the gate of the truck and makes necessary adjustments to the equipment.

Other elements of work such as hooking up the chute, installing binboards, and adjusting the

TABLE 5.—*Labor required by a 3-man crew to receive a 120 cwt. truckload equivalent of potatoes when filling a below ground deep bin storage of 42,000 cwt. using a bulk hopper body truck, flat belt conveyor, canvas chute, and draper chain binloader*

Time item	Truck driver	Trash picker	Equipment operator	Total
	Man-minutes	*Man-minutes*	*Man-minutes*	*Man-minutes*
Set up and miscellaneous:				
Set up and miscellaneous	1.57	1.32	1.05	
Wait	.70	.95	1.22	
Total	2.27	2.27	2.27	6.81
Fill storage (unload truck):				
Pull boards and push potatoes	3.27			
Operate chute in bin		2.28		
Push potatoes in bin		2.31	1.09	
Guide potatoes through hatch			1.09	
Adjust equipment		.05	.98	
Pick trash	8.17	6.80	8.28	
Total	11.44	11.44	11.44	34.32
Unavoidable delay:				
Adjust equipment	.53	.63	.76	
Push potatoes in bin		.45	.29	
Wait	.68	.13	.16	
Total	1.21	1.21	1.21	3.63
Clean up and miscellaneous:				
Close up truck and drive truck out	1.48	.09	.75	
Adjust equipment		1.23	.49	
Push potatoes in bin		.05		
Guide potatoes through hatch			.02	
Wait		.77	.40	
Remove dirt		3.56	4.04	
Total	1.48	5.70	5.70	12.88
Total productive labor	15.02	18.77	18.84	52.63
Total unproductive labor	1.38	1.85	1.78	5.01
Total labor	16.40	20.62	20.62	57.64
Elapsed time	16.40	20.62	20.62	

equipment are performed by the trash picker and equipment operator on certain loads while the truck is backing in and setting up.

During the time the conveyor or binloader is operating (fill storage), the truck driver pulls boards from the truck, pushes the potatoes that are stuck to the sides of the truck body, and picks trash. He controls the operations of the conveyor in the truck except when he is pushing potatoes.

The trash picker operates the chute in the bin, pushes potatoes in the bin, picks trash, assists in adjusting the equipment, and assists in controlling the operation of the conveyor in the truck.

The equipment operator operates the flat-belt conveyor, binloader, and assists in the operation of the conveyor in the truck. He also adjusts the conveyor and binloader when necessary, guides potatoes through the hatch in the driveway floor, pushes potatoes in the bin, and picks trash.

Occasionally the equipment must be stopped to unplug jammed potatoes in the chute, remove a section of the chute, push potatoes in the bin, reposition the boom or the binloader. This is called unavoidable delay (U.D.).

After the potatoes are emptied from the truck and piled, the driver and equipment operator push the boards back in the truck, unhook the motor, and close the gate. On certain loads the trash picker will also help. After closing up, the driver leaves for the field and the trash picker and equipment operator remove the dirt, move the equipment, install binboards, and adjust the equipment when required.

Sacks—5-man crew

Table 6 shows the labor requirement to receive a truckload of potatoes from sacks on a flat bed truck, using a 5-man crew. This operation begins as the truck starts to back into the storage. Other elements of work such as hooking up the chute, installing binboards, and adjusting equipment are performed by

TABLE 6.—*Labor required by a 5-man crew to receive a 120 cwt. truckload equivalent of potatoes when filling a below ground deep bin storage of 42,000 cwt., receiving in sacks on a flat bed truck and using a flat belt conveyor, canvas chute, and draper chain binloader*

Time item	Truck driver	Unloader	Unloader	Trash picker	Binloader operator	Total
	Man-minutes	*Man-minutes*	*Man-minutes*	*Man-minutes*	*Man-minutes*	*Man-minutes*
Set up and miscellaneous:						
Set up and miscellaneous	1.16	0.34	0.53	0.59	0.81	
Wait	.47	1.29	1.10	1.04	.82	
Total	1.63	1.63	1.63	1.63	1.63	8.15
Fill storage (unload truck):						
Unload and empty sacks in hopper of binloader.	17.28	17.28	17.28			
Operate chute in bin				4.17		
Push potatoes in bin				2.31	1.03	
Guide potatoes through hatch					1.09	
Adjust equipment				.05	.98	
Pick trash				10.75	14.18	
Total	17.28	17.28	17.28	17.28	17.28	86.40
Unavoidable delay:						
Adjust equipment	.25	.17	.38	.49	.72	
Push potatoes in bin			.20	.40	.13	
Wait	.75	.83	.42	.11	.15	
Total	1.00	1.00	1.00	1.00	1.00	5.00
Clean up and miscellaneous:						
Assemble and tie down sacks	1.21	1.21				
Close up truck and drive truck out	.51					
Adjust equipment		.10	.20	.52	.33	
Push potatoes in bin				.04		
Guide potatoes through hatch					.02	
Wait		.88	1.69	1.49	1.29	
Remove dirt		1.62	1.92	1.76	2.17	
Total	1.72	3.81	3.81	3.81	3.81	16.96
Total productive labor	20.41	20.72	20.51	21.08	21.46	104.18
Total unproductive labor	1.22	3.00	3.21	2.64	2.26	12.33
Total labor	21.63	23.72	23.72	23.72	23.72	116.51
Elapsed time	21.63	23.72	23.72	23.72	23.72	

the rest of the crew on certain loads while the truck is backing in and setting up. After the truck is positioned, the driver and two men of the storage crew unload and empty sacks into the conveyor.

The trash picker operates the chute in the bin, pushes potatoes, picks trash, and adjusts the equipment.

The equipment operator operates the flat belt conveyor and binloader, adjusts the conveyor and binloader when necessary, guides potatoes through the hatch in the driveway floor, pushes potatoes in the bin, and picks trash.

Occasionally the equipment must be stopped and moved. The chute must be unplugged, a section of the chute removed, or potatoes must be pushed in the bin. This is called unavoidable delay.

After the sacks are emptied from the truck, the driver and one unloader assemble and tie down the empty sacks on the truck while the rest of the crew adjust the equipment and install binboards during certain loads. After the sacks are tied down, the driver leaves for the field and the rest of the crew remove the dirt, move equipment, install binboards, and make necessary adjustments.

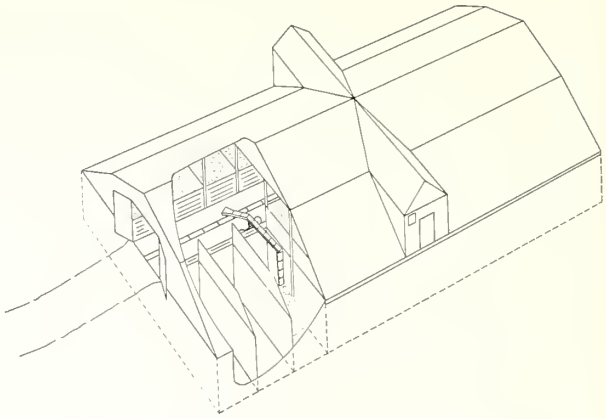

FIGURE 27.—Draper chain binloader filling bin with canvas chute.

TABLE 7.—*Labor required by a 3-man crew to receive a 120 cwt. truckload equivalent of potatoes when filling a below ground deep bin storage of 42,000 cwt. using a bulk hopper body truck, canvas chute, and draper chain binloader*

Time item	Truck driver	Trash picker	Binloader operator	Total
	Man-minutes	*Man-minutes*	*Man-minutes*	*Man-minutes*
Set up and miscellaneous:				
Set up and miscellaneous	1.57	1.00	0.72	
Wait	.23	.80	1.08	
Total	1.80	1.80	1.80	5.40
Fill storage (unload truck):				
Pull boards and push potatoes	3.27			
Operate chute in bin		3.19		
Push potatoes in bin		2.30	1.09	
Guide potatoes through hatch			1.09	
Adjust equipment		.05	.98	
Pick trash	9.93	7.66	10.04	
Total	13.20	13.20	13.20	39.60
Unavoidable delay:				
Adjust equipment	.53	.53	.63	
Push potatoes in bin		.39	.29	
Wait	.44	.05	.05	
Total	.97	.97	.97	2.91
Clean up and miscellaneous:				
Close up truck and drive truck out	1.48	.08	.74	
Adjust equipment		1.23	.48	
Push potatoes in bin		.05		
Guide potatoes through hatch			.02	
Wait		.78	.40	
Remove dirt		4.17	4.67	
Total	1.48	6.31	6.31	14.10
Total productive labor	17.02	20.65	20.75	58.42
Total unproductive labor	.44	1.63	1.53	3.60
Total labor	17.46	22.28	22.28	62.02
Elapsed time	17.46	22.28	22.28	

Deep bin below ground storage—draper chain binloader

Figure 27 shows a binloader with canvas chute filling a deep bin. The storage house and layout is the same as in the previous method. The only difference between this method and the previous method is that the flat conveyor is not used.

Bulk hopper body truck—3-man crew

Table 7 shows the labor requirements to receive a truckload of potatoes from a bulk hopper body truck, using a 3-man crew.

Sacks—5-man crew

Table 8 shows the labor requirements to receive a truckload of potatoes from a flat bed truck.

In the deep bin below-ground storage, a flat draper chain conveyor is used in conjunction with the flat belt conveyor for further removal of dirt when it is excessive. The draper chain conveyor is placed between the truck and the flat belt conveyor as shown in figure 28. The basement alley and upper drive floor are also filled by the use of a flat belt or draper chain conveyor for filling the alleyway and a draper chain binloader to fill the upper drive floor. The center floor board is removed from the driveway. A canvas chute is attached to the flat belt or draper chain conveyor. A cone of potatoes is built up in the basement alleyway by a worker operating the canvas chute. When the cone reaches the slot in the floor, the potatoes are carried from the conveyor directly onto the top of the pile. A sheet of canvas is strung over the pile to contain the roll down of potatoes to a minimum. After the basement alleyway has been filled, the upper drive floor is filled with a draper chain binloader.

