IMPROVED HANDLING METHODS AND LAYOUT IN AFFILIATED FROZEN FOOD WAREHOUSES

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PREFACE

Cooperation of the following frozen food wholesalers for permitting studies of operations in their warehouses is gratefully acknowledged: Associated Grocers of New Hampshire, Manchester, N. H.; Burlington Grocery Co., Burlington, Vt.; Giant Foods, Inc., Landover, Md.; Hendrie's Cold Storage, Inc., Milton, Mass.; J. M. Jones Co., Champaign, Ill.; North East Frozen Foods Park, Inc., North East, Pa.; Ryan Grocery Co., Billings, Mont.; P. A. & S. Small Co., York, Pa.; and P. Tassia Co., York, Pa.

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The work was under the direction of R. W. Hoecker and John C. Bouma of the Transportation and Facilities Research Division.

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Improved Handling Methods and Layout In Affiliated Frozen Food Warehouses[1]

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SUMMARY

Nine frozen food wholesalers reduced man-hour requirements in their warehouses an average of 22 percent through improved work methods and materials-handling equipment, more evenly balanced work crews, and improved layouts. Operations studied included receiving and storing frozen food, replenishing stock in order-selection slots, checking customer orders, and loading cases of merchandise in delivery trucks. Studies also were made of the materials-handling equipment and storage layouts instrumental in accomplishing these operations. Since labor accounted for 54 percent of the total frozen food warehousing cost in the cooperating firms, increased employee productivity was welcomed by management.

Labor requirements in the nine firms for the receiving operation were reduced more than 18 percent, from a total of 764 to 620 man-hours weekly, by using one man instead of a two-man team in trucks or railcars to stack incoming frozen food cases on pallets or other transporting platforms and by using warehouse space to best advantage.

Storing-operations labor was reduced over 31 percent when the wholesalers began buying volume items of frozen food in palletload quantities and when they initiated the practice of having the forklift truck operator in the general receiving area store incoming merchandise directly in the freezer (that area of the warehouse complex set aside for products that require refrigeration at extremely low temperatures). Before the study, the forklift trucks made many trips to storage with only partially filled pallets. Also, incoming frozen food was commonly placed outside the freezer door before the study, and frequently lost quality while being held for deposit by the forklift truck operator assigned to the freezer area.

Order selection required 21 percent less time when improved methods were used, and man-hours were reduced from 1,671 to 1,329. These improvements consisted of (1) slotting and numbering warehouse storage sites to coincide with the order of merchandise listing on the invoice, and (2) improving job scheduling. In one firm productivity increased 50 percent with improvements in the selection and packing of less-than-full cases of merchandise, an important part of the frozen food industry's order-selection process. Formerly, items in such an order were selected from the racks and placed on a small four-wheel handtruck or grocery-store shopping cart that the selector pushed along the aisle. When all the items in the order were selected, they were carried to a packing bench in the order-assembly area and dumped on the bench, checked, and packed in a suitable cardboard box. The box was then sealed and marked with the customer's name and store number. With the improved method, a master container is used. The items on the order are selected from stock and packed directly in the container, which is positioned on a handtruck and pushed to the different racks of merchandise in the room. The container is sealed with a top and is tagged as it is taken to the shipping dock. Increased productivity with use of the master container is principally the result of eliminating double-handling of the merchandise.

Most of the cooperators in the study did not check orders because (1) many buyers, large and small, felt it was unnecessary as discrepancies were handled easily by company credit memo, and (2) some firms placed selected orders directly in an insulated container, which was sealed when filled as part of the order-

[1] Affiliated warehouse distributors handle a complete line of foods and service retail outlets of corporate chains, voluntary groups, retailer-owned cooperative groups, and consumer-owned organizations. Affiliated warehouse management has some control of retail outlets. These distributors may also serve institutional organizations.

selection method. Three of the firms that did check orders reduced the number of checkers from four to two by the adoption of "arranged orders." When orders are arranged, the order selectors place the first half of the items on the invoice on one side of the four-wheel selector truck as they assemble, and the rest on the other side. With this system, requested items can be checked by one man rather than a two-man team.

Some frozen food wholesalers have found the adhesive label invoice system helpful in reducing checking costs and providing retailers with suggested selling prices. The adhesive label attached to the case contains the same information as the invoice and provides an item description that can be checked by the purchaser with the description of the product contained on the case. If an error is found by the wholesaler's customer, the evidence is shown on the label.

Loading time requirements were reduced 18.5 percent, from 680 to 554 man-hours weekly, in the nine firms. This saving of 126 man-hours was accomplished almost entirely by changing from a two-man crew to one-man loading.

Costs were compared for warehouse labor and equipment when five systems were used in selecting, checking, and loading a 100-case order of frozen food. The lowest cost, $2.15, was realized with a system in which the individual order was assembled on a four-wheel selector truck and the cases were loaded in the delivery truck by handstacking. A system in which individual orders were assembled with a double-pallet jack and two pallets and the cases were loaded in the delivery truck by the palletload unit was second lowest in cost, at $2.41.

A layout of one warehouse designed to handle the inventory and selection fronts for about 325 items illustrates how the floorspace could be increased from approximately 5,400 square feet to approximately 8,000 square feet. With this expansion the warehouse would accommodate a business volume of about $4 million annually instead of only $2 million. The layout is designed so that the merchandise can be handled in accordance with efficient materials-handling principles.

BACKGROUND

As recently as 35 years ago, food wholesalers were specialists, handling only one product line like dry groceries, fruits and vegetables, fish and seafoods, or meat and meat products. Later, they took on additional food lines. In 1958, 2,336 food wholesalers of the 30,022 food wholesalers included in the U.S. Census of Business *(11, pp. 1–11 to 1–17)* [2] reported that they sold frozen food. In 1963, the comparable census figures were 3,209 and 29,290 *(12, pp. 8–81 to 8–119)*. For the 5-year span, this is a gain of 37 percent in the number of wholesalers handling frozen food.

Many states have adopted codes applicable to the temperature tolerances at which frozen food may be held in processing and marketing channels. An example is the Pennsylvania code, effective July 1, 1964, with enforcement starting July 1, 1965. The code permitted, until January 1, 1967, temperatures as high as 10° F. for permanent storage of frozen food and 15° for temporary holding conditions. After January 1, 1967, the code lowered permissible temperatures to 0° for permanent storage and 10° for temporary conditions. State frozen food codes indicate the growing awareness of the public to frozen food handling conditions and to the need for correcting them. Adoption of frozen food codes by additional States should cause increasing numbers of wholesalers to remodel their frozen food warehouses to comply with new or changed regulations.

The Department of Agriculture has published reports about frozen food handling methods and warehouse layouts in wholesale warehouses *(1, 2, 8, 9)*. Some effective operating practices of frozen food wholesalers were analyzed in the reports. However, the reports pointed out that methods of receiving food stocks, assembling orders, and loading delivery trucks in many of the plants studied appeared to be inadequate for the efficient handling of frozen food.

To correct these inadequacies, this study developed recommendations for improved methods, equipment, and layout to make frozen food distribution operations more efficient. The data presented here summarize studies of materials-handling operations and warehouse layout both in wholesale establishments that normally supply their customers with frozen foods in addition to groceries, fruits and vegetables, meats, and dairy products, and in wholesale establishments that supply their customers with frozen food and ice cream only. Sizes of the cooperating firms' frozen food warehouses ranged from 2,000 to 55,000 square feet. Two of the warehouses were multistoried and the other seven were singlestoried. Warehouse ceiling height varied from 8 feet to 24 feet and the number of items per warehouse ranged from 210 to 700. Those firms that handled institutional business as well as retail business had 550 to 700 items

[2] Italic numbers in parentheses refer to Literature Cited, p. 31.

in their freezers whereas the firms handling retail business only had 200 to 500 items. The annual business volume of frozen food in the firms studied ranged from $250,000 to $12½ million. The suggestions presented in this report should provide realistic guides for wholesalers to follow in improving operating practices in their frozen food warehouses.

HANDLING METHODS

Product-handling activities at the warehouse include unloading the merchandise from carriers, stacking it in the freezer, selecting it for customers' orders, and checking and loading the orders on delivery trucks. These operations have become progressively more expensive to perform because average hourly earnings per nonsupervisory employee in wholesale trade increased nearly 38 percent from 1955 to 1964, from $1.83 to $2.52 *(13, p. 84)*. A similar gain in wage rates has probably occurred for frozen food warehouse employees.

RECEIVING AND STORING MERCHANDISE

Receiving and storing begins when the carrier delivering the merchandise arrives at the receiving platform of the warehouse. The receiving operation includes (1) noting the condition and temperature of the product, (2) placing merchandise (cases) on a pallet, a four-wheel handtruck, or other transporting platform, (3) moving the pallet or the handtruck out of the carrier to the dock, (4) checking the load's contents against an itemized purchase order, and (5) making a tally of incoming goods for the office record. The storing operation involves moving the receipts to the warehouse storage area, usually by forklift truck if the load is on pallets or by manually pushed handtrucks or skids if it is not. The operation continues with the operator's placing the load either in the assembly-line storage slots for order selection or in an area set aside to hold reserve merchandise. With the forklift truck, the load is deposited as a unit; with the filled handtruck, unloading is accomplished by handstacking each case.

Receiving and storing operations required more than 32 percent of warehouse man-hours in the nine firms studied. More than double the tonnage was handled per man-hour in the receiving and storing operations than in the shipping operation. However, in spite of the quantity of goods handled, merchandise must still be transferred case by case from the carrier (railcar or motortruck) to a pallet or handtruck for transport to storage in the freezer. The cost of case-by-case handling in the receiving operation has been unavoidable except when merchandise is delivered by motortruck; in motortruck deliveries, the truck driver usually places the cases on the pallet.

Motortrucks hauled approximately 85 percent of frozen food receipts to the warehouses during the study; railcars hauled the other 15 percent. Frozen food wholesalers considered the chief advantage to receiving by rail to be a flexible unloading schedule. Merchandise shipped by railcar can be moved when the warehouse workload is light, whereas motortruck deliveries must be unloaded immediately upon the truck's arrival. Wholesalers stated that the advantages of receiving merchandise by motortruck included (1) the customary practice of having truck drivers palletize merchandise in the truck, which eliminates the need for the firm to bear this cost directly; and (2) the simplified handling of damaged merchandise, which is sent back to the shipper on the same delivery truck. (Merchandise damaged in rail transit must usually be held for inspection by a claims adjuster before it can be moved; thus it occupies valuable warehouse space and contributes to congestion.)

Of the nine firms cooperating in the study, seven palletized the merchandise in the receiving operation, one used a four-wheel handtruck, and the other, a semilive skid. In the warehouses that used the pallet system, merchandise was manually placed on the pallet in the railcar and the pallet was moved to and dropped in the surge (holding) area on the dock by pallet jack. The palletload was then picked up by a forklift truck and taken to storage. In the two firms that did not use pallets, the merchandise was handstacked on a four-wheel handtruck or a semilive skid at the receiving dock and was restacked by hand at the storage site.