Another way of filling the basement alleyway is to

TABLE 8.—*Labor required by a 5-man crew to receive a 120 cwt. truckload equivalent of potatoes when filling a below ground deep bin storage of 42,000 cwt., receiving in sacks on a flat bed truck and using a canvas chute and draper chain binloader*

Time item	Truck driver	Unloader	Unloader	Trash picker	Binloader operator	Total
	Man-minutes	*Man-minutes*	*Man-minutes*	*Man-minutes*	*Man-minutes*	*Man-minutes*
Set up and miscellaneous:						
Set up and miscellaneous	1.16	0.01	0.67	0.50	0.47	
Wait	.20	1.35	.69	.86	.89	
Total	1.36	1.36	1.36	1.36	1.36	6.80
Fill storage (unload truck):						
Unload and empty sacks in hopper of binloader.	17.28	17.28	17.28			
Operate chute in bin				4.17		
Push potatoes in bin				2.31	1.03	
Guide potatoes through hatch					1.09	
Adjust equipment				.05	.99	
Pick trash				10.75	14.17	
Total	17.28	17.28	17.28	17.28	17.28	86.40
Unavoidable delay:						
Adjust equipment	.25	.17	.37	.46	.61	
Push potaotes in bin			.21	.35	.13	
Wait	.58	.66	.25	.02	.09	
Total	.83	.83	.83	.83	.83	4.15
Clean up and miscellaneous:						
Assemble and tie down sacks	1.21	1.21				
Close up truck and drive truck out	.51					
Adjust equipment		.10	.20	.99	.33	
Push potatoes in bin				.05		
Guide potatoes through hatch					.02	
Wait		.31	1.42	1.08	1.29	
Remove dirt		2.67	2.67	2.17	2.65	
Total	1.72	4.29	4.29	4.29	4.29	18.88
Total productive labor	20.41	21.44	21.40	21.80	21.49	106.54
Total unproductive labor	.78	2.32	2.36	1.96	2.27	9.96
Total labor	21.19	23.76	23.76	23.76	23.76	116.23
Elapsed time	21.19	23.76	23.76	23.76	23.76	

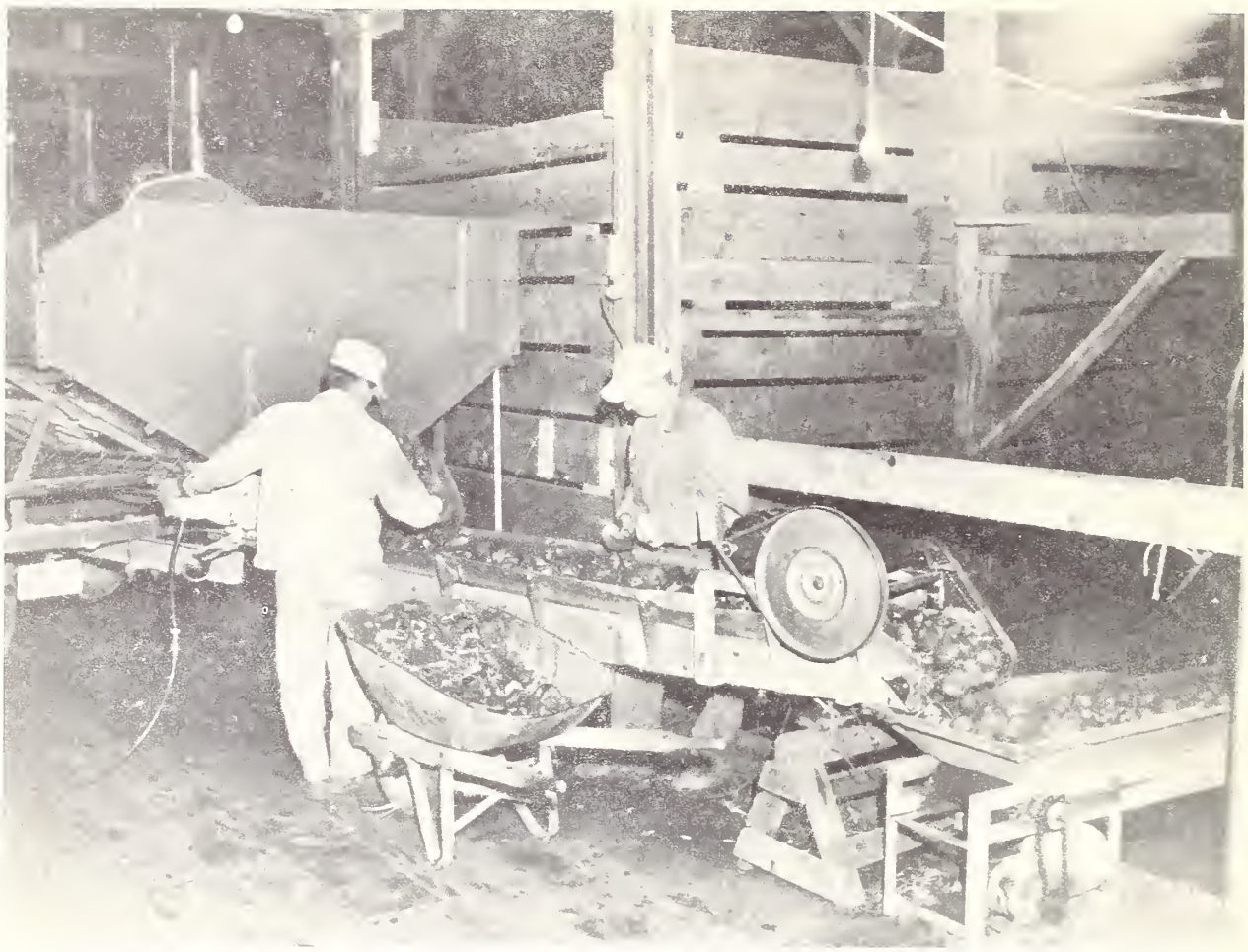

FIGURE 28.—Bulk hopper body truck, flat draper chain conveyor, flat belt conveyor.

build a second cone at the base of the pile and fill in the valley between the cones. This would reduce the roll down of the potatoes, but would increase the time the man operating the chute has to stand on the potatoes.

Above ground one-ton pallet box storage—bulk hopper body truck, trough belt conveyor, box tipper, and forklift truck

An illustration and layout of a 42,000 cwt. storage is given in figures 29 and 30.

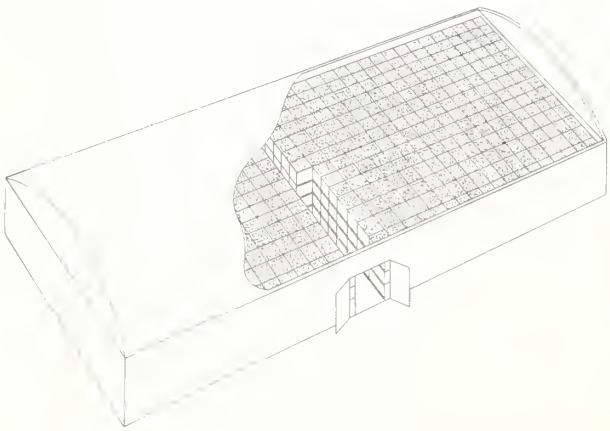

FIGURE 29.—Above ground one-ton pallet box storage.

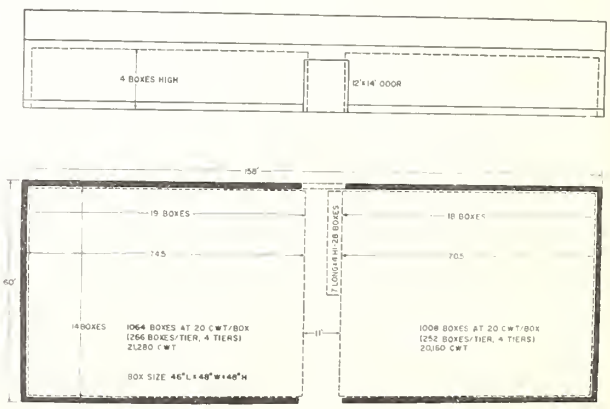

FIGURE 30.—Layout of a one-ton pallet box storage.

The boxes are filled at the storage from a bulk hopper body truck using a trough belt conveyor, box tipper, and roller conveyors to hold full and empty boxes. A forklift truck is used to transport and place boxes in the storage and bring empty boxes to the tipper (figs. 15 and 16).

During the shipping season, the forklift truck, box tipper, and two sections of roller conveyors are used for emptying boxes. When the boxes are being emptied and before the next harvest season, approximately 320 boxes are placed outside the storage to allow room for handling within and into the storage.

Bulk hopper body truck—3-man crew

Table 9 shows the labor requirements to receive a truckload of potatoes from a hopper body truck using a 3-man crew. This operation begins as the truck starts to back into position to the conveyor. After the truck is positioned, the driver hooks up the motor while the box tipper operator opens the gate of the truck.

In this method, the box tipper operator controls the operation of the truck, trough belt, and box tipper motors. The box is lowered as it is being filled. When the box is full, the box tipper operator spreads the potatoes evenly, pushes the pallet box aside, and moves an empty box in position, raises the box, and starts the next filling operation.

The truck driver pulls boards and pushes the potatoes when stuck to the sides of the truck box, and picks trash.

TABLE 9.—*Labor required by a 3-man crew to receive and unload a 120 cwt. truckload equivalent of potatoes into 6 one-ton capacity pallet boxes, and place into a single door above ground storage of 42,000 cwt. capacity using a bulk hopper body truck, trough belt conveyor, box tipper, roller conveyor and forklift truck*

Time item	Truck driver	Box tipper operator	Forklift truck operator	Total
Set up:	*Man-minutes*	*Man-minutes*	*Man-minutes*	*Man-minutes*
Set up	1.56	0.19		
Wait		1.09		
Total	1.56	1.28		2.84
Unload truck:				
Pull boards and push potatoes	3.27			
Pick trash	9.91			
Total	13.18			13.18
Fill boxes:				
Fill boxes		7.68		
Spread potatoes		3.00		
Move full box		1.92		
Move empty box in position and raise		1.68		
Wait			2.48	
Total		14.28	2.48	16.76
Transport to storage:				
Pick up full box			.90	
Transport full box 90′			2.82	
Position full box to 4 high			1.92	
Transport empty to full box 90′			1.17	
Transport empty to full box 35′			.72	
Transport empty to empty boxes 60′			.93	
Pick up two empty boxes			.87	
Transport two empty boxes 100′			1.77	
Position two empty boxes in conveyor			1.98	
Total			13.08	13.08
Clean up:				
Close up truck and drive truck out	1.79	.56		
Remove dirt		2.88	2.88	
Wait		.16	.72	
Total	1.79	3.60	3.60	8.99
Total productive labor	16.53	17.91	15.96	50.40
Total unproductive labor		1.25	3.20	4.45
Total labor	16.53	19.16	19.16	54.85
Elapsed time	16.53	19.16	19.16	

The forklift truck operator picks up the full pallet box from the tippers' roller conveyor, transports the full box an average of 90 feet and stacks the box in storage up to 4 boxes high. After positioning the box in storage, the forklift truck operator returns empty an average of 90 feet back to pick up another full box from the roller conveyor. The second full box is stored in the same manner. After placing the second box in storage, the operator moves the empty forklift truck an average of 60 feet to the empty pallet box supply, which is located either in or outside the storage building. Here he picks up two empty pallet boxes and transports them an average of 100 feet to the box tipper and positions the two empty boxes on the roller conveyor which leads into the tipper. The operator then moves empty to the roller conveyor on the other side of the box tipper an average of 35 feet, and picks up a full box. This cycle is repeated three times. This is equivalent to one truckload of 120 cwt.

After the potatoes are emptied from the truck, the driver pushes the boards back in the truck while the box tipper operator unhooks the motor and closes the gate. After the truck leaves, the box tipper operator and forklift truck operator remove the dirt.

Bulk hopper body truck—4-man crew

Table 10 shows the labor requirements to receive a truckload of potatoes from a bulk hopper body truck using a 4-man crew.

In this method an additional operator was added to remove dirt during the unloading time. He also picks trash and assists in the set up and close up of the truck.

TABLE 10.—*Labor required by a 4-man crew to receive and unload a 120 cwt. truckload equivalent of potatoes into 6 one-ton capacity pallet boxes and place into a single door above ground storage of 42,000 cwt. capacity using a bulk hopper body truck, trough belt conveyor, box tipper, roller conveyors and forklift truck*

Time item	Truck driver	Trash picker	Box tipper operator	Forklift truck operator	Total
Set up:	*Man-minutes*	*Man-minutes*	*Man-minutes*	*Man-minutes*	*Man-minutes*
Set up	1.56	0.19			
Wait		1.37	1.56	1.26	
Total	1.56	1.56	1.56	1.26	5.94
Unload truck:					
Pull boards and push potatoes	3.27				
Pick trash	9.91	7.43			
Remove dirt		5.75			
Total	13.18	13.18			26.36
Fill boxes:					
Fill boxes			7.68		
Spread potatoes			3.00		
Move full box			1.92		
Move empty box in position and raise			1.68		
Wait				1.45	
Total			14.28	1.45	15.73
Transport to storage:					
Pick up full box				.90	
Transport full box 90′				2.82	
Position full box to 4 high				1.92	
Transport empty to full box 90′				1.17	
Transport empty to full box 35′				.72	
Transport empty to empty boxes 60′				.93	
Pick up two empty boxes				.87	
Transport two empty boxes 100′				1.77	
Position two empty boxes on conveyor				1.98	
Total				13.08	13.08
Clean up:					
Close up truck and drive truck out	1.15	1.20			
Wait	.30	.25	.35	.40	
Total	1.15	1.45	.35	.40	3.35
Total productive labor	15.89	14.57	14.28	13.08	57.82
Total unproductive labor	.30	1.62	1.91	3.11	6.94
Total labor	16.19	16.19	16.19	16.19	64.76
Elapsed time	16.19	16.19	16.19	16.19	

COMPARISON OF COSTS OF ALL METHODS

The lowest cost method when receiving without wait time between truckloads is the below-ground deep bin storage using a draper chain binloader and a canvas chute with a three-man crew and receiving in a bulk hopper body truck (table 11).