A labor productivity study of the two methods of receiving was made in one firm (table 1). With the pallet system, 505 cases, 4.62 tons, were unloaded per man-hour; with the handstack system, 302 cases, 2.76 tons, were unloaded per man-hour. More labor was required with the handtruck-handstack system than with the pallet system because the merchandise was handled twice—once when it was placed on the handtruck for removal from the carrier and again when it was stacked in the freezer. With the pallet system, merchandise was handled once—when it was placed on the pallet. It was then transported and placed in storage as a unit load by mechanical equipment.

The findings in table 1 are based on a study of a 5,192-case railcar of frozen fruits and vegetables weighing 94,928 pounds. Merchandise was stacked in the warehouse an average distance of 150 feet from the railcar. Handstacking was not more than 8 feet high. With both systems, one man was used in the railcar and one man was used to move filled pallets or handtrucks out of the car and to bring in empties. With the handtruck system, another man was used to stack the merchandise in the warehouse.

Table 1 shows that it took approximately 44 minutes longer to place the merchandise in the car on pallets than it did to place the merchandise on the four-wheel handtruck: 294.35 minutes compared with 250.20 minutes. This difference in time was caused by the necessity of placing merchandise on the pallet in an interlocking case pattern called a "merchandise block."

Some of the freezers had such low ceilings that forklift trucks could not be operated. In warehouses with higher ceilings, the type of forklift truck used most frequently was powered by electric battery. Only forklifts powered by electricity are recommended for use in frozen food warehouses because electricity releases less fumes than other fuels. In the highly insulated freezer, fumes cannot escape easily; they may be harmful to operating personnel and may affect the quality of the frozen food. Electric forklift trucks are depreciated over an 8-year period and the power batteries over a 5-year period.[3]

The size of the pallet selected when the pallet system (see table 1) is used can influence the forklift truck operator's productivity. For example:

Item	Pallet size 40 in.×32 in.	Pallet size 40 in.×48 in.
(1) Pallet capacity—		
Pounds	[1] 1,187	[2] 1,800
Cases	[1] 65	[2] 98
(2) Pallet transport time [3]—(man-min.)	1.346	1.346
(3) No. pallets equivalent to one ton [4]	1.68	1.11
(4) Storing time per ton [5] —(man-min.)	2.261	1.494

[1] Average pallet weight of 1,187 pounds and case weight of 18.3 pounds derived from tables 1 and 2.

[2] Assumed pallet weight of 1,800 pounds and actual case weight (table 1).

[3] 107.68 man-minutes (table 1) divided by 80 pallets (table 2).

[4] 2,000 pounds divided by 1,187 pounds and 1,800 pounds respectively.

[5] The storing time per ton is the product of items (2) and (3). It includes time for (1) transporting loaded pallet to working slot or reserve storage, an average distance of 150 feet; (2) elevating loaded forklift to varied rack levels, depositing load, and lowering forklift tines; and (3) returning forklift to receiving dock.

[3] This rate of depreciation may appear somewhat accelerated. It was chosen to reflect the risk of obsolescence of such equipment, and to offset increasing maintenance costs generally occurring toward the end of the equipment's useful life.

TABLE 1.—*Comparative time required by 2 handling systems to unload and stack a railcar shipment containing 5,192 cases [1] of frozen packaged fruits and vegetables [2]*

Unloading and stacking operations	Pallet system	Handtruck system
	Man-minutes	*Man-minutes*
Make ready (open/close car door, remove dunnage/car dividers, note condition and temperature of product, etc.)	17.50	17.50
Obtain cases and place on handtruck [3]		250.20
Move handtruck into and out of railcar		101.52
Bring empty pallet into car	35.25	
Obtain cases and place on pallet [3]	294.35	
Move loaded pallet out of car	49.35	
Forklift time for transporting and stacking	107.68	
Transport time for handtruck from railcar to storage point and return		231.84
Handstacking cases at storage site		240.78
Total for unloading and stacking operations	504.13	841.84
Personal and fatigue allowance [4]	113.43	189.41
Total man-minutes	617.56	1,031.25

[1] The shipment weighed approximately 95,000 pounds.

[2] A breakdown of the car's contents is given in table 2, p. 6.

[3] Includes the time to break down stack facings for easier handling.

[4] Allowances of 15 percent for carrier and dock operations and 30 percent for freezer operations are included. Computations for personal and fatigue time allowances are described on p. 32.

Pallet size in the railcar unloading study was 40 inches by 32 inches. Had pallets 40 inches by 48 inches been used, the entry for "forklift time for transporting and stacking" in table 1 would have been 71.15 man-minutes rather than 107.68 man-minutes, and the railcar unloading operation would have been performed at a productivity rate of 544 cases per man-hour. The additional time required to move a larger palletload with a forklift is negligible, but because of the increase in the load carried per trip on the larger pallet, fewer trips are required to unload the car. However, other factors must be considered when selecting the size of pallet to use in the warehouse, such as the number and kinds of items to be stocked in the freezer and the type of order-selection line to be used. (A word of caution—many warehousemen tend to place as many packages on a piece of equipment as it will carry. This may appear to be an efficient procedure but it is likely to be costly. Forklift trucks, for example, are designed to handle weights to a predetermined maximum and this limit should not be exceeded. Packages were observed to fall off the pallet very frequently in frozen food warehouses while the palletload was being transported. Apparently, this occurred because the intense cold (—10° F. in the frozen food warehouse), combined with the humidity, caused greater package slippage than in grocery and produce warehouses. Further, when forklift truck equipment is overloaded it becomes harder to maneuver and the operator, losing some degree of control over the load, is endangered by the possibility that the truck and its load will upset.)

Effect of Delay on Productivity in Receiving and Storing Merchandise

Two factors contributed to major delays in the receiving and storing operations:

Waiting for a forklift to store receipts in the freezer.—In five of the warehouses studied the general truck dock was used to receive frozen food. When the truck drivers had the palletload of frozen food ready, the forklift truck operator assigned to the general receiving area picked up the palletload and transported it to the holding area outside the entrance to the freezer. Delay ensued while the palletload was held in a makeshift surge (holding) area until put away by the frozen food warehouse personnel.

Too-high stacking of product on pallet.—Merchandise was placed on the pallet 10 cases high in some frozen food warehouse receiving operations. When the palletload was taken to the freezer, the forklift operator had to hand-stack some of the newly received merchandise in the working slot to reduce the height of the palletload so it could clear the slot opening. Stacking merchandise too high on the pallet also caused product damage, as shown in figure 1.

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FIGURE 1.—Damage to product from stacking merchandise too high on pallets.

Improved Methods of Receiving Merchandise

The following methods were used to reduce the delays in the receiving operation in the firms studied. Delays caused by waiting for forklift trucks to store merchandise in the freezer were eliminated by directing the forklift truck operator in the general receiving area to enter the freezer and store the merchandise instead of dropping it at the freezer entrance. The freezer supervisor was directed to supply the forklift operator with the numbers of freezer slots available for immediate use and for anticipated frozen food receipts. Receiving productivity increased 10 percent when this method was used. Advantages included (1) less congestion in grocery and produce warehouse aisles adjacent to the freezer, and (2) prevention of frozen food being exposed for long periods to higher than optimum temperatures. The temperature outside the freezer in the produce warehouses was 50° F. and in grocery warehouses it varied with fluctuating climatic conditions. During the study, palletloads of frozen food were observed to remain outside one firm's freezer for 2 hours. During this period, thermometer readings of the product ranged from 4° to 22° although the optimum holding temperature for frozen food is —10°.

Delays caused by stacking the product too high on the pallet were eliminated by including a pattern for stacking the cases on the pallets with the receiving clerk's copy of the frozen food purchase order, and by directing the receiving clerk to instruct truck drivers to use the specified stacking pattern. One firm cooperating in the study controlled overstacking by using a wooden slat marked with the height of freezer racks as a stacking gage. Finally, discussions held between the firm's buyers and warehouse personnel stressed the point of buying only in pallet or pallet-layer quantities. Table 2 shows the stacking patterns used and the number of pallets required for an incoming shipment of 14 frozen food items totaling 5,192 cases.

Only one of the 14 purchased items, twenty-four 10-ounce packages of sliced strawberries (brand 1), was ordered in a full palletload quantity. Had the other purchases been in multiples of the palletload quantities listed in table 2 (60, 65, 68, 70, or 100 cases) rather than in random quantities, the time required to receive and store the merchandise could have been reduced. With each trip out of the railcar to the dock, the pallet and jack would have handled a full load and the receiving clerk would have needed only to check (count) the palletloads. Each trip of the forklift operator to the storage area in the warehouse would also have been made with full palletloads. Instead, 13 trips with partial palletloads were required during the actual receiving operation. For example, the 300-case receipt of Fordhook lima beans required five pallets. Four pallets had full loads and the fifth had a partial load of 28 cases ($17 \times 4 = 68$; $68 \times 4 + 28 = 300$). The trip with the 28-case partial palletload required the same amount of labor and equipment time as the trips handling the full palletloads of 68 cases. If the forklift truck operator doubled his load (two 68-case palletloads per trip) he would still be making one trip at less-than-full capacity.

Limited productivity because of less-than-full palletload transport also occurred later when the forklift truck operator replenished the order-selection slots from reserve stock. The 28-case load (discussed above) did not completely fill the working slot. Therefore, the forklift truck operator had either to lower another palletload of the item and manually remove enough cases to fill the working slot or he had to service the working slot sooner than would otherwise be necessary.

Another saving accruing from buying in palletload quantities is easier warehouse inventory taking. The full palletloads in reserve storage can be counted from the warehouse aisle, and the number of palletloads noted can be multiplied later by the full pallet pattern of cases listed on the inventory sheet. This reduces the time required for the warehouse inventory and improves inventory accuracy.

TABLE 2.—*Breakdown of a railcar's frozen food contents* [1]

Item	Packages per case		Number of cases per item	Weight of cases	Stacking pattern of cases on pallet [2]	Number of pallets required
	Number	Weight per package				
		Ounces		*Pounds*	*Cases*	
Fordhook limas	24	10	300	5,250	17 x 4	5
Peas and carrots	24	10	100	1,700	17 x 4	2
Chopped spinach	24	10	200	3,600	13 x 5	3
Leaf spinach	24	10	100	1,800	17 x 4	2
Chopped broccoli (brand 1)	24	10	269	4,864	17 x 4	4
Chopped broccoli (brand 2)	24	10	100	1,800	17 x 4	2
Broccoli spears	24	10	500	9,000	15 x 4	8
Cauliflower	24	10	423	7,614	15 x 4	7
Mixed vegetables	24	10	300	5,100	13 x 5	5
Cut corn	24	10	500	8,500	13 x 5	8
Sliced strawberries (brand 1)	24	10	300	5,400	10 x 10	3
Sliced strawberries (brand 2)	24	16	500	13,500	10 x 7	7
Brussels sprouts	24	10	800	14,000	17 x 4	12
Italian green beans	24	9	800	12,800	17 x 4	12
Total	-------	---------	---------	94,928	---------	80

[1] Table 1 provides other data on this railcar shipment.
[2] Pallet size, 40 in. stringer by 32 in. face.