Although this method is lowest in cost, the elapsed time of the truck and the operation is the highest. This elapsed time may cause the use of an additional truck to avoid delaying the harvesting crew, depending upon the round-trip driving time and the harvesting time per truckload and as a result would increase the cost of the harvesting operation.

The next lowest cost method is the below-ground deep-bin storage using a flat belt conveyor, draper chain binloader, and a canvas chute with a 3-man crew and receiving in a bulk hopper body truck. The cost of this method is higher by $0.02 per truckload. The truck and operation elapsed time is lowest of all except the one-ton box storage.

The highest cost method is the above ground one-ton box storage using a trough belt conveyor, box tipper, roller conveyor, forklift truck, and receiving in a bulk hopper body truck with 3- and 4-man crews. This has the lowest elapsed time for truck and operation. Using a 5-man crew and receiving in sacks would increase the cost considerably.

Receiving in sacks with a 5-man crew is considerably higher in cost than the methods receiving in a bulk hopper body truck and using a 3-man crew.

To determine the cost per hundredweight, divide the cost in the "Total Cost per Truckload" column by 120 (table 11). To determine the total cost per storage, multiply the cost in this column by 350.

TABLE 11.—*Labor and equipment costs to receive a 120 cwt. truckload equivalent of potatoes into a 42,000 cwt. capacity storage by various methods and crew sizes*

Methods and storage	Truck elapsed time	Operation elapsed time	Total labor	Labor cost per truckload	Equipment cost per truckload [1]	Total cost per truckload
Received in bulk hopper body truck	*Minutes*	*Minutes*	*Man-min.*	*Dollars*	*Dollars*	*Dollars*
3 man crew—						
Above-ground single door storage—cleated belt binloader	16.77	22.11	60.99	1.27	.92	2.19
Above-ground multiple door storage—cleated belt binloader	16.58	21.85	60.28	1.26	.92	2.18
Below-ground deep bin storage—flat conveyor-draper chain binloader, canvas chute	16.40	20.62	57.64	1.20	.61	1.81
Below-ground deep bin storage—draper chain binloader, canvas chute	17.46	22.28	62.02	1.29	.50	1.79
Above-ground one-ton pallet box, storage—filling equipment, forklift truck	16.53	19.16	54.85	1.14	4.90	6.04
4-man crew—						
Above-ground one-ton pallet box storage—filling equipment, forklift truck	16.19	16.19	64.76	1.35	4.90	6.25
Received in sacks on truck						
5-man crew—						
Above-ground single door storage—cleated belt binloader	20.54	23.68	115.26	2.40	.92	3.32
Above-ground multiple door storage—cleated belt binloader	20.41	23.51	114.45	2.38	.92	3.30
Below-ground deep bin storage—flat conveyor-draper chain binloader, canvas chute	21.63	23.72	116.51	2.43	.59	3.02
Below-ground deep bin storage—draper chain binloader, canvas chute	21.19	23.76	116.23	2.42	.48	2.90

[1] For computation of these costs see table 16 in Appendix.

COMPARISON OF RECEIVING COSTS AT STORAGES OF THREE DIFFERENT SIZES

Labor and equipment costs, when receiving without wait time between truckloads, were developed for handling into larger size storages of 60,000 and 120,000 cwt. (table 12).

The above ground single door bulk storage was increased to 60,000 cwt. capacity by changing the dimensions from 64 by 130 feet to 80 by 144 feet. The number of bins were increased from 8 to 10. The dimensions were further increased from 80 by 144 feet to 80 by 275 feet to raise the capacity to 120,000 cwt. Another door was added to the other end of the alleyway. The number of bins remained at 10.

The above-ground multiple door bulk storage was

TABLE 12.—*Labor and equipment costs to receive a 120 cwt. truckload equivalent of potatoes into three different size storages by various methods and crew sizes*

Methods and storage	Size storage	Truck elapsed time	Operation elapsed time	Total labor	Cost per truckload		
					Labor	Equipment [1]	Total
	1,000 cwt.	*Minutes*	*Minutes*	*Man-minutes*	*Dollars*	*Dollars*	*Dollars*
Received in bulk hopper body truck							
3-amn crew—							
Above-ground single door storage—cleated belt binloader	42	16.77	22.11	60.99	1.27	0.92	2.19
	60	16.88	22.32	61.52	1.28	.68	1.96
	120	17.13	23.10	63.33	1.32	.68	2.00
Above-ground multiple door storage—cleated belt binloader	42	16.58	21.85	60.28	1.26	.92	2.18
	60	16.79	22.19	61.17	1.27	.68	1.95
	120	17.07	23.00	63.07	1.31	.68	1.99
Below-ground deep bin storage—flat conveyor, draper chain binloader, canvas chute	42	16.40	20.62	57.64	1.20	.61	1.81
	60	16.55	20.86	58.27	1.21	.44	1.65
	120	16.99	21.74	60.47	1.26	.44	1.70
Below-ground deep bin storage—draper chain binloader, canvas chute	42	17.46	22.28	62.02	1.29	.50	1.79
	60	17.59	22.57	62.73	1.31	.37	1.68
	120	18.03	23.39	64.81	1.35	.36	1.71
Above-ground one-ton pallet box storage—filling equipment, forklift truck	42	16.53	19.16	54.85	1.14	4.90	6.04
	60	16.53	19.16	54.85	1.14	4.40	5.54
4-man crew—							
Above-ground one-ton pallet box storage—filling equipment, forklift truck	42	16.19	16.19	64.76	1.35	4.90	6.25
	60	16.19	16.19	64.76	1.35	4.40	5.75
	120	16.19	16.19	64.76	1.35	3.90	5.25
Received in sacks on truck							
5-man crew—							
Above-ground single door storage—cleated belt binloader	42	20.54	23.68	115.26	2.40	.92	3.32
	60	20.68	23.91	116.32	2.42	.68	3.10
	120	21.02	24.45	118.82	2.48	.68	3.16
Above-ground multiple door storage—cleated belt binloader	42	20.41	23.51	114.45	2.38	92	3.30
	60	20.61	23.81	115.85	2.41	.68	3.09
	120	20.98	24.39	118.54	2.47	.68	3.15
Below-ground deep bin storage—flat conveyor, draper chain binloader, canvas chute	42	21.63	23.72	116.51	2.43	.59	3.02
	60	21.81	23.96	117.65	2.46	.43	2.89
	120	22.28	24.55	120.69	2.52	.43	2.95
Below-ground deep bin storage—draper chain binloader, canvas chute	42	21.19	23.76	116.22	2.42	.48	2.90
	60	21.34	24.07	117.62	2.45	.35	2.80
	120	21.80	24.72	120.64	2.51	.35	2.86

[1] For computation of these costs see tables 16, 17, and 18 in appendix.

increased to 60,000 cwt. capacity by changing the dimensions from 74 by 112 feet to 74 by 160 feet. The number of bins increased from 7 to 10. The dimensions were increased to 140 by 160 feet for the 120,000 cwt. capacity. The bins remained at 10.

The below ground deep bin storage was changed from 60 by 120 feet to 60 by 167 feet for the 60,000 cwt. capacity. The number of bins increased from 18 to 26. To increase the capacity to 120,000, two layouts of 60 by 167 feet were placed side by side making a dimension of approximately 119 by 167 feet. Bins in this type of structure cannot be lengthened because of difficulty of filling, or deepened because of possible increase in pressure bruises for depth of over 20 feet.

The above ground one-ton pallet box storage was changed from 60 by 158 feet to 60 by 221 feet for the 60,000 cwt. capacity. To increase the capacity

to 120,000 cwt., the size of the building was doubled, minus the adjoining walls. This allowed for layout of two doors and two alleyways, making the building 60 by 440 feet. This capacity building can also be 119 by 158 feet plus space for storing empty boxes outside and the filling of boxes.

The equipment costs per truckload are considerably less for the 60,000 cwt. capacity storages than the 42,000 cwt. storages due to the greater utilization of the equipment.

In filling the 120,000 cwt. storages, all methods except the 4-man crew pallet box handling method required two sets of crews and equipment because the elapsed time of the operation does not permit the storage to be filled in 24 days, working 12 hours per day.

At volumes of 60,000 and 120,000 cwt. the below-ground deep bin storage using a flat belt conveyor, draper chain binloader, and a canvas chute with a 3-man crew, and receiving in a bulk hopper body truck was the lowest cost method. The truck and operation elapsed time was also lowest, except for the one-ton pallet box method.

EFFECT OF VARIOUS RECEIVING RATES ON COSTS

Wait time will occur between truckloads at the storage when the time to harvest a truckload of potatoes is greater than the time to unload and place the potatoes into storage (operation elapsed time).

Total labor and equipment costs for all receiving methods were computed on an annual and per truckload basis to show the effect on the cost of handling into storage when receiving truckloads at various rates per 12-hour working day (tables 13, 14, and 15). These costs include wait time between truckloads. The various receiving rates selected allowed the storages to be filled in approximately 24 days.

Labor costs increase, equipment costs remain constant, when the number of truckloads received per day decreases from the maximum the method is capable of handling when the same crew size, and the same units of equipment are used.

As shown in table 12, the lowest cost method when receiving into a 42,000 cwt. storage without wait time between truckloads is the below-ground deep bin storage using a draper chain binloader and a canvas chute with a 3-man crew and receiving in a bulk hopper body truck. At volumes of 60,000 and 120,000 cwt. the lowest cost method is the below-ground deep bin storage using a flat belt conveyor, draper chain binloader, and a canvas chute with a 3-man crew and receiving in a bulk hopper body truck.

TABLE 13.—*Labor and equipment costs for filling a 42,000 cwt. storage with potatoes at various receiving rates using various methods and crew sizes*

Methods and storage	Receiving rate per 12-hour day in truckloads			
	15	18	24	30
	Dollars	*Dollars*	*Dollars*	*Dollars*
Received in bulk hopper body truck				
3-man crew—				
Above ground single door storage—cleated belt binloader				
Labor	822.19	705.61	559.78	472.27
Equipment	322.49	322.49	322.49	322.49
Total	1,144.68	1,028.10	882.27	794.76
Cost/truckload	3.27	2.94	2.52	2.27
Above ground multiple door storage—cleated belt binloader				
Labor	820.80	704.22	558.39	470.88
Equipment	322.47	322.47	322.47	322.47
Total	1,143.27	1,026.69	880.86	793.35
Cost/truckload	3.27	2.93	2.52	2.27
Below ground deep bin storage—flat conveyor, draper chain binloader, canvas chute				
Labor	819.49	702.91	557.08	469.57
Equipment	213.61	213.61	213.61	213.61
Total	1,033.10	916.52	770.69	683.18
Cost/truckload	2.95	2.62	2.20	1.95
Below ground deep bin storage—draper chain binloader, canvas chute				
Labor	827.21	710.63	564.80	477.29
Equipment	175.21	175.21	175.21	175.21
Total	1,002.42	885.84	740.01	652.50
Cost/truckload	2.86	2.53	2.11	1.86

TABLE 13.—*Labor and equipment costs for filling a 42,000 cwt. storage with potatoes at various receiving rates using various methods and crew sizes*—Continued

Methods and storage	Receiving rate per 12-hour day in truckloads			
	15	18	24	30
	Dollars	*Dollars*	*Dollars*	*Dollars*
Received in bulk hopper body truck				
3-man crew—				
Above ground one-ton pallet box storage—filling equipment, fork-lift truck				
Labor	820.53	703.86	558.03	470.52
Equipment	1,713.40	1,713.40	1,713.40	1,713.40
Total	2.533.93	2,417.26	2,271.43	2,183.92
Cost/truckload	7.24	6.91	6.48	6.24
4-man crew—				
Above ground one-ton pallet box storage—filling equipment, fork-lift truck				
Labor	1,168.03	993.02	774.28	643.01
Equipment	1,713.94	1,713.94	1,713.94	1,713.94
Total	2,881.97	2,706.96	2,488.22	2,356.95
Cost/truckload	8.23	7.73	7.11	6.73
Receiving in sacks on truck				
5-man crew—				
Above ground single door storage—cleated belt binloader				
Labor	1,549.76	1,316.42	1,024.76	849.74
Equipment	322.75	322.75	322.75	322.75
Total	1,872.51	1,639.17	1,347.51	1,712.49
Cost/truckload	5.35	4.68	3.85	3.35
Above ground multiple door storage—cleated belt binloader				
Labor	1,548.81	1,315.47	1,023.81	848.79
Equipment	322.73	322.73	322.73	322.73
Total	1,871.54	1,638.20	1,346.54	1,171.52
Cost/truckload	5.35	4.68	3.85	3.35
Below ground deep bin storage—flat conveyor, draper chain binloader, canvas chute				
Labor	1,557.71	1,324.37	1,032.71	857.69
Equipment	207.50	207.50	207.50	207.50
Total	1,765.21	1,531.87	1,240.21	1,065.19
Cost/truckload	5.04	4.38	3.54	3.04
Below ground deep bin storage—draper chain binloader, canvas chute				
Labor	1,554.49	1,321.15	1,029.49	854.47
Equipment	168.83	168.83	168.83	168.83
Total	1,723.32	1,489.98	1,198.32	1,023.30
Cost/truckload	4.92	4.26	3.42	2.92

TABLE 14.—*Labor and equipment costs for filling a 60,000 cwt. storage with potatoes at various receiving rates using various methods and crew sizes*

Methods and storage	Receiving rate per 12-hour day in truckloads		
	20	24	30
	Dollars	*Dollars*	*Dollars*
Received in bulk hopper body truck			
3-man crew—			
Above ground single door storage—cleated belt binloader			
Labor	925.84	800.83	675.82
Equipment	339.61	339.61	339.61
Total	1,265.45	1,140.44	1,015.43
Cost/truckload	2.53	2.28	2.03

TABLE 14.—*Labor and equipment costs for filling a 60,000 cwt. storage with potatoes at various receiving rates using various methods and crew sizes*—Continued

Methods and storage	Receiving rate per 12-hour day in truckloads		
	20	24	30
	Dollars	*Dollars*	*Dollars*
Received in bulk hopper body truck			
3-man crew—			
Above ground multiple door storage—cleated belt binloader			
Labor	924.90	799.89	674.88
Equipment	339.59	339.59	339.59
Total	1,264.49	1,139.48	1,014.47
Cost/truckload	2.53	2.28	2.03
Below ground deep bin storage—flat conveyor, draper chain binloader, canvas chute			
Labor	922.40	797.39	672.38
Equipment	219.27	219.27	219.27
Total	1,141.67	1,016.66	891.65
Cost/truckload	2.28	2.03	1.78
Below ground deep bin storage—draper chain binloader, canvas chute			
Labor	933.33	808.32	683.31
Equipment	182.63	182.63	182.63
Total	1,115.96	990.95	865.94
Cost/truckload	2.23	1.98	1.73
Above ground one-ton pallet box storage—filling equipment, forklift truck			
Labor	922.19	797.18	672.17
Equipment	2,198.42	2,198.42	2,198.42
Total	3,120.61	2,995.60	2,870.59
Cost/truckload	6.24	5.99	5.74
4-man crew—			
Above ground one-ton pallet box storage—filling equipment, forklift truck			
Labor	1,293.65	1,106.14	918.62
Equipment	2,198.57	2,198.57	2,198.57
Total	3,492.22	3,304.71	3,117.19
Cost/truckload	6.98	6.61	6.24
Received in sacks on truck			
5-man crew—			
Above ground single door storage—cleated belt binloader			
Labor	1,715.41	1,465.41	1,215.37
Equipment	342.10	342.10	342.10
Total	2,057.51	1,807.51	1,557.47
Cost/truckload	4.12	3.62	3.11
Above ground multiple door storage—cleated belt binloader			
Labor	1,714.69	1,464.69	1,214.65
Equipment	342.08	342.08	342.08
Total	2,056.77	1,806.77	1,556.73
Cost/truckload	4.11	3.61	3.11
Below ground deep bin storage—flat conveyor, draper chain binloader, canvas chute			
Labor	1,727.19	1,477.19	1,227.15
Equipment	213.82	213.82	213.82
Total	1,941.01	1,691.01	1,440.97
Cost/truckload	3.88	3.38	2.88
Below ground deep bin storage—draper chain binloader, canvas chute			
Labor	1,722.28	1,472.28	1,222.24
Equipment	177.06	177.06	177.06
Total	1,899.34	1,649.34	1,399.30
Cost/truckload	3.80	3.30	2.80

Table 12 gives the labor, equipment, and total cost per truckload when receiving at the maximum receiving rate the method is capable of handling. Annual costs can be determined by multiplying the cost per truckload by the number of truckloads required to fill the storage.

TABLE 15.—*Labor and equipment costs for filling a 120,000 cwt. storage with potatoes at various receiving rates using various methods and crew sizes*

Methods and storage	Receiving rate per 12-hour day in truckloads		
	40	48	58
	Dollars	*Dollars*	*Dollars*
Received in bulk hopper body truck			
Two 3-man crews—			
Above ground single door storage—cleated belt binloader			
Labor	1,856.88	1,606.86	1,391.28
Equipment	675.63	675.63	675.63
Total	2,532.51	2,282.49	2,066.91
Cost/truckload	2.53	2.28	2.07
Above ground multiple door storage—cleated belt binloader			
Labor	1,855.63	1,605.61	1,390.03
Equipment	675.61	675.61	675.61
Total	2,531.24	2,281.22	2,065.64
Cost/truckload	2.53	2.28	2.07
Below ground deep bin storage—flat conveyor, draper chain binloader, canvas chute			
Labor	1,853.96	1,603.94	1,388.36
Equipment	437.40	437.40	437.40
Total	2,291.36	2,041.34	1,825.76
Cost/truckload	2.29	2.04	1.83
Below ground deep bin storage—draper chain binloader, canvas chute			
Labor	1,875.63	1,625.61	1,410.03
Equipment	363.91	363.91	363.91
Total	2,239.52	1,989.52	1,773.94
Cost/truckload	2.24	1.99	1.77
Two 4-man crews—			
Above ground one-ton pallet box storage—filling equipment, forklift truck			
Labor	[1] 1,462.29	2,212.26	1,888.98
Equipment	3,895.34	4,826.54	4,826.54
Total	5,357.63	7,038.80	6,715.52
Cost/truckload	5.36	7.04	6.72
Received in sacks on truck			
Two 5-man crews—			
Above ground single door storage—cleated belt binloader			
Labor	3,437.91	2,937.87	2,506.71
Equipment	680.41	680.41	680.41
Total	4,118.32	3,618.28	3,187.12
Cost/truckload	4.12	3.62	3.19
Above ground multiple door storage—cleated belt binloader			
Labor	3,437.08	2,937.04	2,505.89
Equipment	680.41	680.41	680.41
Total	4,117.49	3,617.45	3,186.30
Cost/truckload	4.12	3.62	3.19
Below ground deep bin storage—flat conveyor, draper chain binloader, canvas chute			
Labor	3,464.17	2,964.17	2,532.96
Equipment	426.89	426.89	426.89
Total	3,891.06	3,391.06	2,959.85
Cost/truckload	3.89	3.39	2.96
Below ground deep bin storage—draper chain binloader, canvas chute			
Labor	3,454.17	2,954.17	2,522.96
Equipment	353.08	353.08	353.08
Total	3,807.25	3,307.25	2,876.04
Cost/truckload	3.81	3.31	2.88

[1] One crew only.

CONCLUSIONS AND RECOMMENDATIONS

Both below-ground storage methods are less costly than either the above-ground bulk or one-ton pallet box methods. The 5-man crew sack methods are more costly than the 3-man crew bulk methods. The 3- and 4-man crew one-ton pallet box method is the most costly of all methods.

When potatoes are received in sacks on a flat bed truck, it is best to use three men to unload and empty sacks onto the equipment. This is true because the time required to empty the sacks sets the pace of the workers and permits the three men to consecutively perform the complete cycle of operations; which consists of emptying a sack, setting the empty sack aside, and getting a full sack.

Using a 6-man crew (4 unloaders, 1 trash picker, and 1 equipment operator) would not significantly reduce the elapsed time of the truck and operation, but would increase the total labor requirement and total cost.

Using a 4-man crew (2 unloaders, 1 trash picker, and 1 equipment operator) increases the elapsed time of the truck, operation elapsed time, total labor, and total cost. This smaller crew would reduce the receiving capacity of the method. With two unloaders, the time of the rest of the crew is not used efficiently.

The 3-man crew is the most economical crew in the methods using bulk hopper body trucks. Increasing the crew from 3 to 4 would reduce the elapsed time of the truck and operation slightly, and increase the receiving capacity slightly, but the total labor and costs would increase considerably.

If all the trash (vines, clods and culls) were removed during the harvesting operation, the crew could be reduced from 3 to 2 in the bulk method and 5 to 4 in the sack method: The truck elapsed time would increase slightly, but the operation elapsed time would increase substantially for the bulk method, if the equipment operator only was available to clean up the dirt. If the truck driver helped him, the truck and operation elapsed time would increase substantially. In the sack method, the truck and operation elapsed time would increase slightly without the truck driver assisting in cleaning up the dirt. The receiving capacity would be reduced in all cases. This could cause an increase in the cost of the harvesting operation by increasing the harvesting time per load up to the elapsed time of the handling-into-storage operation. The harvesting operation cannot proceed faster than the handling at the storage without causing wait time between truckloads.

If there is no trash picker, the equipment operator and truck driver assume this work in the bulk methods. The truck driver, unloaders, and equipment operator assume it in the sack methods. In those methods requiring a canvas chute, the equipment operator operates the chute and the truck driver operates the equipment.

If all the trash and dirt is removed during the harvesting operation, and trash picking is not necessary during the handling-into-storage operation, the truck elapsed time would increase slightly but the elapsed time of the operation, total labor and cost, would decrease for the bulk and sack methods.

Less dirt handled at the storage reduces the elapsed time of the operation at the storage and increases the receiving capacity of the method for all methods and crew sizes.

Because of the large cost of the pallet boxes the one-ton pallet box method is the most costly of all methods. The 3-man crew is more economical than the 4-man crew when filling storages of 42,000 and 60,000 cwt. Filling a storage of 120,000 cwt. within 24 days requires two 3-man crews and 2 sets of equipment. A 4-man crew can fill it with one crew and one set of equipment up to a receiving rate of 44.5 truckloads per 12-hour working day.