ASSEMBLING CUSTOMER ORDERS

Assembling customer orders in the frozen food warehouses involves the grouping together from warehouse stocks of all merchandise ordered by a customer.[4]

This assembly of merchandise requires many operations, including (1) securing the invoice (order), (2) obtaining a pallet or handtruck or other type of platform to hold the cases on order, (3) traveling to the selection area of the warehouse, (4) reading the invoice and selecting cases of merchandise from warehouse stocks, (5) positioning the cases on the pallet or handtruck, (6) moving the pallet along the selection line until the order is completed or the pallet is filled, and (7) traveling to the shipping dock with the load. Different methods of assembling orders may involve a greater or a lesser number of steps than those enumerated. Methods used by the cooperating firms are discussed in this section of the report.

Labor for the assembly of orders in the nine warehouses ranged from 33 percent to 60 percent of total warehouse man-hours, and averaged nearly 47 percent. It varied in individual firms because of different materials-handling equipment, order-assembly systems, order sizes and warehouse layouts.

Materials-Handling Equipment for Order Assembly

Table 3 gives estimated costs of ownership and operation for each type of equipment used for order selection in the warehouses studied, on a per-year and a per-hour basis. Advantages and disadvantages of each type of equipment are discussed in the following paragraphs:

The *four-wheel selector truck* (handtruck) has the following advantages when it is compared with other materials-handling equipment: (1) its initial cost and maintenance cost are low; (2) it has flexibility because it can be used for both receiving and for shipping merchandise; and (3) it can carry approximately three to four times the weight and bulk carried by a two-wheel handtruck. This means fewer trips to the shipping dock with assembled orders.

The unit of *jack and semilive skid* has the advantages listed for the four-wheel handtruck and in addition is cheaper to operate per year and per hour of use. For example, for 2,000 hours' use (one-shift operation), the jack and semilive skid costs total $26.45 and the four-wheel selector truck cost is $29.61 (table 3). Best results can be obtained with semilive skids if full advantage is taken of two features of the equipment: (1) several cases can be handled simultaneously as a unit load to reduce time required for moving a given quantity and to increase labor productivity; and (2) products can be stored on semilive skids as on dead skids and pallets.

Three types of *insulated containers* were studied in the order assembly operations of the cooperating firms: the steel upright shipper, the steel chest, and the canvas hamper. All have a common advantage—they hold frozen food at zero-degree temperature up to 24 hours. This is important when frozen food is shipped in mixed loads of groceries, produce, and meats. Supplementary protection can also be provided with dry ice. The upright shipper uses the unit load principle to best advantage because it handles the largest payload with its carrying capacity of approximately 50 cubic feet. However, its weight is a disadvantage: the average dead weight of the upright shipper is approximately 500 pounds whereas the steel chest weighs 175 pounds and the hamper 50 pounds. The main disadvantage of the other containers is their limited holding capacity; only 5 cubic feet of product can be packed in a canvas hamper and the chest holds but 15 cubic feet.

The battery-powered *low-lift pallet jack* has the advantage of speed. Both single- and double-pallet jacks can travel in excess of 5 miles per hour with a full load of frozen food. Another advantage is that the order selector works with less fatigue because he rides on the battery casing of the jack while traveling the longer distances in the freezer—for example, between the order-selection area and the shipping dock or from the end of one selection aisle to the beginning of the next aisle. Lessened fatigue generates greater productivity. Disadvantages are the high initial cost and ownership and operating costs of the jacks.

Advantages of the *pallet* are that (1) it carries about 27 percent more product than the upright shipper; (2) its initial cost, as well as its ownership and operating costs, are low; and (3) the order selector can deposit his selection (case) on the pallet from any side. When the order selector uses the upright shipper, he has to approach it from the door side to deposit the selected case. Disadvantages of the pallet are the pallet weight (90 pounds), and loss of the cubic space taken by pallets in the truck or trailer being loaded out. A previous study showed a loss of 29½ percent *(10, p. 16)*. The "loss of cube" disadvantage may be overcome by substituting for the pallet a plywood sheet

[4] Merchandise is assembled in the warehouse in full-case or in less-than-case lots. Full-case assembly is discussed here. Less-than-case lot assembly is treated in a later section of the report.

TABLE 3.—*Estimated cost of ownership and operation of nine types of warehouse equipment used to select frozen food, for 1 shift and 2 shifts*

Equipment and number of shifts (assumed use per year)	Initial cost [1]	Expected useful life [2]	Ownership cost per year				Operating cost per year			Total ownership and operating cost	
			Depreciation	Interest at 5 percent	Insurance and taxes at 4 percent	Total	Electricity [3]	Maintenance [4]	Total	Per year	Per hour
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Cents*
4-wheel selector truck (3,000-lb. capacity; rubber tires; 36 by 60 in. platform)											
1 shift 2,000 hr.	123.36	10	12.34	6.17	4.93	23.44	--------	6.17	6.17	29.61	01.48
2 shifts 4,000 hr.	123.36	10	12.34	6.17	4.93	23.44	--------	12.34	12.34	35.78	0.89
Jack for semilive skid (3,000-lb. capacity; rubber tires)											
1 shift	75.75	10	7.58	3.79	3.03	14.40	--------	3.79	3.79	18.19	0.91
2 shifts	75.75	10	7.58	3.79	3.03	14.40	--------	7.58	7.58	21.98	0.55
Semilive skid (3,000-lb. capacity; rubber tires; 36 by 60 in. platform)											
1 shift	34.38	10	3.44	1.72	1.38	6.54	--------	1.72	1.72	8.26	0.41
2 shifts	34.38	10	3.44	1.72	1.38	6.54	--------	3.44	3.44	9.98	0.25
Steel upright shipper, 50 cu. ft. (outside dimensions 76½ by 42¾ by 40 in.)											
1 shift	303.00	10	30.30	15.15	12.12	57.57	--------	15.15	15.15	72.72	3.64
2 shifts	303.00	10	30.30	15.15	12.12	57.57	--------	30.30	30.30	87.87	2.20
Steel chest, 15 cu. ft. (outside dimensions 44 by 38½ by 28 in.)											
1 shift	191.00	10	19.10	9.55	7.64	36.29	--------	9.55	9.55	45.84	2.29
2 shifts	191.00	10	19.10	9.55	7.64	36.29	--------	19.10	19.10	55.39	1.38
Canvas hamper, 5 cu. ft. (outside dimensions 26½ by 29 by 21 in.)											
1 shift	69.00	5	13.80	3.45	2.76	20.01	--------	3.45	3.45	23.46	1.17
2 shifts	69.00	5	13.80	3.45	2.76	20.01	--------	6.90	6.90	26.91	0.67
Low-lift single-pallet jack (4,000-lb. capacity)											
1 shift											
Machine	1,850.00	8	231.25	--------	--------	--------	--------	--------	--------	--------	-------
Battery (4.99 kw.-hr. capacity)	550.00	5	110.00	--------	--------	--------	--------	--------	--------	--------	-------
Charger	600.00	8	75.00	--------	--------	--------	--------	--------	--------	--------	-------
Total, 1 shift	3,000.00	--------	416.25	150.00	120.00	686.25	[5] 45.00	45.00	90.00	776.25	38.81
Total, 2 shifts	[6] 3,550.00	--------	526.25	177.50	142.00	845.75	90.00	90.00	180.00	1,025.75	25.64

Low-lift double-pallet jack (4,000-lb. capacity)											
1 shift											
Machine	2,624.00	8	328.00	--------	--------	--------	--------	--------	--------	--------	--------
Batteries (2, each 4.99 kw.-hr. capacity)	1,100.00	5	220.00	--------	--------	--------	--------	--------	--------	--------	--------
Charger	600.00	8	75.00	--------	--------	--------	--------	--------	--------	--------	--------
Total, 1 shift	4,324.00	--------	623.00	216.20	172.96	1,012.16	[5] 90.00	64.86	154.86	1,167.02	58.35
Total, 2 shifts	[6] 5,424.00	--------	843.00	271.20	216.96	1,331.16	180.00	129.72	309.72	1,640.88	41.02
Pallet, wood (various sizes)	2.80	5	0.56	.14	.11	.81	--------	.14	.14	.95	.05

[1] Obtained from manufacturers of equipment.

[2] In accordance with U.S. Internal Revenue Service Revenue Procedure 62-21 (*15*), based on reasonable life expectancy.

[3] An average power rate of $0.027 per kilowatt hour (*14*).

[4] Maintenance costs computed at 5 percent of initial cost for all equipment except pallet jacks when machines are used 2,000 hours per year. Costs for pallet jacks are computed at $1\frac{1}{2}$ percent when used 2,000 hours per year. Maintenance costs are doubled if the machines are used 4,000 hours per year.

[5] Power requirements for batteries computed in accordance with manufacturers' specifications using the following formula:

$$\frac{\underset{\$0.027}{\text{(Power cost)}} \times \underset{4.99}{\text{(Kw.-hr. battery capacity)}} \times \underset{0.80}{\text{(Percent battery use)}} \times \underset{1.25}{\text{(Percent increase for battery efficiency)}}}{0.75 \text{ (Charger efficiency)}}$$

= $0.180, per charge per battery per day.

$0.18×250 (approximate working days) equals $45, annual power cost for 2,000 hours of use. With the double-pallet jack (two batteries), this would be $90.

[6] Electric low-lift pallet jacks that are used 4,000 hours per year require a standby battery. With the double-pallet jack, two standby batteries are needed.

and a load transfer rack, a piece of equipment for order assembly that positions the loaded plywood sheet in the delivery truck. This equipment has been used successfully in grocery warehouses. Advantages claimed include (1) additional cubic space for loading merchandise because, whereas a pallet is approximately 5⅜ inches high, the plywood "slip" sheet is only ¾-inch thick; and (2) elimination of the problems of handling and storing pallets.

Order-Assembly Systems

Five systems of order assembly were studied and in this report are called "A"—truckload reassembled into individual orders; "B"—individual retail order assembly using four-wheel handtruck; "C"—order selector filling an individual order with battery-powered, single-pallet jack and pallet; "D"—order selector using single-pallet jack and upright shipper; and "E"—order selector using double-pallet jack and two pallets. A description of each system, with some of its advantages and disadvantages, follows.