Although the pallet box is more costly, it appears to offer some advantages over the other methods, including:

1. Less injury to the potatoes.
2. Better maintenance of quality during storage through better air circulation and temperature control.
3. Varieties can be more easily separated.
4. Adaptable to sizing and sorting before storage.
5. Adaptable to washing potatoes before storage.
6. Restricts any spreading of diseases to the individual pallet boxes.
7. Adaptable to use of different types of bulk truck boxes, such as the side dump box.

Box costs can be reduced by the use of other designs and species of wood. Costs can also be reduced by making the box larger, probably a capacity of 2,750 lb. This capacity with a box weight of approximately 250 lb. would make a gross weight of 3,000 lb. This would make more efficient use of a 3,000-pound capacity forklift truck. The elapsed time of the truck and operation would be reduced and the receiving capacity of the method increased.

Increasing the capacity of each pallet box decreases the number of boxes required, decreases the space required to store the boxes, thereby reducing the size of the storage structure and its costs.

The forklift truck used in this comparison is a gasoline model. The forced air circulation system of the storage will remove the carbon monoxide from the air if the system is large enough, is in operation, and the storage is being ventilated. However, it is an unsafe practice to operate a gasoline engine in a closed atmosphere. A gasoline model with a bottled gas (LP) unit properly adjusted to minimize carbon monoxide would be much safer. An electric forklift truck will eliminate all danger of carbon monoxide.

Above-ground storage structures have certain advantages over below-ground structures such as adaptability for shop use, and ease in storage of equipment, materials, and merchandise.

Handling potatoes into storage is one of many costs involved in the total cost of storing potatoes.

When comparing methods, consideration should be given to the following:

1. Type and cost of the storage structure.
2. Cost of maintaining the quality of potatoes in storage.
3. Cost of moving potatoes from storage.
4. Cost of the transporting from field to storage.
5. Effect the truck and operation elapsed time has on the harvesting cost in the field.
6. Monetary losses resulting from injury to the potatoes caused by the handling method.

APPENDIX

In this study, time study techniques were used for determining the base time for performing the various elements of work and delay times involved. All workers in all operations were studied. Base times were developed for all elements of work, then adjusted for fatigue and personal allowances. Delay times were established as they occurred. These times were compiled for all workers to establish an elapsed time and total time for placing each load into storage. Time elements of work were used as required for each worker for each load into storage, working as a unit. After all loads were placed into storage, these element times, delay times, and wait times were averaged to determine the average time devoted to each per load. The labor requirement tables show the average time per load for each element of work, wait, or delay.

Description and labor requirements per truckload of 120 cwt. for various elements of work in placing 42,000 cwt. of potatoes in storage

	Labor required per truckload Man-minutes
Above-ground single door storage, cleated belt binloader, bulk hopper body truck, 3-man crew.	
Set up and miscellaneous:	
Begins as truck starts to back into storage. Consists of hooking up the motor and opening the gate of the truck, moving and adjusting the binloader and backboard, and installing bin boards. Ends when motor to unload truck is started	5.55
Fill storage (unload truck):	
Begins as motor on truck is started. Consists of pulling the boards on the truck and pushing the potatoes down, adjusting the backboard and binloader, installing bin boards and picking trash during machine time of 13.20 min. Ends when motor is stopped	39.60
Unavoidable delay:	
Begins as equipment is stopped during filling operation. Consists of moving, adjusting binloader, and installing bin boards. Ends when equipment is started again	.57
Clean up and miscellaneous:	
Begins when motor is stopped. Consists of pushing the boards back in the truck, removing the motor, closing the gate, driving the truck out, installing bin boards, moving and adjusting the binloader and removing the dirt. Ends when truck starts to back in	15.27
Above-ground single door storage, cleated belt binloader, sacks, 5-man crew.	
Set up and miscellaneous:	
Begins as truck starts to back into storage. Consists of moving and adjusting binloader and backboard and installing bin boards. Ends when reach for first sack is made	6.80
Fill storage (unload truck):	
Begins as reach for first sack is made. Consists of unloading the sacks into the hopper of the binloader, and adjusting the backboard and binloader, installing bin boards, and picking trash during the sack unloading time of 17.28 min. Ends when potatoes come from last sack onto equipment	86.40
Unavoidable delay:	
Begins as equipment is stopped during filling operation. Consists of moving, adjusting binloader and installing bin boards. Ends when equipment is started again	.95
Clean up and miscellaneous:	
Begins when the potatoes come out of the last sack onto the equipment. Consists of assembling and tying the sacks on the truck, driving the truck out, installing bin boards, moving and adjusting the binloader, and removing the dirt. Ends when truck starts to back in	21.12
Above ground multiple door storage, cleated belt binloader, bulk hopper body truck, 3-man crew.	
Set up and miscellaneous:	
Begins as truck starts to back into storage. Consists of hooking up the motor and opening the gate of the truck, moving and adjusting the binloader and backboard, and installing bin boards. Ends when motor to unload truck is started	5.31
Fill storage (unload truck):	
Begins as motor on truck is started. Consists of pulling the boards on the truck and pushing the potatoes down, adjusting the backboard and binloader, installing bin boards and picking trash during machine time of 13.20 min. Ends when motor is stopped	39.60
Unavoidable delay:	
Begins as equipment is stopped during filling operation. Consists of moving, adjusting binloader and installing bin boards. Ends when equipment is started again	.33
Clean up and miscellaneous:	
Begins when motor is stopped. Consists of pushing the boards back in the truck, removing the motor, closing the gate, driving the truck out, installing bin boards, moving and adjusting the binloader and removing the dirt. Ends when the truck starts to back in	15.04
Above-ground multiple-door storage, cleated belt binloader, sacks, 5-man crew.	
Set up and miscellaneous:	
Begins as truck starts to back into storage. Consists of moving and adjusting binloader and backboard and installing bin boards. Ends when reach for first sack is made	6.50
Fill storage (unload truck):	
Begins as reach for first sack is made. Consists of unloading the sack into the hopper of the binloader, and adjusting the backboard and binloader, installing bin boards and picking trash during the sack unloading time of 17.28 min. Ends when potatoes come from last sack onto equipment	86.40

	Labor required per truckload Man-minutes
Unavoidable delay:	
Begins as equipment is stopped during filling operation. Consists of moving, adjusting binloader, and installing bin boards. Ends when equipment is started again	.55
Clean up and miscellaneous:	
Begins when the potatoes come out of the last sack onto the equipment. Consists of assembling and tying the sacks on the truck, driving the truck out, installing bin boards, moving and adjusting binloader, and removing the dirt. Ends when truck starts to back in	21.00

Below-ground deep bin storage, flat belt conveyor, draper chain binloader, canvas chute, bulk hopper body truck, 3-man crew.

Set up and miscellaneous:	
Begins as truck starts to back into storage. Consists of hooking up the motor and opening the gate of the truck, moving and adjusting the flat conveyor and binloader, hooking up the canvas chute and installing bin boards. Ends when motor to unload truck is started	6.81
Fill storage (unload truck):	
Begins as motor on truck is started. Consists of pulling the boards on the truck and pushing potatoes down, operating the chute in the bin, guiding potatoes through the hatch, adjusting the flat conveyor and binloader, installing bin boards, and picking trash, during an average machine time of 11.44 minutes. Ends when motor is stopped	34.32
Unavoidable delay:	
Begins as equipment is stopped during filling operation. Consists of moving, adjusting flat belt conveyor and binloader, unplugging the chute, removing sections of the chute, pushing potatoes in the bin, and installing bin boards. Ends when equipment is started again	3.63
Clean up and miscellaneous:	
Begins when the motor is stopped. Consists of pushing the boards back in the truck, removing the motor, closing the gate, driving the truck out, removing sections of the chute, pushing potatoes in the bin, installing bin boards, guiding potatoes through the hatch, moving and adjusting flat conveyor and binloader, and removing the dirt. Ends when truck starts to back in	12.88

Below ground deep bin storage, flat-belt conveyor, draper chain binloader, canvas chute, sacks, 5-man crew.

Set up and miscellaneous:	
Begins as truck starts to back into the storage. Consists of moving and adjusting the flat conveyor and binloader, hooking up the canvas chute, and installing bin boards. Ends when reach for first sack is made	8.15
Fill storage (unload truck):	
Begins as reach for first sack is made. Consists of unloading sacks into the flat belt conveyor or hopper of the binloader, operating the chute in the bin, pushing potatoes in the bin, guiding potatoes through the hatch, adjusting the flat belt conveyor and binloader, installing bin boards and picking trash, during the sack unloading time of 17.28 minutes. Ends when potatoes come from last sack onto equipment	86.40
Unavoidable delay:	
Begins as equipment is stopped during filling operation. Consists of moving, adjusting flat belt conveyor and binloader, unplugging the chute, removing sections of the chute, pushing potatoes in the bin, and installing bin boards. Ends when equipment is started again	5.00
Clean up and miscellaneous:	
Begins when potatoes come out of the last sack onto the equipment. Consists of assembling and tying the sacks on the truck, driving the truck out, removing sections of the chute, pushing potatoes in the bin, installing bin boards, guiding potatoes through the hatch, moving and adjusting flat belt conveyor and binloader, and removing the dirt. Ends when truck starts to back in	16.96

Below-ground deep-bin storage, draper chain binloader, canvas chute, bulk hopper body truck, 3-man crew.

Set up and miscellaneous:	
Begins as truck starts to back into the storage. Consists of hooking up the motor and opening the gate of the truck, moving and adjusting the binloader, hooking up the canvas chute and installing bin boards. Ends when motor to unload the truck is started	5.40
Fill storage (unload truck):	
Begins as motor on truck is started. Consists of pulling the boards on the truck and pushing potatoes down, operating the chute in the bin, pushing potatoes in the bin, guiding potatoes through the hatch, adjusting the binloader, installing bin boards and picking trash, during machine time of 13.20 minutes. Ends when motor is stopped	39.60
Unavoidable delay:	
Begins as equipment is stopped during filling operation. Consists of moving, and adjusting the binloader, unplugging the chute, removing sections of the chute, pushing potatoes in the bin, and installing bin boards. Ends when equipment is started again	2.91
Clean up and miscellaneous:	
Begins when the motor is stopped. Consists of pushing the boards back in the truck, removing the motor, closing the gate, driving the truck out, removing sections of the chute, pushing potatoes in the bin, installing bin boards, guiding potatoes through the hatch, moving and adjusting the binloader, and removing the dirt. Ends when truck starts to back in	14.10

Below ground deep bin storage, draper chain binloader, canvas chute, sacks, 5-man crew.

Set up and miscellaneous:	
Begins as truck starts to back into storage. Consists of moving and adjusting the binloader, hooking up the canvas chute and installing bin boards. Ends when reach for the first sack is made	6.80
Fill storage (unload truck):	
Begins as reach for first sack is made. Consists of unloading the sacks into the hopper of the binloader, and adjusting the binloader, installing bin boards, and picking trash during the sack unloading time of 17.28 minutes. Ends when potatoes come from last sack onto equipment	86.40
Unavoidable delay:	
Begins as equipment is stopped during filling operation. Consists of moving and adjusting binloader, unplugging the chute, removing sections of the chute, pushing potatoes in the bin, and installing bin boards. Ends when equipment is started again	4.15

	Labor required per truckload Man-minutes
Clean up and miscellaneous:	
Begins when the potatoes come out of the last sack onto the equipment. Consists of assembling and tying down the sacks on the truck, driving the truck out, removing sections of the chute, pushing potatoes in the bin, installing bin boards, guiding potatoes through the hatch, moving and adjusting the binloader, and removing the dirt. Ends when truck starts to back in	18.88

Pallet box method

Time elements of work were used as required for each worker, working as a unit to receive and unload a 120 cwt. truckload equivalent of potatoes into 6 one-ton pallet boxes and place into storage, considering the various distances traveled to transport the full box, transport empty and transport empty boxes. Labor requirement tables show the time required for each element of work, wait or delay. Above-ground single door storage, one-ton pallet boxes, trough belt conveyor, box tipper, roller conveyor, forklift truck, bulk hopper body truck, 3-man crew.

Set up:	
Begins as truck starts to back into position to the conveyor. Consists of hooking up the motor and opening the gate of the truck. Ends when motor to unload truck is started	2.84
Unload truck:	
Begins as motor on truck is started. Consists of pulling boards on the truck and pushing potatoes down, and picking trash. Ends when motor is stopped	13.18
Fill boxes:	
Begins as motor on truck is started. Consists of filling the box and lowering it as it is being filled, stopping the equipment after the box is full, spreading the potatoes on top of the box, moving the full box to the side, moving the empty box in position on the box tipper and raising the box. This cycle is repeated for six boxes. Ends as motor on truck is started	16.76
Transport to storage:	
Begins when forklift truck enters zone 5′ in front of box. Consists of picking up the box, transporting to storage, position box in stack piled 4-high, driving back to full box on box tipper or driving empty to empty boxes stored either in storage or outside, picking up two empty boxes, transporting to roller conveyor, position boxes on conveyor and driving empty to full box on roller conveyor. This cycle is repeated through six full boxes. Ends as truck reaches 5′ zone in front of box	13.08
Clean up:	
Begins when the motor on the truck is stopped. Consists of pushing the boards back in the truck, removing the motor, closing the gate, driving the truck out, and removing the dirt. Ends when truck starts to back in	8.99

Above-ground single door storage, one-ton pallet boxes, trough belt conveyor, box tipper, roller conveyor, forklift truck, bulk hopper body truck, 4-man crew.

Set up:	
Begins as truck starts to back into position to the conveyor. Consists of hooking up the motor and opening the gate of the truck. Ends when motor to unload truck is started	5.94
Unload truck:	
Begins as motor on truck is started. Consists of pulling boards on the truck and pushing potatoes down, picking trash, and removing dirt. Ends when motor is stopped	26.36
Fill boxes:	
Begins as motor on truck is started. Consists of filling the box and lowering it as it is being filled, stopping the equipment after the box is full, spreading the potatoes on top of the box, moving the full box to the side, moving the empty box in position on the box tipper and raising the box. This cycle is repeated for six boxes. Ends as motor on truck is started	15.73
Transport to storage:	
Begins when forklift truck enters zone 5′ in front of box. Consists of picking up the box, transporting to storage, position box in stack piled 4 high, driving back to full box on box tipper or driving empty to empty boxes stored either in storage or outside, picking up two empty boxes, transporting to roller conveyor, position boxes on conveyor and driving empty to full box on roller conveyor. This cycle is repeated through six full boxes. Ends as truck reaches 5′ zone in front of box	13.08
Clean up:	
Begins when the motor on the truck is stopped. Consists of pushing the boards back in the truck, removing the motor, closing the gate, and driving the truck out. Ends when truck starts to back in	3.35

Component work elements of fill boxes and transport to storage:	*Productive time per occurrence Man-minutes*
Fill boxes:	
Fill boxes: Begins as motor on truck and equipment starts. Consists of controlling the operation of the conveyor in the truck, trough belt conveyor, and box tipper. Lowers box as it is being filled. Ends when motors are stopped	1.28
Spread potatoes: Begins as equipment is stopped. Consists of spreading the potatoes evenly on the top of the box. Ends when hands are released from the potatoes	.50
Move full box: Begins when hands are released from the potatoes. Consists of moving the full box off the box tipper onto the roller conveyor. Ends when full box is released	.32
Move empty box and raise: Begins when full box is released. Consists of moving the empty box from the roller conveyor onto the box tipper and raising the box to its top position for filling. Ends when equipment is started again	.28
Transport to storage:	
Pick full box from roller conveyor: Begins as forklift truck enters zone 5′ of box. Ends when truck leaves 5′ zone	.15
Transport full box to storage: Begins as forklift truck leaves zone 5′ of box. Ends when truck reaches zone 5′ of place to position box.	

Driving distance in feet	*Productive time per occurrence Man-minutes*
60	.39
70	.42
80	.44
90	.47
100	.50
110	.52
120	.55
130	.58
140	.60

For additional distances use formula t = 0.00265d + 0.232 when d = driving distance between points in feet and t = productive time in minutes.

Position full box in storage: Begins as forklift truck reaches zone 5′ of place to position. Ends when forklift truck leaves 5′ zone.

	Productive time per occurrence Man-minutes
1st tier	.13
2d tier	.29
3d tier	.34
4th tier	.52
Average	.32

Transport empty to full box on conveyor: Begins as forklift truck leaves 5′ zone. Ends as forklift truck reaches 5′ zone of box.

Driving distance in feet	*Productive time per occurrence Man-minutes*
60	.31
70	.34
80	.36
90	.39
100	.42
110	.45
120	.47
130	.50
140	.53

For additional distances use formula t = 0.00276d + 0.143 when d = driving distance between points in feet and t = productive time in minutes.

Transport empty from full box in storage to empty boxes: Begins when forklift truck leaves zone 5′ of box. Ends when reaches zone 5′ of empty box.

Driving distance in feet	*Productive time per occurrence Man-minutes*
60	0.31
70	.33
80	.36
90	.39
100	.42
110	.45
120	.47
130	.50
140	.53

For additional distances use formula t = 0.00285d + 0.132 when d = driving distance between points in feet and t = productive time in minutes.

Pick up two empty boxes: Begins as forklift truck reaches zone 5′ of empty boxes. Ends when forklift truck leaves 5′ zone — .29

Transport two empty boxes to roller conveyor: Begins as forklift truck leaves 5′ zone of empty boxes. Ends when forklift truck reaches 5′ zone of roller conveyor where boxes are to be positioned.

Driving distance in feet	*Productive time per occurrence Man-minutes*
60	.48
70	.51
80	.53
90	.56
100	.59
110	.61
120	.64
130	.67
140	.69

For additional distance use formula t = 0.00268d + 0.319 when d = driving distance between points in feet and t = productive time in minutes.

Position two empty boxes on conveyor: Begins as forklift truck reaches 5′ zone of conveyor. Ends as forklift truck leaves 5′ zone — .66

Fatigue and personal allowance for performing various handling elements

A personal allowance of 5 percent was used for all elements of work.

	Fatigue allowance Percent
Set up	5
Fill storage (unload truck)	5
Unload and empty sacks	15
Fill boxes, spread potatoes, move empty and raise box	5
Move full box	25
Close up	5
Reposition cleated belt binloader and truck—3-man crew	15
Reposition cleated belt binloader and truck—5-man crew	5
Reposition flat conveyor and truck—3-man crew	10
Reposition flat conveyor and truck—5-man crew	5
Reposition draper chain binloader and truck—3-man crew	10
Reposition draper chain binloader and truck—5-man crew	5
Move cleated belt binloader to other bin—3-man crew	15
Move cleated belt binloader to other bin—5-man crew	5
Move flat conveyor to other bin—3-man crew	25
Move flat conveyor to other bin—5-man crew	15
Move draper chain binloader to other bin—3-man crew	25
Move draper chain binloader to other bin—5-man crew	15
Move backboard to other bin—3-man crew	15
Move backboard to other bin—5-man crew	5
Reposition backboard	10
Mechanical adjustment of conveyors and binloaders and other miscellaneous elements	5
Transport to storage—forklift truck	5
Clean up dirt	10

Equipment costs

In order to make comparisons between different types of equipment for performing the handling operations, it was neeessary to determine eost figures for each of the types of equipment ineluded in the study. Costs per truckload for eaeh type of equipment based on different annual volumes were determined. For those types of equipment used in more than one operation, the cost was allocated to the pereentage of time the equipment was used in each operation. Tables 16, 17, and 18 show the basis for the development of the annual cost for eaeh type of equipment in the method used and the eost per truckload at various volumes.

TABLE 16.—*Ownership and operating costs for potato handling equipment of annual volume of 42,000 cwt.*

Storage and method	Amount of equipment	Initial cost	Expected life (Years)	Ownership cost				Operating cost			Total annual cost	Cost per truckload
				Depreciation	Interest	Insurance and taxes	Total	Power	Maintenance	Total		
Above-ground single door storage—cleated belt binloader, bulk truck, 3-man crew.	1 cleated belt binloader 30′	$2,000	15	$133.33	$50.00	$80.00	$263.33	$9.99	$22.10	$32.09	$295.42	$0.844
	1 bulk hopper body motor	58	15	3.87	1.45	2.32	7.64	2.50	.67	3.17	10.81	.031
	2 backboards	50	15	3.33	1.25	2.00	6.58		.49	.49	7.07	.020
	2 wheelbarrows	50	15	3.33	1.25	2.00	6.58		.49	.49	7.07	.020
	2 shovels	8	5	1.60	.20	.32	2.12				2.12	.006
		2,166		145.46	54.15	86.64	286.25	12.49	23.75	36.21	322.49	.921
Above-ground single door storage—cleated belt binloader, sacks, 5-man crew.	1 cleated belt binloader 30′	2,000	15	133.33	50.00	80.00	263.33	12.86	30.24	43.10	306.43	.875
	2 backboards	50	15	3.33	1.25	2.00	6.58		.52	.52	7.10	.020
	2 wheelbarrows	50	15	3.33	1.25	2.00	6.58		.52	.52	7.10	.020
	2 shovels	8	5	1.60	.20	.32	2.12				2.12	.006
		2,108		141.59	52.70	84.32	278.61	12.86	31.28	44.14	322.75	.921
Above-ground multiple door storage—cleated belt binloader, bulk truck, 3-man crew.	1 cleated belt binloader 30′	2,000	15	133.33	50.00	80.00	263.33	9.99	22.10	32.09	295.42	.844
	1 bulk hopper body motor	58	15	3.87	1.45	2.32	7.64	2.50	.67	3.17	10.81	.031
	2 backboards	50	15	3.33	1.25	2.00	6.58		.48	.48	7.06	.020
	2 wheelbarrows	50	15	3.33	1.25	2.00	6.58		.48	.48	7.06	.020
	2 shovels	8	5	1.60	.20	.32	2.12				2.12	.006
		2,166		145.46	54.15	86.64	286.25	12.49	23.73	36.22	322.47	.921
Above-ground multiple door storage—cleated belt binloader, sacks, 5-man crew.	1 cleated belt binloader 30′	2,000	15	133.33	50.00	80.00	263.33	12.86	30.24	43.10	306.43	.875
	2 backboards	50	15	3.33	1.25	2.00	6.58		.51	.51	7.09	.020
	2 wheelbarrows	50	15	3.33	1.25	2.00	6.58		.51	.51	7.09	.020
	2 shovels	8	5	1.60	.20	.32	2.12				2.12	.006
		2,108		141.59	52.70	84.32	278.61	12.86	31.26	44.12	322.73	.921
Below-ground deep bin storage—flat belt conveyor, draper chain binloader, canvas chute, bulk truck, 3-man crew.	1 flat belt conveyor 10′	325	15	21.67	8.13	13.00	42.80	.69	1.00	1.69	44.49	.127
	1 draper chain binloader	935	15	62.33	23.38	37.40	123.11	2.07	6.48	8.55	131.66	.376
	1 canvas chute	33	2	16.50	.83	1.32	18.65				18.65	.053
	1 bulk hopper body motor	58	15	3.87	1.45	2.32	7.64	2.24	.58	2.82	10.46	.030
	2 wheelbarrows	50	15	3.33	1.25	2.00	6.58		.45	.45	7.03	.020
	2 shovels	8	10	.80	.20	.32	1.32				1.32	.004
		1,409		108.50	35.21	56.36	200.10	5.00	8.51	13.51	213.61	.610
Below-ground deep bin storage—flat belt conveyor, draper chain binloader, canvas chute, sacks, 5-man crew.	1 flat belt conveyor 10′	325	15	21.67	8.13	13.00	12.80	1.35	1.97	3.32	46.12	.132
	1 draper chain binloader	935	15	62.33	23.38	37.40	123.11	2.71	8.49	11.20	134.31	.384
	1 canvas chute	33	2	16.50	.83	1.32	18.65				18.65	.053
	2 wheelbarrows	50	15	3.33	1.25	2.00	6.58		.52	.52	7.10	.020
	2 shovels	8	10	.80	.20	.32	1.32				1.32	.004
		1,351		104.63	33.79	54.01	192.46	1.06	10.98	15.04	207.50	.593
Below-ground deep bin storage—draper chain binloader, canvas chute, bulk truck, 3-man crew.	1 draper chain binloader	935	15	62.33	23.38	37.40	123.11	3.45	10.80	14.25	137.36	.393
	1 canvas chute	33	2	16.50	.83	1.32	18.65				18.65	.053
	1 bulk hopper body motor	58	15	3.87	1.45	2.32	7.64	2.50	.67	3.17	10.81	.031
	2 wheelbarrows	50	15	3.33	1.25	2.00	6.58		.49	.49	7.07	.020
	2 shovels	8	10	.80	.20	.32	1.32				1.32	.004
		1,084		86.83	27.11	43.36	157.30	5.95	11.96	17.91	175.21	.501
Below-ground deep bin storage—draper chain binloader, canvas chute, sacks, 5-man crew.	1 draper chain binloader	935	15	62.33	23.38	37.40	123.11	4.51	14.14	18.65	141.76	.405
	1 canvas chute	33	2	16.50	.83	1.32	18.65				18.65	.053
	2 wheelbarrows	50	15	3.33	1.25	2.00	6.58		.52	.52	7.10	.020
	2 shovels	8	10	.80	.20	.32	1.32				1.32	.004
		1,026		82.96	25.66	41.04	149.66	1.51	14.66	19.17	168.83	.482