System A, *Truckload reassembled into individual orders*.—With this system, the shipping clerk or another company employee prepared a tabulation (recap sheet) for each truckload of outgoing orders. The recap sheet listed the number of cases of each item of frozen food required for all orders included in the truckload. The shipping clerk then sent three men to the freezer to assemble the merchandise listed on the recap. Each assembler had a semilive skid and jack. Using the recap sheet, each employee obtained cases of the items from warehouse stock until his skid was filled. The skid was then pulled to the front of the freezer and was dropped in a holding area near the freezer door. The employee repeated the operation until the total truckload of merchandise was assembled. The entire order-assembly crew was then used to unscramble the individual orders for loading in the truck.

Perhaps the main advantage of system A was that warehousemen with poor reading ability could be used to assemble orders. Disadvantages were (1) frozen food cases were held out of the freezer and the truck longer and therefore were exposed to higher temperatures than when other systems were used, (2) more time was spent in assembly because each item was handled twice, and (3) more time was required for the assemblers to listen to the shipping clerk call out items than for them to read orders. These factors accounted for the low productivity rate of 49 cases per man-hour when a 30-case order was assembled with this system (table 4).

TABLE 4.—*Labor productivity and comparative time required by 5 systems of order selection to assemble a 30-case order*

Elements of order assembly	Truckload reassembled into individual orders (System A)	Individual retailer order assembly using 4-wheel handtruck (System B)	Order selector filling an individual order with single-pallet jack and pallet (System C)	Order selector using single-pallet jack and upright chest (System D)	Order selector using double-pallet jack and two pallets (System E)
	Man-minutes	*Man-minutes*	*Man-minutes*	*Man-minutes*	*Man-minutes*
Travel time [1]	17.05	9.22	10.58	14.23	11.61
Selection time	6.48	4.54	3.24	5.57	3.24
Obtaining and reading or writing on invoice	----------	1.09	1.09	1.09	1.09
Listening for item calls	3.82	----------	----------	----------	----------
Miscellaneous time [2]	.95	.95	.95	.95	.95
Total time	28.30	15.80	15.86	21.84	16.89
Personal and fatigue allowance [3]	8.49	4.74	4.76	6.55	5.07
Standard time [4]	36.79	20.54	20.62	28.39	21.96
	Number	*Number*	*Number*	*Number*	*Number*
Cases handled per man-hour	49	88	87	63	82

[1] Includes time to obtain a pallet, jack, chest, or other materials-handling equipment.
[2] Includes irregular elemental time requirements, such as rearranging or rebuilding load, and picking up fallen cases from floor.
[3] Figured at 30 percent for freezer operations. See p. 32 for computation.
[4] The computation of standard time is described on p.32.

System B, *Individual retail order assembly using four-wheel handtruck.*—Order-selector productivity when this system was used for selecting a 30-case order was highest of the five systems—88 cases per man-hour. System B operated as follows:

Invoices of orders to be loaded on each delivery truck were arranged in the sequence they were to be loaded. The invoices were then placed in the order box from which order selectors picked up enough invoices to make a load on a four-wheel handtruck. The average carrying capacity of the handtruck was 85 to 90 frozen food cases. If more than one retailer's order was to go on the handtruck, items for each order were placed in separate piles on the handtruck. If an order included more cases than a single handtruck could hold, the order selector obtained additional empty handtruck(s) until the order was filled. When all the items on the invoices were selected, the handtruck(s) was pushed to the holding area for finished orders and the order selector obtained the invoice(s) for his next order.

The main advantage of system B over system A was the productivity increase. The increase occurred because each item was handled only once. There was a decrease of approximately 30 percent in selection time (4.54 man-minutes against 6.48 man-minutes). Also, order selectors spent about 71 percent less time reading items on the invoice than in waiting and listening while the shipping clerk called out items (1.09 man-minutes compared with 3.82 man-minutes). The low equipment and maintenance cost of the four-wheel handtruck is another advantage. A disadvantage is the slow speed of a manually pushed loaded four-wheel handtruck—less than 2 miles per hour.

System C, *Order selector filling an individual order with battery-powered, single-pallet jack and pallet.*—Invoices for a single order were obtained by the order selector and he proceeded to the freezer to fill the order. The capacity of the pallet averaged 95 frozen food cases; however, order sizes in the firms using this system averaged slightly less than pallet capacity. Occasionally, however, more than one pallet was needed to hold an order, and the order selector then traveled to the dock with the first palletload and returned to the selection area with an empty pallet to complete the order. The chief advantages of this system are that (1) the full pallet can be loaded directly in the delivery truck without handstacking individual cases and (2) travel time is decreased since the pallet jack achieves a forward speed of approximately 5 miles per hour. Order selector productivity under system C averaged 87 cases per man-hour (table 4). A disadvantage of the system is the higher initial and maintenance costs of the equipment.

System D, *Order selector using single-pallet jack and upright shipper.*—System D was used by cooperators to ship frozen food as part of a mixed load of groceries, frozen food, fruits and vegetables, and dairy products or meat. The order selector obtained his order, engaged the chest with a pallet jack, and traveled to the warehouse order-selection area. Before starting order selection, the operator opened and secured the chest's doors. When the order selector selected each case, he positioned it in the chest to best utilize the chest's space. Each chest held an average of 75 cases. At the completion of order selection, the order selector moved the chest by pallet-jack transporter to the holding area, dropped the load, and locked the chest's doors with a lead seal. Figure 2 shows the filled chest awaiting sealing and loading onto the truck.

BN-32681

FIGURE 2.—An upright shipper of frozen food ready to be closed, sealed, and shipped.

The main advantage of system D is that placing the selected merchandise *directly* into the shipping chest eliminates double-handling. Almost all of the firms used the upright shipper to transport frozen food to retail stores, but the merchandise was usually double-handled in the selecting and loading operations. A disadvantage of the system is that the order selector has to walk around the pallet to approach the chest by the door side to deposit his selected case(s). This "walk around" was necessary in depositing about half of the selected items and was a prime factor in the low productivity when system D was used in assembling a 30-case order—63 cases per man-hour (table 4).

Time studies were made of system D using two variations in assembling a 100-case order: (1) placing selections directly into the upright shipper, and (2) performing separate selecting and loading operations. Productivity was 128 cases per man-hour when selections were placed directly into the shipper, and 102 cases per man-hour when selections were first loaded on a four-wheel handtruck in the freezer and then, in accordance with a recap sheet, packed into an upright shipper *outside* the freezer. The basic cause for the 25-percent decrease in productivity with the second method was that each item was handled twice.

System E, *Order selector using double-pallet jack and two pallets.*—Order selection with this system was similar to that of system C. However, the average order size assembled under system E was larger than that assembled under system C. The tines of the double-pallet jack picked up two empty pallets in tandem at the start of order selection and the order selector obtained approximately 185 to 190 cases on each trip through the order-assembly area. System E is particularly suitable for firms having large orders, customers with truckbed-high unloading docks, and refrigerated trucks that handle frozen food only. In table 4, the productivity (82 cases per man-hour) is low because the order used for comparing the assembly systems was small. System E is not recommended for assembly of small orders. Its chief disadvantage is that it has the highest initial and maintenance costs for equipment of the five systems compared. The pallets and jack used with this system are shown in figure 3.

BN-32682

FIGURE 3.—A pallet jack that handles two pallets, used to select frozen food orders.

Effect of Delay on Order-Selector Productivity

Productivity in filling orders, although largely dependent on the materials-handling equipment, the order-assembly system, and the order size, may be affected by delays that prevent maximum output. The following examples indicate how these delays, though often considered minor, become significant when the time loss occurs repeatedly.

In one of the multifloor warehouses using system A (the truckload reassembled into individual orders), employees assigned to filling orders were observed to spend an average of 5 percent of the time waiting for items in each order to be assembled in the "repack" room. Because items in the repack room are small and of relatively high unit value, one man was assigned responsibility for assembling these items and for maintaining the stock. With system A, the shipping clerk called out the repack items on each order as the order was being assembled. Investigation showed the 5-percent delay was caused by the repack man's inability to assemble the repack orders as fast as the shipping clerk could call them. The delay was eliminated by giving the repack man an extra copy of the recap, which lists repack items on each order, and by having him assemble his orders an hour earlier than the other order assemblers. The extra hour gave the repack man the necessary time to work ahead of the order-assembly schedule and to stay ahead during the actual loading-out operation of the system. Elimination of the delay saved 1.6 man-hours in an 8-hour day as follows: 8 (hours) × 4 (men) × 5 (percent) equals 1.6 (man-hours). However, an additional delay occurred while the repack man waited for new orders to be assembled.

Time was also lost in waiting for retailer orders in several firms. In three warehouses, the delay in order-filling time because of this factor ranged from 8.8 to 12.7 percent. To solve this problem in the warehouse having the 8.8 percent delay, an improved schedule was worked out for the warehouse workload as well as for the office routine. The delay was caused by failure of the salesmen to return from their sales routes early enough for the order selectors to handle new orders. The salesmen were instructed to be in the office with new orders by 3 p.m., or failing that, to telephone their orders to the office by 3 p.m. Productivity of order selectors in this firm increased 15 percent, from 60 cases to 69 cases per man-hour, when this practice was initiated.

In one warehouse where order selections were placed on double-pallet jacks, 3.7 percent of the order assembler's time was spent in writing store numbers on the cases with a grease pencil. The store number was marked on frozen food cases to indicate to the checker(s) and the loaders on the shipping dock the order to which the cases belonged, and to advise the truck driver of which palletloads of cases to unload at a given delivery stop. Each palletload of frozen food was marked with the store number an average of 12 times. The amount of time used was excessive because the firm's customers were equipped to receive their orders in palletload quantities. The delay was reduced from 3.7 percent to 2 percent and saved 0.6 man-hours per 8-hour shift when each load was marked with the store number once on each side of the palletload.

A recent development that should eliminate this delay factor is the adhesive label invoice system *(3)*. With this system, the order selector in the grocery warehouse places a label on each case as he selects it. The cases of merchandise for a particular store can be kept together on the warehouse loading dock because the store number is listed on the label. Also, the label readily identifies each case for the checking and truckloading operations. Several wholesalers are using the adhesive label on frozen food, dairy, and warehouse meat items (except fresh meats). However, the frozen food label is more expensive than the grocery case label because a different type of adhesive is needed for the temperature and humidity conditions in the frozen food warehouse.

Other delays in filling orders encountered during the study included time spent in (1) correcting mistaken order selections, (2) waiting because of aisle blockage, and (3) waiting for a forklift truck operator to lower inaccessible merchandise or to bring merchandise to the selection area from reserve storage. These delays were not of major importance in the firms studied. However, they could be important in other firms.

Importance of Order Size on Order-Selector Productivity

The productivity of order selectors increases as order size increases, largely because a greater part of total order-assembly time is spent in selecting cases than in travel. Table 5 shows the direct influence of order size on the productivity of order selectors. In one firm the selectors used a four-wheel handtruck for filling an individual order (system B), and in the other firm they used a pallet jack and two pallets for filling an individual order (system E). Under system B, productivity of the order selector who filled an order with 76 or more items was over 200 percent greater than when he filled an order with 1 to 5 items; for orders

TABLE 5.—*Productivity of order selectors in the assembly of various sizes of orders, using 2 assembly systems*

Order size	Cases per man-hour assembled under system B [1 2]	Cases per man-hour assembled under system E [2 3]
	Number	*Number*
1 to 5 cases	56	42
6 to 10 cases	67	51
11 to 20 cases	79	62
21 to 40 cases	114	123
41 to 75 cases	156	164
76 cases or more	181	251

[1] Individual retail order assembly with order selector using a 4-wheel handtruck.
[2] Order selectors receive a 30-percent personal and fatigue allowance. The computation for this allowance is described on p. 32.
[3] Individual retail order assembly with order selector using a battery-powered pallet jack and two pallets.

of the same sizes with system E, order-selector productivity was more than four times greater when an order with 76 or more items was filled.

Selecting Orders for Less-Than-Case Lots

Less-than-full cases of merchandise were sold by six frozen food wholesalers because some frozen food cases contained more units (packages) of product than the wholesaler's customers cared to purchase. The customers' reasons for declining to buy full cases were reported by the wholesalers to include lack of storage space at the display case or in the backroom freezer, and lack of demand for the product. The average number of items sold by the wholesalers in less-than-case quantities was 50 per firm, and the sales unit of the less-than-case item was usually either one, three, or six packages.

Analysis of the less-than-case order-assembly operation was made in a number of firms. Traditionally the order-assembly and repacking operations were performed separately. The firms studied assembled merchandise in the packing room on small four-wheel handtrucks or grocery-store shopping carts, moved the assembled merchandise to a packing table, and checked, packed, and sealed the merchandise in cardboard boxes. Orders assembled by this method required 50 percent more time than orders assembled in master containers, as was demonstrated in a pilot study (table 6). With the master container method, the order selections were placed directly in the container, which was positioned on a handtruck that was pushed to the merchandise racks in the packing room. When cardboard boxes were used, the merchandise was tightly packed to avoid damage while in the delivery truck, whereas with the master container, the merchandise was not tightly packed because the master container was rigid.

Productivity with use of a master container for assembly and shipment was approximately 1½ times greater: 143 packages assembled per man-hour compared with 96 packages assembled, checked, packed, and sealed per man-hour when cardboard boxes were used. Increased productivity with use of the master container was caused principally by eliminating the need to pack the merchandise in boxes after selection (table 6). The firm using the master container reported no increase in frozen food damage. The master container has a wooden top that is placed on the container before it is taken to the shipping dock to protect the merchandise during shipment. A disadvantage of this container is that accounting is necessary to assure its return to the warehouse.

TABLE 6.—*Time required to assemble and pack a 50-unit frozen food order when cardboard boxes and when master containers are used*

Assembling and packing operations	Time required with cardboard boxes [1]	Time required with master container [1]
	Man-minutes	*Man-minutes*
Obtain invoice and selector truck	0.45	0.45
Obtain master container	----------	.23
Travel	4.37	4.37
Read/study invoice	3.48	3.48
Select merchandise	11.74	11.74
Place packages on packing bench	1.85	----------
Obtain packing boxes	1.65	----------
Check, pack, and seal cardboard boxes	5.93	----------
Place top on master container	----------	.27
Mark store number on containers and dispose of them	1.94	.39
Total time	31.41	20.93
	Units	*Units*
Assembled per man-hour	96	143

[1] Includes 30-percent personal and fatigue allowance. The computation for this allowance is described on p. 32.

CHECKING ASSEMBLED ORDERS

More than half of the firms did not check the merchandise assembled by their order selectors. Reasons given by management were as follows: (1) Buyers, large and small, felt that checking was unnecessary because order shortages or overages were easily handled by a company credit memorandum; (2) in two firms the frozen food warehouse was manned by a single employee who would, in effect, be checking on himself; and (3) some firms packed the cases directly in the shipper and placed a lead security seal over the container's door latch as part of the order-selection method.

For the firms that checked orders, productivity was measured for each order-assembly system. Results of time studies of the checking operation are shown in table 7.

With order-assembly system A (the truckload reassembled into individual orders), the checker or shipping clerk checked several items at a time after calling them out to a warehouseman who selected the items from the assembled skidload and placed them on a conveyor line running into the truck for loading. Checking was performed in the breakup room of the freezer. With this method, 363 cases per man-hour were checked (table 7).

When employees filling orders assembled individual retailer orders on a four-wheel handtruck (system B) in an unarranged manner, productivity with two men checking increased over 20 percent, from 363 cases to 437 cases per man-hour (table 7). With this method, one checker called out the items on the invoice and checked the side of the four-wheel truck facing him while the other man checked his own side. A mark was placed on each case when it was found.

When one man checked arranged individual orders on a four-wheel handtruck (system B), production per man-hour was increased from 437 cases to 1,049 cases per man-hour, more than twice the productivity rate of two men checking unarranged orders as a team (table 7). To arrange orders on a four-wheel truck, order selectors placed the first half of the invoice items on one side of the truck and the remaining half on the other side, thus eliminating the need for the checker to search for each item on both sides. By having each man work individually, delays caused by one checker waiting for the other were eliminated. In the three firms that checked unarranged orders on four-wheel handtrucks, the number of checkers was reduced from four to two by the adoption of the arranged-orders method of checking. Figure 4 shows one man checking arranged orders.

Some of the firms cooperating in the study double-checked assembled orders. For example, employees filling orders checked the assembled orders by piece count and item description and the order was again checked by a regular order checker. In these instances, the double-checking of all orders resulted in unnecessary work because of the small number of errors found in the second check. The solution was to have the selectors initial the invoice copy and to hold them responsible for selection errors.

Some wholesalers with a good order-assembly system question the value of checking all orders by both piece count and item description because few order-filler errors are discovered in such a check. One method of deciding

TABLE 7.—*Comparative productivity with 3 methods of checking retailers' orders*

Method	Checkers required	Time per case [1]	Cases per man-hour
	Number	*Man-minutes*	*Number*
Checking from assembled skidload—System A	1	0.1653	363
Checking unarranged order on 4-wheel handtruck—System B	2	.1373	437
Checking arranged order on 4-wheel handtruck—System B	1	.0572	1,049

[1] Includes a 30-percent personal and fatigue allowance. This computation is described on p. 32.

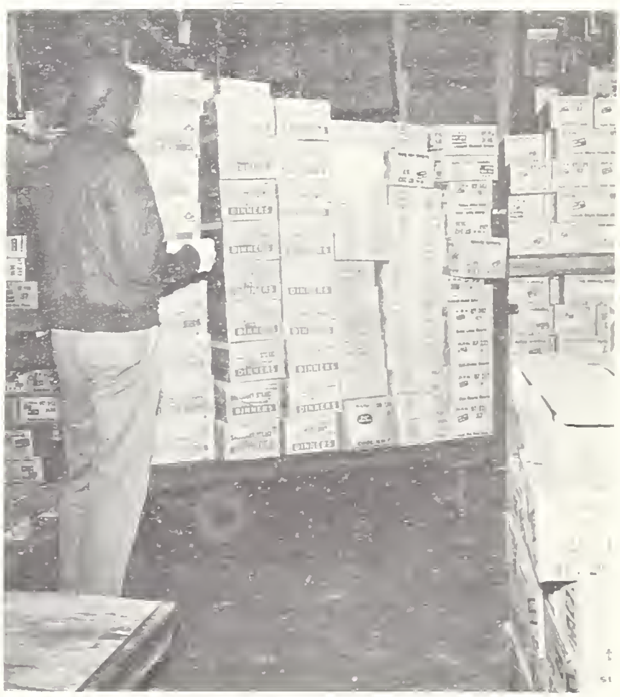

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FIGURE 4.—Checking orders arranged on a four-wheel selector truck.

how much checking should be done is to determine the cost of discovering errors and to weigh the cost against the need to eliminate such errors from the retailer's order.

The use of sample checking and case counting[5] has the following advantages: (1) it can reduce labor costs by keeping employees who fill orders from getting careless, and can be used as a means of detecting those fillers who are error prone; and (2) it can reduce delivery costs by encouraging retailers to accept merchandise on the basis that a case count is made for all outgoing orders. Retailer complaints of receiving incorrect deliveries would then be handled by the wholesaler, who would supply the correct merchandise for the merchandise received in error. The use of sample checking and case counting of assembled merchandise can be readily utilized in those wholesale frozen food firms having good working relationships with their customers.

With the adhesive label invoice system, the warehouse merchandise check is unnecessary in grocery warehouses because the adhesive label attached to each case contains the same information as the invoice and provides an item description of the contents that should agree with the product name and other information that is printed on the case *(3)*. The label cannot be transferred to another case without damage to label or cardboard case. If an error is found by the wholesaler's customer, he can present the label as evidence of the error.

In a study of grocery warehouse adhesive label price-marking *(3)*, the elimination of warehouse checking resulted in a labor saving of $2.48 per thousand cases shipped. Additional advantages of the adhesive label include more legible and accurate presentation of the suggested retail price, better retail-store stock rotation because the adhesive labels show delivery dates, and improved control between the warehouse and retail store on incorrectly assembled merchandise because data necessary to trace the error(s) is shown on each case misshipped.

LOADING ORDERS ON TRUCKS AND TRAILERS

The loading-out operation required nearly 21 percent of the total warehouse man-hours in the cooperating firms. This function, performed after completion of the checking operation, involves the loading of merchandise in trucks for delivery to the frozen food wholesaler's accounts. Both straight and tractor-trailer trucks are used for delivering orders from the warehouse. In the firms studied, the warehouse man-hours spent in loading orders ranged from 10 to 28 percent and were directly related to the work methods and equipment used in the various firms.

Methods and Equipment

Delivery trucks were loaded either by a two-man team or by one man. Merchandise to be loaded on trucks reached the loading area by conveyor line, four-wheel handtruck, and pallet(s). Table 8 shows a comparison of the productivity of truck loaders using various loading methods and equipment. Production data shown in the table include times for placing the bridgeplate between the dock and delivery truck with all systems, setting up and taking down the conveyor line, obtaining the loaded four-wheel handtruck or pallet, guiding it inside the delivery truck and positioning it, loading it with the merchandise, and removing the empty handtruck or jack from the delivery truck.

Productivity of one truck loader with the conveyor system was 612 cases per man-hour. Two loaders working as a team achieved 500

TABLE 8.—*Comparative productivity of truck loaders using 4 methods of loading* [1]

Method and number of loaders	Standard loading time per case [2]	Cases loaded: Per hour	Cases loaded: Per man-hour
	Man-minutes	*Cases*	*Cases*
Conveyor line extended into delivery truck (system A):			
2 men	0.0600	1,000	500
1 man	.0980	612	612
Selector truck inside delivery truck (system B):			
2 men	.0820	732	366
1 man	.1230	488	488
Battery-powered pallet jack and single pallet (system C):			
1 man	.0495	1,212	1,212
Battery-powered pallet jack and two pallets (system E):			
1 man	.0381	1,575	1,575

[1] The loading operation for system D is discussed later in the report.