Above-ground one-ton pallet box storage—filling equipment, forklift truck, bulk truck, 3-man crew.	1 trough belt conveyor 12'----------	600	15	40.00	15.00	24.00	79.00	3.88	4.02	7.90	86.90	.248
	1 box tipper----------	964	15	64.27	24.10	38.56	126.93	7.44	6.48	13.92	[1] 77.39	.221
	5 roller conveyors 4' sections----------	707	15	47.13	17.68	28.28	93.09	----------	11.85	11.85	[2] 86.32	.247
	1 forklift truck-3000 lb. cap----------	5,355	15	357.00	133.88	214.20	705.08	20.10	16.29	36.39	[3] 388.93	1.111
	2,100 one-ton pallet boxes----------	29,400	25	1,176.00	735.00	1,176.00	3,087.00	----------	26.25	26.25	[4] 1,055.25	3.015
	1 bulk hopper body motor----------	58	15	3.87	1.45	2.32	7.64	1.46	.39	1.85	9.49	.027
	2 wheelbarrows----------	50	15	3.33	1.25	2.00	6.58	----------	.42	.42	7.00	.020
	2 shovels----------	8	5	1.60	.20	.32	2.12	----------	----------	----------	2.12	.006
		37,142	----------	1,693.20	928.56	1,485.68	4,107.44	32.88	65.70	98.58	1,713.40	4.895
Above-ground one-ton pallet box storage—filling equipment, forklift truck, bulk truck, 4-man crew.	1 trough belt conveyor 12'----------	60	15	40.00	15.00	24.00	79.00	3.88	4.02	7.90	86.90	.248
	1 box tipper----------	964	15	64.27	24.10	38.56	126.93	7.42	6.48	13.90	[1] 77.37	.221
	5 roller conveyors 4' sections----------	707	15	47.13	17.68	28.28	93.09	----------	10.02	10.02	[2] 84.49	.241
	1 forklift truck—3,000 lb. cap----------	5,355	15	357.00	133.88	214.20	705.08	21.45	17.39	38.84	[3] 391.38	1.118
	2,100 one-ton pallet boxes----------	29,400	25	1,176.00	735.00	1,176.00	3,087.00	----------	26.25	26.25	[4] 1,055.25	3.015
	1 bulk hopper body motor----------	58	15	3.87	1.45	2.32	7.64	1.46	.39	1.85	9.49	.027
	2 wheelbarrows----------	50	15	3.33	1.25	2.00	6.58	----------	.36	.36	6.94	.020
	2 shovels----------	8	5	1.60	.20	.32	2.12	----------	----------	----------	2.12	.006
		37,142	----------	1,693.20	928.56	1,485.68	4,107.44	34.21	64.91	99.12	1,713.94	4.896

[1] 50 percent of ownership cost was allocated to removing from storage operation.
[2] 50 percent of ownership cost of two sections was allocated to removing from storage operation.
[3] 50 percent of ownership cost was allocated to removing from storage operation.
[4] 33 1/3 percent of ownership cost was allocated to removing from storage operation and 33 1/3 percent to storage.

TABLE 17.—*Ownership and operating costs for potato handling equipment of annual volume of 60,000 cwt.*

Storage and method	Amount of equipment	Initial cost	Expected life (Years)	Ownership cost				Operating cost			Total annual cost	Cost per truckload
				Depreciation	Interest	Insurance and taxes	Total	Power	Maintenance	Total		
Above ground single door storage—cleated belt binloader, bulk truck, 3-man crew.	1 cleated belt binloader 30'	$2,000	15	$133.33	$50.00	$80.00	$263.33	$13.54	$33.00	$46.54	$309.87	$0.619
	1 bulk hopper body motor	58	15	3.87	1.45	2.32	7.64	3.39	.96	4.35	11.99	.024
	2 backboards	50	15	3.33	1.25	2.00	6.58		.70	.70	7.28	.015
	2 wheelbarrows	50	15	3.33	1.25	2.00	6.58		.70	.70	7.28	.015
	2 shovels	8	3	2.67	.20	.32	3.19				3.19	.006
		2,166		146.53	54.15	86.64	287.32	16.93	35.36	52.29	339.61	.679
Above ground single door storage—cleated belt binloader, sacks, 5-man crew.	1 cleated belt binloader 30'	2,000	15	133.33	50.00	80.00	263.33	17.72	43.20	60.92	324.25	.648
	2 backboards	50	15	3.33	1.25	2.00	6.58		.75	.75	7.33	.015
	2 wheelbarrows	50	15	3.33	1.25	2.00	6.58		.75	.75	7.33	.015
	2 shovels	8	3	2.67	.20	.32	3.19				3.19	.006
		2,108		142.66	52.70	84.32	279.68	17.72	44.70	62.42	342.10	.684
Above ground multiple door storage—cleated belt binloader, bulk truck, 3-man crew.	1 cleated belt binloader 30'	2,000	15	133.33	50.00	80.00	263.33	13.54	33.00	46.54	309.87	.619
	1 bulk hopper body motor	58	15	3.87	1.45	2.32	7.64	3.39	.96	4.35	11.99	.024
	2 backboards	50	15	3.33	1.25	2.00	6.58		.69	.69	7.27	.015
	2 wheelbarrows	50	15	3.33	1.25	2.00	6.58		.69	.69	7.27	.015
	2 shovels	8	3	2.67	.20	.32	3.19				3.19	.006
		2,166		146.53	54.15	86.64	287.32	16.93	35.34	52.27	339.59	.679
Above ground multiple door storage—cleated belt binloader, sacks, 5-man crew.	1 cleated belt binloader 30'	2,000	15	133.33	50.00	80.00	263.33	17.72	43.20	60.92	324.25	.648
	2 backboards	50	15	3.33	1.25	2.00	6.58		.74	.74	7.32	.015
	2 wheelbarrows	50	15	3.33	1.25	2.00	6.58		.74	.74	7.32	.015
	2 shovels	8	3	2.67	.20	.32	3.19				3.19	.006
		2,108		142.66	52.70	84.32	279.68	17.72	44.68	62.40	342.08	.684
Below ground deep bin storage—flat belt conveyor, draper chain binloader, canvas chute, bulk truck, 3-man crew.	1 flat belt conveyor 10'	325	15	21.67	8.13	13.00	42.80	1.01	1.45	2.46	45.26	.091
	1 draper chain binloader	935	15	62.33	23.38	37.40	123.11	2.91	9.13	12.04	135.15	.270
	1 canvas chute	33	2	16.50	.83	1.32	18.65				18.65	.037
	1 bulk hopper body motor	58	15	3.87	1.45	2.32	7.64	3.19	.83	4.02	11.66	.023
	2 wheelbarrows	50	15	3.33	1.25	2.00	6.58		.65	.65	7.23	.015
	2 shovels	8	10	.80	.20	.32	1.32				1.32	.003
		1,409		108.50	35.24	56.36	200.10	7.11	12.06	19.17	219.27	.439
Below ground deep bin storage—flat belt conveyor, draper chain binloader, canvas chute, sacks, 5-man crew.	1 flat belt conveyor 10'	325	15	21.67	8.13	13.00	42.80	1.97	2.86	4.83	47.63	.095
	1 draper chain binloader	935	15	62.33	23.38	37.40	123.11	3.82	11.96	15.78	138.89	.278
	1 canvas chute	33	2	16.50	.83	1.32	18.65				18.65	.037
	2 wheelbarrows	50	15	3.33	1.25	2.00	6.58		.75	.75	7.33	.015
	2 shovels	8	10	.80	.20	.32	1.32				1.32	.003
		1,351		104.63	33.79	54.04	192.46	5.79	15.57	21.36	213.82	.428
Below ground deep bin storage—draper chain binloader, canvas chute, bulk truck, 3-man crew.	1 draper chain binloader	935	15	62.33	23.38	37.40	123.11	4.84	15.43	20.27	143.38	.287
	1 canvas chute	33	2	16.50	.83	1.32	18.65				18.65	.037
	1 bulk hopper body motor	58	15	3.87	1.45	2.32	7.64	3.39	.96	4.35	11.99	.024
	2 wheelbarrows	50	15	3.33	1.25	2.00	6.58		.71	.71	7.29	.015
	2 shovels	8	10	.80	.20	.32	1.32				1.32	.003
		1,084		86.83	27.11	43.36	157.30	8.23	17.10	25.33	182.63	.366
Below ground deep bin storage—draper chain binloader, canvas chute, sacks, 5-man crew.	1 draper chain binloader	935	15	62.33	23.38	37.40	123.11	6.45	20.20	26.65	149.76	.299
	1 canvas chute	33	2	16.50	.83	1.32	18.65				18.65	.037
	2 wheelbarrows	50	15	3.33	1.25	2.00	6.58		.75	.75	7.33	.015
	2 shovels	8	10	.80	.20	.32	1.32				1.32	.003
		1,026		82.96	25.66	41.04	149.66	6.45	20.95	27.40	177.06	.354