[2] Includes a 15-percent personal and fatigue allowance. The computations for standard time and for personal and fatigue allowances are described on p. 32.

[5] For a detailed description of sample checking and methods of determining whether a check is worthwhile, see Bouma and Kriesberg *(4)*.

cases per man-hour. The conveyor line ran directly into the truck from the holding area for skidloads of assembled orders (system A). The productivity of one man loading from a conveyor was 112 cases, or more than 22 percent greater, than that of two men working as a team under the same system. For a balanced work crew with system A, two-man truck loading was not necessary. The checker and one selector in the order-assembly area and one loader in the truck constituted a balanced work crew.

One man loading delivery trucks from a four-wheel selector truck (system B) averaged 488 cases per man-hour whereas two men working as a team averaged 366 cases per man-hour. The production per man-hour with one man was 122 cases, or 33 percent more than when two men worked together using the same method. Production per man-hour was lower with a two-man team because team members get in the way of each other in close quarters; further, only one man is required to remove the empty selector truck and to push in the loaded one in most instances. In practice, too, there is a tendency for the team to adapt its rate of work to that of the slower member; members of the team also spend considerable time in visiting.

Productivity with system C (battery-powered pallet jack and a single palletload) was 1,212 cases per man-hour. This system was used for loading straight truckloads of frozen food only. Productivity was approximately 1½ times greater than that of system B. Increased productivity with system C resulted because the truck loader did not handstack individual cases but handled the palletload as a unit with the battery-powered pallet jack.

Productivity with system E (loading two palletloads of frozen foods as a unit) was 1,575 cases per man-hour, 30 percent greater than when a single palletload was handled with system C. The increased productivity of this system over that of system C is the result of a double load being handled as a unit each trip and cases not being handpiled atop the palletloads.

Adequate space in the freezer for holding assembled orders affects the output of warehousemen in the loading operation because, with sufficient space, the orders can be easily found by the loader. When this space, called a "surge" area, is provided, "hunt" time and "travel" time are reduced. Only one cooperating firm had adequate surge area. The assembled orders were grouped by truckload and did not interfere with freezer order assembly, receiving, or forklift truck operations. The other cooperators stored assembled orders in freezer aisles. This caused traffic congestion and interfered with productivity in two ways: (1) Employee movement in obtaining assembled orders to load was slowed by the congested area; and (2) assembled orders were not segregated by truckloads in the aisles, causing "hunt" time. Figure 5 shows aisle congestion in a cooperating firm's warehouse.

Insulated Containers

Packing of frozen food orders in three sizes of insulated containers was observed in the loading-out operation of five cooperating firms. The containers are used to protect frozen food in a mixed shipment of groceries, fruits and vegetables, dairy products, and meat. The upright shipper held an average of 75 cases, the chest, 30 cases, and the canvas hamper, six cases. The size of the frozen food order or the number of frozen food cases on the truck's delivery schedule determines which container(s) should be used.

The packing operation was performed *outside* the freezer in all warehouses studied because of limited space in the freezer. In two warehouses, four-wheel selector trucks filled with assembled orders were positioned in a grocery warehouse aisle immediately outside the freezer door, and packing occurred here. In three warehouses, packing was performed in a produce warehouse aisle directly outside the freezer door. Each container was tagged with an identifying number when packed and the grocery warehouse loading clerk was given a list of containers going on mixed loads. Results of time study of the packing operation with

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FIGURE 5.—Assembled frozen food orders are held for loading in warehouse aisle. This holding method interferes with work flow.

the three types of containers are shown in table 9. Greater productivity was achieved with the upright shipper and the steel chest than with the canvas hamper because fewer containers were needed to hold 100-package orders. Figure 6 shows two men packing frozen food orders into a shipping container outside the freezer.

TABLE 9.—*Comparative productivity with operator packing 100-case frozen food orders in 3 types of insulated containers*

Item	Upright shipping chest	Steel chest	Canvas hamper
Container capacity ... cases	75	30	6
Time to load a single container [1] ... man-minutes	11.81	7.57	5.54
Containers required [2] ... number	1.33	3.33	16.67
Time to load 100 cases [3] ... man-minutes	15.71	25.21	92.31
Time to load each case [4] ... man-minutes	0.157	0.252	0.923
Cases loaded per man-hour [5] ... number	382	238	65

[1] Includes a 15-percent personal and fatigue allowance. The computation for this allowance is described on p. 32.
[2] Total number of cases (100) divided by number of cases held by container.
[3] Time required to load a single container multiplied by number of containers required.
[4] Time to load all cases divided by total number of cases.
[5] Minutes in one man-hour (60) divided by time required to load each case.

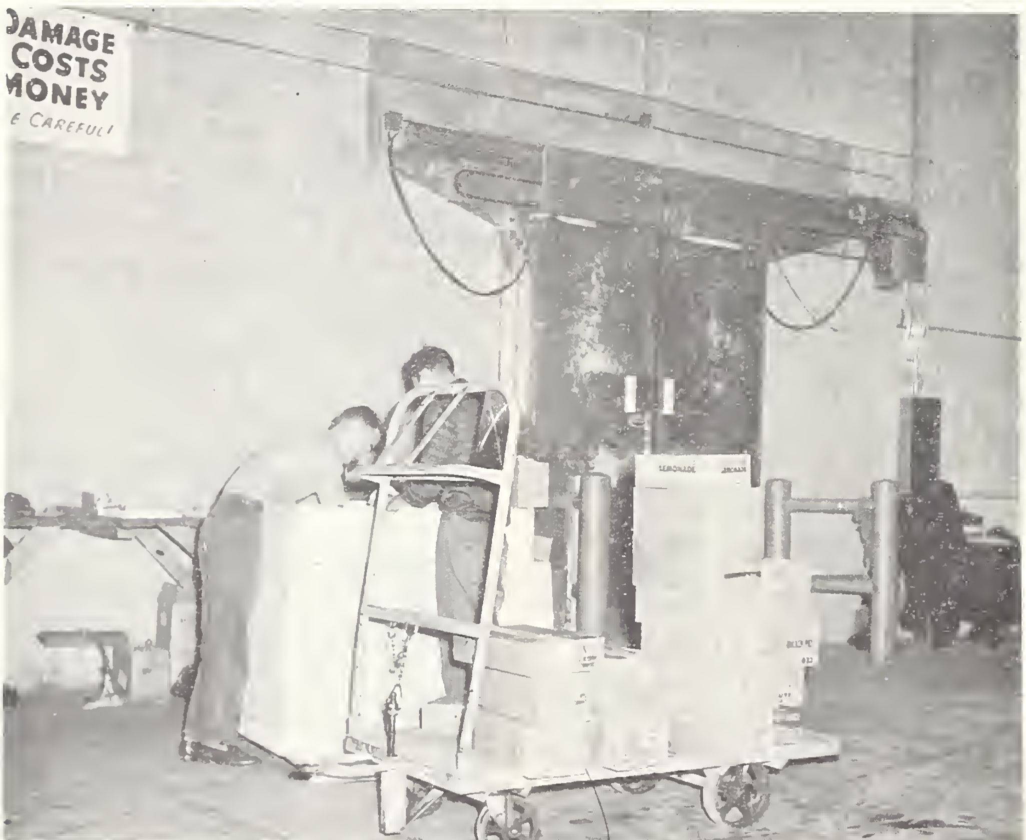

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FIGURE 6.—Packing a frozen food order in a shipping container. The door beyond the loaders leads directly into the frozen food warehouse.

COST COMPARISON FOR WAREHOUSE LABOR AND EQUIPMENT WITH FIVE HANDLING SYSTEMS

Costs were measured for the five systems of selecting, checking, and loading analyzed in this study. Order-selection system E (order selector using a double-pallet jack and two pallets) had the lowest labor cost—$1.37—for a 100-case order (table 10). The highest cost, $2.50, was with system A, the only system of the five analyzed in which each order was handled twice (once as part of a truckload assembly and again when selected for assembly into an individual order). The four order-selection systems with the lowest labor costs (systems B, C, D, and E) had one common factor. They all functioned in such a manner that after an individual order item was handstacked on the transport platform, it was not rehandled until it was loaded in an outgoing shipment. System B had the lowest checking labor cost of $0.22 for an order of 100 cases (table 10). For checking 100 cases of merchandise on pallets, systems C and E had higher checking labor costs—$0.40—mainly because cases on pallets frequently had to be shifted or removed from the pallet by the checker so he could read labels on cases hidden in the center of the palletload. Labor costs for loading for systems C and E—19 cents and 14 cents respectively—were lower than the other systems' loading costs because, with the other systems, cases were handstacked in the truck or upright chest.

Equipment costs for order selection of a 100-case order (table 11) ranged from $0.02 with system B, individual retailer order assembly using a four-wheel handtruck, to $0.36 with system D, order selector using single-pallet jack and upright chest, and system E, order selector using a double-pallet jack and two pallets. Costs for materials-handling equipment during the checking operation totaled less than 1 cent for system B and 15 cents for system D. (Between the low and high cost figures were 2 cents, system A; 10 cents, system E; and 14 cents, system C). Loading-equipment costs ran from 1 cent for system B to 22 cents for system D, with systems E, A, and C grouped at 4 to 6 cents.

By studying the combinations of labor and equipment costs for a typical business period, the management of a firm can decide on the best handling method for assembling and loading outgoing merchandise. Costs of labor and equipment for the five systems are given in table 12. For an order of 100 packages, system B offers the lowest cost ($2.15) for labor and equipment. System E is next lowest, with a cost of $2.41. System B combines low equipment cost with high productivity for small orders (100 cases or less). System E's high equipment cost and low labor cost should produce a lower total cost at order sizes greater than 100 cases, assuming the rates of productivity shown in table 10 are maintained.

TABLE 10.—*Comparative labor costs for 5 systems of selecting, checking, and loading a 100-case frozen food order* [1]

Operation	Truckload reassembled into individual orders (System A)	Individual retailer order assembly using 4-wheel handtruck (System B)	Order selector filling an individual order with battery-powered single-pallet jack and pallet (System C)	Order selector using single-pallet jack and upright chest (System D)	Order selector using double-pallet jack and two pallets (System E)
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Selecting	2.500	1.442	1.541	1.758	1.372
Checking [2]	[3].620	[3].215	[4].398	[4].398	[4].398
Loading	.368	.461	.186	.589	.143
Total	3.488	2.118	2.125	2.745	1.913

[1] Based on a wage rate of $2.25 per hour.
[2] Calculated on basis that every item in order is checked.
[3] Based on productivity figures given in table 7, p. 15.
[4] Based on previous research (*10, table 2, pp. 9 and 10*) because firms cooperating in this study that used systems C, D, and E did not check orders.