Above ground one-ton pallet box storage—filling equipment, forklift truck, bulk truck, 3-man crew.	1 trough belt conveyor 12'	600	15	40.00	15.00	24.00	79.00	5.25	5.76	11.01	91.01	.182
	1 box tipper	964	15	64.27	24.10	38.56	126.93	10.09	9.25	19.34	[1] 82.81	.166
	5 roller conveyors 4' sections	707	15	47.13	17.68	28.28	93.09	----------	16.93	16.93	[2] 91.41	.183
	1 forklift truck—3000 lb. cap	5,355	15	357.00	133.88	214.20	705.08	29.06	23.55	52.61	[3] 405.15	.810
	3,000 one-ton pallet boxes	42,000	25	1,680.00	1,050.00	1,680.00	4,410.00	----------	37.50	37.50	[4] 1,507.50	3.015
	1 bulk hopper body motor	58	15	3.87	1.45	2.32	7.64	1.97	.56	2.53	10.17	.020
	2 wheelbarrows	50	15	3.33	1.25	2.00	6.58	----------	.60	.60	7.18	.014
	2 shovels	8	3	2.67	.20	.32	3.19	----------	----------	----------	3.19	.006
		49,742	----------	2,198.27	1,243.56	1,989.68	5,431.51	46.37	94.15	140.52	2,198.42	4.396
Above ground one-ton pallet box storage—filling equipment, forklift truck, bulk truck, 4-man crew.	1 trough belt conveyor 12'	600	15	40.00	15.00	24.00	79.00	5.25	5.76	11.01	91.01	.182
	1 box tipper	964	15	64.27	24.10	38.56	126.93	10.06	9.25	19.31	[1] 82.78	.166
	5 roller conveyors 4' sections	707	15	47.13	17.68	28.28	93.09	----------	14.32	14.32	[2] 88.80	.178
	1 forklift truck—3,000 lb. cap	5,355	15	357.00	133.88	214.20	705.08	30.65	24.84	55.49	[3] 408.03	.816
	3,000 one-ton pallet boxes	42,000	25	1,680.00	1,050.00	1,680.00	4,410.00	----------	37.50	37.50	[4] 1,507.50	3.015
	1 bulk hopper body motor	58	15	3.87	1.45	2.32	7.64	1.97	.56	2.53	10.17	.020
	2 wheelbarrows	50	15	3.33	1.25	2.00	6.58	----------	.51	.51	7.09	.014
	2 shovels	8	3	2.67	.20	.32	3.19	----------	----------	----------	3.19	.006
		49,742	----------	2,198.27	1,243.56	1,989.68	5,431.51	47.93	92.74	140.67	2,198.57	4.397

[1] 50 percent of ownership cost was allocated to removing from storage operation.
[2] 50 percent of ownership cost of two sections was allocated to removing from storage operation.
[3] 50 percent of ownership cost was allocated to removing from storage operation.
[4] 33 1/3 percent of ownership cost was allocated to removing from storage operation and 33 1/3 percent to storage.

TABLE 18.—*Ownership and operating costs for potato handling equipment of annual volume of 120,000 cwt.*

Storage and method	Amount of equipment	Initial cost	Expected life (Years)	Ownership cost				Operating cost			Total annual cost	Cost per truckload
				Depreciation	Interest	Insurance and taxes	Total	Power	Maintenance	Total		
Above ground single door storage—cleated belt binloader, bulk truck, 3-man crew.	2 cleated belt binloaders, 30′	$4,000	15	$266.67	$100.00	$160.00	$526.67	$24.13	$66.00	$90.13	$616.80	$0.617
	2 bulk hopper body motors	116	15	7.73	2.90	4.64	15.27	6.04	1.92	7.96	23.23	.023
	4 backboards	100	15	6.66	2.50	4.00	13.16		1.45	1.45	14.61	.015
	4 wheelbarrows	100	15	6.66	2.50	4.00	13.16		1.45	1.45	14.61	.015
	4 shovels	16	3	5.34	.40	.64	6.38				6.38	.006
		4,332		293.06	108.30	173.28	574.64	30.17	70.82	100.99	675.63	.676
Above ground single door storage—cleated belt binloader, sacks, 5-man crew.	2 cleated belt binloaders, 30′	4,000	15	266.67	100.00	160.00	526.67	31.58	86.40	117.98	644.65	.644
	4 backboards	100	15	6.66	2.50	4.00	13.16		1.53	1.53	14.69	.015
	4 wheelbarrows	100	15	6.66	2.50	4.00	13.16		1.53	1.53	14.69	.015
	4 shovels	16	3	5.34	.40	.64	6.38				6.38	.006
		4,216		285.33	105.40	168.64	559.37	31.58	89.46	121.04	680.41	.680
Above ground multiple door storage—cleated belt binloader, bulk truck, 3-man crew.	2 cleated belt binloaders, 30′	4,000	15	266.67	100.00	160.00	526.67	24.13	66.00	90.13	616.80	.617
	2 bulk hopper body motors	116	15	7.73	2.90	4.64	15.27	6.04	1.92	7.96	23.23	.023
	4 backboards	100	15	6.66	2.50	4.00	13.16		1.44	1.44	14.60	.015
	4 wheelbarrows	100	15	6.66	2.50	4.00	13.16		1.44	1.44	14.60	.015
	4 shovels	16	3	5.34	.40	.64	6.38				6.38	.006
		4,332		293.06	108.30	173.28	574.64	30.17	70.80	100.97	675.61	.676
Above ground multiple door storage—cleated belt binloader, sacks, 5-man crew.	2 cleated belt binloaders, 30′	4,000	15	266.67	100.00	160.00	526.67	31.58	86.40	117.98	644.65	.644
	4 backboards	100	15	6.66	2.50	4.00	13.16		1.53	1.53	14.69	.015
	4 wheelbarrows	100	15	6.66	2.50	4.00	13.16		1.53	1.53	14.69	.015
	4 shovels	16	3	5.34	.40	.64	6.38				6.38	.006
		4,216		285.33	105.40	168.64	559.37	31.58	89.46	121.04	680.41	.680
Below ground deep bin storage—flat belt conveyor, draper chain binloader, canvas chute, bulk truck, 3-man crew.	2 flat belt conveyors, 10′	650	15	43.34	16.26	26.00	85.60	1.84	2.90	4.74	90.34	.090
	2 draper chain binloaders	1,870	15	124.66	46.76	74.80	246.22	5.34	18.26	23.60	269.82	.270
	2 canvas chutes	66	2	33.00	1.66	2.64	37.30				37.30	.037
	2 bulk hopper body motors	116	15	7.73	2.90	4.64	15.27	5.85	1.66	7.51	22.78	.023
	4 wheelbarrows	100	15	6.66	2.50	4.00	13.16		1.36	1.36	14.52	.015
	4 shovels	16	10	1.60	.40	.64	2.64				2.64	.003
		2,818		216.99	70.48	112.72	400.19	13.03	24.18	37.21	437.40	.438
Below ground deep bin storage—flat belt conveyor, draper chain binloader, canvas chute, sacks, 5-man crew.	2 flat belt conveyors, 10′	650	15	43.34	16.26	26.00	85.60	3.68	5.72	9.40	95.00	.095
	2 draper chain binloaders	1,870	15	124.66	46.76	74.80	246.22	7.12	23.92	31.04	277.26	.277
	2 canvas chutes	66	2	33.00	1.66	2.64	37.30				37.30	.037
	4 wheelbarrows	100	15	6.66	2.50	4.00	13.16		1.53	1.53	14.69	.015
	4 shovels	16	10	1.60	.40	.64	2.64				2.64	.003
		2,702		209.26	67.58	108.08	381.92	10.80	31.17	41.97	426.89	.427
Below ground deep bin storage—draper chain binloader, canvas chute, bulk truck, 3-man crew.	2 draper chain binloaders	1,870	15	124.66	46.76	74.80	246.22	9.03	30.86	39.89	286.11	.286
	2 canvas chutes	66	2	33.00	1.66	2.64	37.30				37.30	.037
	2 bulk hopper body motors	116	15	7.73	2.90	4.64	15.27	6.04	1.92	7.96	23.23	.023
	4 wheelbarrows	100	15	6.66	2.50	4.00	13.16		1.47	1.47	14.63	.015
	4 shovels	16	10	1.60	.40	.64	2.64				2.64	.003
		2,168		173.65	54.22	86.72	314.59	15.07	34.25	49.32	363.91	.364
Below ground deep bin storage—draper chain binloader, canvas chute, sacks, 5-man crew.	2 draper chain binloaders	1,870	15	124.66	46.76	74.80	246.22	11.82	40.40	52.22	298.44	.298
	2 canvas chutes	66	2	33.00	1.66	2.64	37.30				37.30	.037
	4 wheelbarrows	100	15	6.66	2.50	4.00	13.16		1.54	1.54	14.63	.015
	4 shovels	16	10	1.60	.40	.64	2.64				2.64	.003
		2,052		165.92	51.32	82.08	299.32	11.82	41.94	53.76	353.08	.353

Above ground one-ton pallet box storage—filling equipment, forklift truck, bulk truck, 4-man crew.	1 trough belt conveyor, 12'	600	15	40.00	15.00	24.00	79.00	9.55	11.52	21.07	100.07	.100
	1 box tipper	964	15	64.27	24.10	38.56	126.93	18.29	18.50	36.79	[1] 100.26	.100
	5 roller conveyor 4' sections	707	15	47.13	17.68	28.28	93.09		28.62	28.62	[2] 103.10	.103
	1 forklift truck—3,000 lb. cap	5,355	10	535.50	133.88	214.20	883.08	61.29	49.68	110.97	[3] 552.51	.552
	6,000 one-ton pallet boxes	84,000	25	3,360.00	2,100.00	3,360.00	8,820.00		75.00	75.00	[4] 3,015.00	3.015
	1 bulk hopper body motor	58	15	3.87	1.45	2.32	7.64	3.58	1.11	4.69	12.33	.012
	2 wheelbarrows	50	15	3.33	1.25	2.00	6.58		1.02	1.02	7.60	.008
	2 shovels	8	2	4.00	.20	.32	4.52				4.52	.005
		91,742		4,058.10	2,293.56	3,669.68	10,020.84	92.71	185.45	278.16	3,895.39	3.895
Above ground one-ton pallet box storage—filling equipment, forklift truck, bulk truck, two 4-man crews.	2 trough belt conveyors, 12'	1,200	15	80.00	30.00	48.00	158.00	9.55	11.52	21.07	179.07	.179
	2 box tippers	1,928	15	128.54	48.20	77.12	253.86	18.29	18.50	36.79	[5] 227.19	.227
	10 roller conveyors, 4' sections	1,414	15	94.26	35.36	56.56	186.18		28.62	28.62	[2] 196.18	.196
	2 forklift trucks—3,000 lb. cap	10,710	15	714.00	267.75	428.40	1,410.15	61.29	49.68	110.97	[5] 1,168.58	1.169
	6,000 one-ton pallet boxes	84,000	25	3,360.00	2,100.00	3,360.00	8,820.00		75.00	75.00	[4] 3,015.00	3.015
	2 bulk hopper body motors	116	15	7.73	2.90	4.64	15.27	3.58	1.11	4.69	19.96	.020
	4 wheelbarrows	100	15	6.66	2.50	4.00	13.16		1.02	1.02	14.18	.014
	4 shovels	16	3	5.34	.40	.64	6.38				6.38	.006
		99,484		4,396.53	2,487.11	3,979.36	10,863.00	92.71	185.45	278.16	4,826.54	4.826

[1] 50 percent of ownership cost was allocated to removing from storage operation.
[2] 50 percent of ownership cost of two sections was allocated to removing from storage operation.
[3] 50 percent of ownership cost was allocated to removing from storage operation.
[4] 33 1/3 percent of ownership cost was allocated to removing from storage operation and 33 1/3 percent to storage.
[5] 50 percent of ownership cost of one unit was allocated to removing from storage operation.

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