TABLE 11.—*Comparative costs of equipment for 5 systems of selecting, checking, and loading a 100-case frozen food order* [1]

Operation	Truckload reassembled into individual orders (System A)	Individual retailer order assembly using 4-wheel handtruck (System B)	Order selector filling an individual order with battery-powered single-pallet jack and pallet (System C)	Order selector using single-pallet jack and upright chest (System D)	Order selector using double-pallet jack and two pallets (System E)
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Selecting	0.071	0.019	0.266	0.360	0.356
Checking	.022	.003	.137	.150	.103
Loading	.048	.006	.064	.222	.037
Total	.141	.028	.467	.732	.496

[1] Based on estimated costs of warehouse equipment used for 1 shift (see table 3, p. 8).

TABLE 12.—*Comparative costs of labor and equipment for 5 systems of selecting, checking, and loading a 100-case frozen food order*

System	Labor	Equipment	Total cost
	Dollars	*Dollars*	*Dollars*
A—Truckload reassembled into individual orders	3.49	0.14	3.63
B—Individual retailer order assembly using 4-wheel handtruck	2.12	.03	2.15
C—Order selector filling an individual order with single-pallet jack and pallet	2.13	.47	2.60
D—Order selector using single-pallet jack and upright shipping chest	2.75	.73	3.48
E—Order selector using double-pallet jack and two pallets	1.91	.50	2.41

LAYOUT DESIGN

A food distributor will obtain greater efficiency and lower costs when operations are begun with a frozen food warehouse that has had detailed planning given to all building layout details. The design of a frozen food warehouse determines its size and shape, whether it is single-floor or multifloor, its column spacing, its requirement for lighting, and many other features. Frozen food wholesalers have found it beneficial to tour the layouts of new freezers and to share with the host management experiences with common professional problems. By such exchanges, the prospective builders supplement their knowledge of problems that occur in frozen food warehouse planning. If the frozen food warehouse is to be part of a food distribution warehouse, the wholesaler should consider the arrangement and functional use made of the warehouse components to obtain maximum efficiency of layout.

SIZE AND SHAPE

Warehouse construction plans should consider the size and movement of warehouse stock. Of two firms with the same volume of business (for example, $2 million), one firm with nine turnovers of stock per year will need an average merchandise inventory of $225,000 whereas another firm with 16 turnovers will require an average inventory of about $125,000.[6] The warehouse for the firm with nine turnovers will need to be nearly twice as large as the warehouse for the firm with 16 turnovers. The number of items to be stocked in a warehouse is most important because it definitely affects the selection fronts (merchandise storage slots) needed in a particular warehouse—that is, the warehouse size. For example, an average grocery warehouse would require from 4,000 to 7,000 selection fronts, whereas an average frozen food warehouse would require only 300 to 500, or a minimum of 700 fronts if institutional items are handled together with retail items.

A warehouse should be designed on the basis of good materials-handling principles so the building can be expanded without interfering with the use of these principles or changing the basic building shape. The building should be square, or nearly square, because some layouts, such as the "U" and the "L," are hard to organize for efficient use of labor and equipment. A building site that is too narrow should be avoided because it could be expanded only in one direction, which would cause further disproportion in the warehouse's shape and thus increase operating costs.

One firm in the study determined the size of its proposed frozen food warehouse as follows:

Assumptions

Stock stored per 1,000 square feet (tons)	40
Average wholesale value per ton (dollars)	650
Value of frozen food per 1,000 square feet (dollars)	26,000
Stock turnovers per year (number)	15
Sales per 1,000 square feet per year (dollars)	390,000

From an operational viewpoint the tons of stock that could be stored per 1,000 square feet (40 tons) was considered a practical working estimate. This was 65 percent of total warehouse capacity. The firm's annual frozen food volume was about $2 million. The following formula was set up by the firm:

$$\frac{\$2,000,000}{\$390,000} \times 1,000 \text{ square feet} = 5,128 \text{ square feet} = \text{warehouse size}$$

[6] Stock-turnover estimates are obtained by dividing a firm's annual cost of merchandise sold by the average cost of its warehouse stock inventory.

The cooperator decided to build a 5,200-square-foot frozen food warehouse and provided for future business growth by planning for an expansion area of approximately 50 percent of the new building. This provision resulted in a plan for an 8,000-square-foot building that could handle an annual volume of as much as $4 million.

The dimensions of the 5,200-square-foot building were set at 80 feet by 65 feet and the addition was planned so that the 65-foot dimension would be expanded to 100 feet. Thus, the ultimate shape would measure 80 feet deep by 100 feet wide, a total of 8,000 square feet, and would form a nearly square building.

SINGLE-FLOOR OR MULTIFLOOR

Research has proved that labor can be used more efficiently in a one-floor warehouse than in a multifloor warehouse. Order-filling productivity, with order selectors using the same assembly methods, was 16 percent greater in one-floor grocery warehouses than in multistory warehouses where freight elevators were used *(5)*. This finding holds equally well for frozen food warehouse operations in a multistory freezer. The most important cause of lowered labor productivity in the two multistory freezers studied was probably the time required for travel between floors with merchandise. One warehouse had four floors and the other had three floors; each was served by a single elevator.

Some frozen food wholesalers operate in a multistory building and the problems they experience include the following:

First, an elevator is normally used both for elevating and lowering the worker and his equipment. Thus, the worker must wait both to ascend and to descend. When the elevator arrives, he must open the door, move his equipment on, close the door, and start the mechanism. At his destination he opens, then closes, the door again. If the elevator is being used by another worker, these delays can be increased substantially. The time involved in waiting for and using the elevator increases the man-hour requirements for assembly. The magnitude of the man-hour increase would be related to the condition of the elevator, its load-carrying capacity, its speed, and the square feet of floorspace available.

A second feature of multistory plant operation is the added difficulty in supervising the labor force: an entire labor crew can virtually disappear from sight during the varied handling operations. Thus, lost time often occurs because of the relaxed working habits that result from the enforced indirect supervision.

SUPPORT-COLUMN SPACING

Research in support-column spacing in grocery warehouses, discussed by Bouma and Lundquist *(6, pp. 7 and 8)*, recommended a spacing of 40 feet between columns. The research finding for column spacing in grocery warehouses applies generally to frozen food warehouses. The support columns should be in a square pattern—for example, 40 feet for both length and width of the warehouse—so that the direction of warehouse aisles can be changed without causing the columns to intrude into them. With existing forklift trucks and with a column spacing of 40 feet, the 90-inch aisle can be used. In planning the column spacing for a frozen food warehouse, the problem should be reviewed with the architect to determine the relative costs of different spacings.

LIGHTING [7]

Efficient operation (high productivity) will be enhanced by adequate illumination in a frozen food warehouse. Adequate illumination should be planned and installed to insure good vision for all visual tasks within the operation of frozen food warehouses. Good lighting will provide the extra benefits of personnel safety and high morale as well as promote good housekeeping habits.

Good illumination is required by employees who must locate items, read labels and weights, and handle the paper work in order processing. Good lighting will contribute to personnel safety by permitting employees to identify objects or obstacles that present a hazard to safe operation. Moreover, darkness is a natural depressant, whereas adequate lighting contributes to the feeling of well-being by personnel and will be an invaluable aid to high morale. A well-lighted warehouse will normally be kept cleaner by operating personnel as a point of personal pride.

Lighting intensity levels for frozen food warehouses should average 30 to 50 foot-candles (maintained). Luminaires should be arranged over the aisles to provide uniform illumination. Minimum foot-candle values should be factored to compensate for anticipated maintenance practices. Normally a 70-percent maintenance factor would be acceptable to account for lamp lumen depreciation and possible dirt accumulation on the luminaire reflector or optical system.

Shipping and receiving areas should also have adequate lighting. Generally, the visual tasks in these areas will be the same as those within the storage area. Loading docks should be equipped with auxiliary lighting to illuminate the interior of trucks or railcars. These auxiliary luminaires should be low-brightness sources to prevent temporary blinding of operating personnel during the loading or unloading process. Convenience outlets and portable cords with lamps on retractable cords may be provided on the docks so the lamps can be placed inside trucks or railcars.

Mercury vapor lamps are recommended for lighting frozen food warehouses. Incandescent lamps have a very high component of heat energy, which adds to the refrigeration load required to maintain proper storage temperatures. Fluorescent lamps are temperature sensitive, and mechanical means for stabilizing their operation in low ambient temperatures add substantially to overall cost. Consequently, mercury vapor lamps are the best choice for frozen food warehouses.

Mercury vapor lamps are available in a choice of clear or phosphor coatings. Phosphor coatings provide better light-output color. However, the resultant color will not generally be of prime importance; therefore, the clear lamps will be the best choice.

Mercury vapor lamps require a ballast (transformer) for operation. The ballast may be mounted integrally within the light fixture (luminaire) or may be remotely located. Generally, the integral ballast will be least costly; however, such considerations as the fact that ballasts contribute a small amount of heat may make a remote location desirable.

Careful selection of the ballast's electrical output characteristics (voltage) is a prime requisite. To reliably start and operate mercury vapor lamps, the ballast should be "Premium" quality constant wattage and should provide a minimum of 270 volts (root mean square) open circuit. Primary voltage selection will be determined by service voltage provided to the building.

To insure receipt of benefits designed into the lighting system, good maintenance practices are necessary. Reflectors or optical systems and lamps should be cleaned every 6 months. Mercury lamps are rated for 16,000+ hours of operation, an economical life rating considering light output in relation to the electrical energy consumed. Good operating practice is to replace lamps at approximately 16,000 hours of operating life, even though the lamps are still burning and capable of longer life. Light output at 16,000 hours of operation will have decreased to a point where it will be eco-

[7] This section on illumination is based on recommendations by Power Systems Division, McGraw-Edison Co., Milwaukee, Wis.

nomically advantageous to replace the lamps. A planned program of cleaning semiannually and replacing lamps on a planned schedule will provide maximum return on the invested lighting dollar. If the operation is based on a 24-hour-day schedule, lamps should be replaced every 2½ years. For 16 hours per day of operation, lamps should be replaced every 4 years and for 8 hours per day of operation, they should be replaced every 7 years.

RECOMMENDED LAYOUT

The warehouse layout discussed in this section (fig. 7) illustrates research findings presented in this report. The initial warehouse dimensions cover approximately 5,400 square feet and are designed to handle $2 million per year in frozen food. The layout is designed for a stock of merchandise averaging 325 frozen food items, for use of electronic data processing, and for 15 annual stock turnovers.[8] With expansion of the warehouse, frozen food floorspace could be increased to approximately 8,000 square feet and could adequately handle an annual volume of $4 million.

The 325 items in the stock require a like number of selection fronts (merchandise storage slots) positioned along the warehouse aisles. This requirement is accomplished in the layout by providing almost the entire freezer area with one-deep pallet racks and by using 40- by 32-inch pallets. The racks are five layers high so that reserve stock can be stored above the layers readily accessible to the order selectors.

Since order selectors will probably be pushing selector trucks by hand at this warehouse's volume of business, fast-moving merchandise is placed in a two-deep floor slot near the end of the selection line to avoid having order selectors push the bulk of the merchandise through the entire selection line. The less-than-full-case operation is also located near the end of the selection line. Items assembled in this operation may be deposited outside the room for pickup by the regular order selector as he completes his order. Slower moving ("bench") items are not palletized but are handstacked on ¾-inch plywood sheets placed on three-level racks.

The layout is planned with the following desirable features: (1) the rail and truck docks are on opposite sides of the warehouse so that the rail and truck traffic will not interfere with each other; (2) adequate dock space is provided for receiving and shipping operations; (3) a 10-foot-wide passageway connects the frozen food area with the other sections of the warehouse; (4) the order selector's travel route begins and ends at the truck shipping-receiving dock to eliminate needless transport of frozen food cases; (5) the 7½-foot-wide freezer aisles are one way so workers can move freely without congestion caused by two-way traffic; (6) the ceiling has 21 feet of clear stacking space; (7) support columns are spaced the same distance in the expansion area as in the original layout (40 feet) so that interior expansion will cause minimum interference with the work flow; (8) the basic design is such that with expansion, the warehouse shape will become more nearly square and no distortion will occur to hinder continued efficient use of labor and materials-handling equipment; and (9) the design facilitates handling of an increased volume of business by providing for additional doors, which, as the warehouse is expanded, can be joined to those already in use for shipping and receiving at the truck and rail docks.

EVALUATING THE EXISTING WAREHOUSING FACILITY

The basic functions of a frozen food warehouse are (1) to store merchandise in a temperature-controlled building, and (2) to provide a layout with good materials-handling principles so that, with equipment, inbound and outbound goods will be efficiently handled. A properly built warehouse performs the first function with minimal cost. The second function obviously requires the attention of management.

In evaluating an existing facility, the management might feel that the warehouse tons per man-hour are not up to average. An inspection of the warehouse might reveal that it is overcrowded with much aisle blockage, that warehouse cubic space is not used efficiently, or that some other factor has impaired the operating system. For example, most of the warehouses in the study were built when more merchandise was received by railcar than at present, and the warehouse's current ratio of railcar dock space to motortruck dock space may not realistically reflect its existing incoming and outgoing rail and motortruck traffic. (The volume of merchandise handled per square foot of dock space is far greater for motortrucks than for railcars and congested dock space frequently occurs at the motortruck dock whereas relatively little use is made of the rail dock space.)

The wholesaler with an old freezer that is fully depreciated probably wonders if his total operations cost could be lowered in a new warehouse. He currently has a low facility cost and

[8] See footnote 6, p. 21, for definition of term "stock turnover."

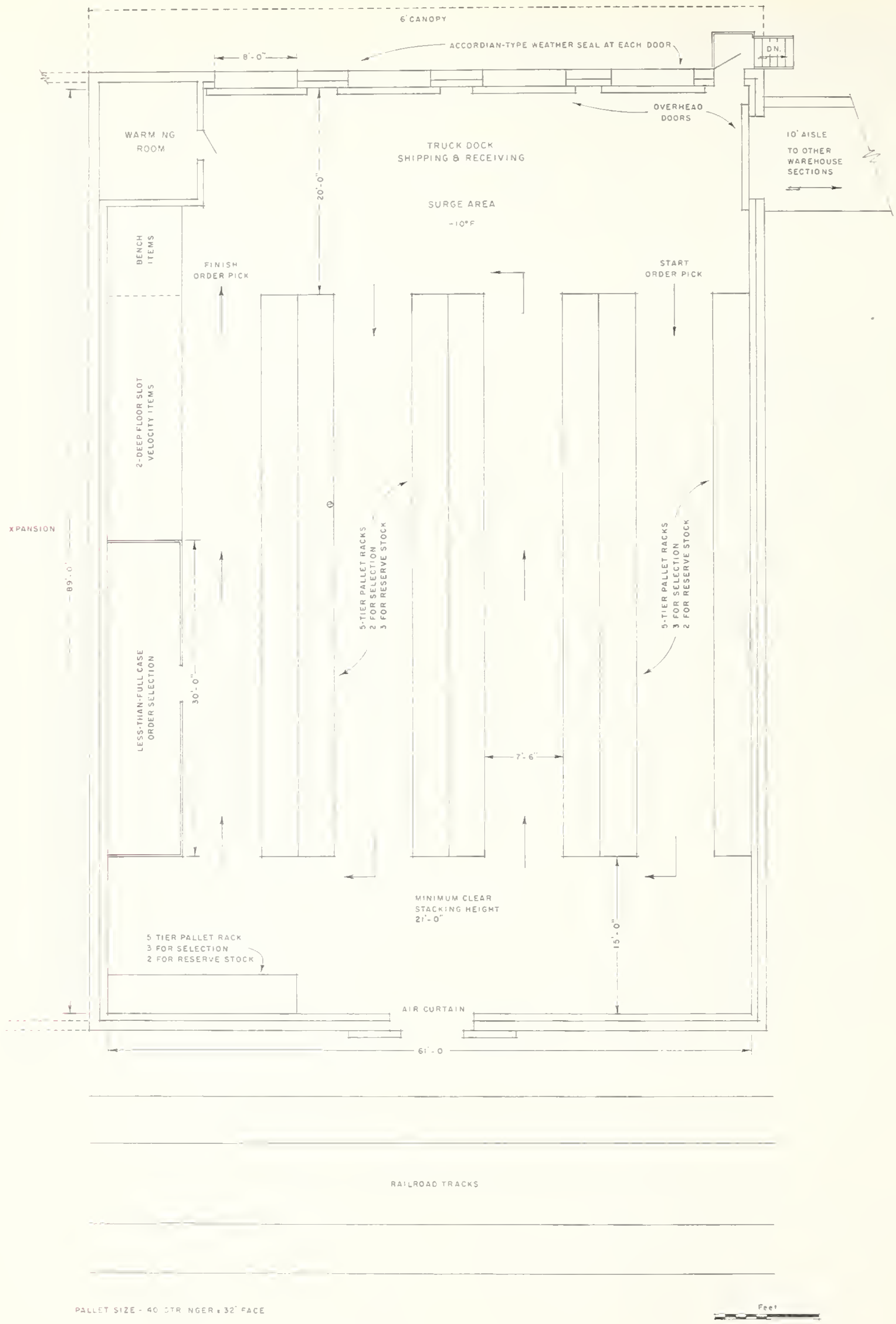

FIGURE 7.—A suggested warehouse layout designed for approximately 325 frozen food items and a $2 million annual business volume, with expansion area.

a high labor cost. By comparison, the facility cost with a new warehouse would be relatively high and the labor cost should be relatively low. The problem is to determine whether or not the cost of a new freezer will be offset by decreased labor costs. This section of the report discusses the analyses presented to two firms cooperating in this study to help them answer their questions on the problem.

Case A

Wholesaler A sold produce and frozen food to unaffiliated retailers and institutional outlets, and frozen food only to a retailer-owned wholesale food cooperative that did not have a frozen food freezer in its warehouse complex. The largest part of the wholesaler's business was to supply frozen food to this cooperative.

Wholesaler A's warehouse was 42 years old and had been designed as a cold-storage house for apples. It had approximately 55,000 square feet on three floors and a basement. Clear stacking height on the four levels varied from 8 to 11 feet. Merchandise was moved between floors with a single elevator and laterally on each level with semilive skids and jacks, and was handstacked in storage because this wholesaler did not use racks, forklift trucks, or pallets. Volume approximated $600,000 annually. Six warehousemen were each paid an annual base wage of $4,160.

Though this wholesaler's frozen food sales had increased over the years, his fruit and vegetable business had steadily declined. Analysis of this problem revealed these alternatives: (1) Build a new freezer, or (2) remodel or modernize the existing warehouse.

Estimated costs were obtained for construction of a new one-floor, 2,700-square-foot warehouse with 21 feet of clear stacking height, equipped to handle efficiently about 1½ times the existing business volume. Estimated costs of the land and building, including office space and pallet racks, totaled $50,000. Amortizing a loan of $50,000, principal and interest, over a 20-year period at 5½ percent interest would cost $4,184 per year. Annual maintenance costs were estimated by using a rate of 4 percent on a base of $0.50 per square foot of usable storage and office space.[9]

[9] The base figure was used by the U.S. General Services Administration in its 1967 estimate of the cost of maintaining all federally leased storage areas. The rate, believed to represent a realistic maintenance figure for frozen food storage areas only, was derived from data acquired from GSA and from the York Division of the Borg-Warner Corporation, which is conducting research in refrigeration systems.

Additional equipment needed in the new warehouse would include one battery-powered forklift truck at an estimated cost of $5,500 and 1,000 pallets at a cost of $3 each. The cost of this equipment would total $8,500 and would be depreciated over an 8-year period at a rate of $1,063 annually. Estimated annual insurance and taxes in the new warehouse would total $550. Table 13 gives a comparison of estimated annual warehousing costs in a new warehouse with costs in an existing facility.

TABLE 13.—*Annual warehousing cost in a 55,000-square-foot multistory warehouse and estimated cost in a new one-floor, 2,700-square-foot warehouse*

Expense item	Existing warehouse	New warehouse
	Dollars	*Dollars*
Facility cost [1]	------	4,184
Maintenance cost [2]	1,100	54
Equipment depreciation	------	1,063
Insurance and taxes [3]	1,012	550
Supervision	5,500	5,500
Labor	24,960	12,480
Total expense	32,572	23,831

[1] Clowes, Elliott, and Crow (*7, Appendix D*).
[2] See p. 25 for this computation.
[3] See appendix table 17 for these computations.

Most of wholesaler A's business was sales of less-than-case lots. It was estimated a new warehouse could be operated with half the labor force of six men required by his existing warehouse. Comparisons of his existing warehouse costs with the projected estimates indicated the wholesaler's saving in a new warehouse would total about $8,725 annually.[10]

The firm studied the possibility of reducing warehousing costs in the existing facilities by modernizing them. This study revealed that, with the present warehouse operation, 40 percent of the warehouse space was taken by produce. In addition, merchandise could not be stacked high because the warehouse used the salt-brine-solution cooling system, which required a maze of piping projected from the ceiling on each floor. This piping took 20 percent of warehouse cube. The brine system required 20 hours of labor weekly to defrost. The

[10] This saving would be considerably more if allowances were made for the value of the land and buildings at the end of the 20-year amortization period and for the market value of the old facilities, the proceeds of which would, if applied to the cost of the new facilities, reduce the annual amortization payments.

use of an ammonia cooling system would eliminate the need for this piping and the space gained would adequately store merchandise that currently was being selected from the second and third floors. With space gained by removal of the piping, an additional 12,000 cases could be placed in the warehouse and all order selections could be made on the first floor. Because clear stacking height on the second and third floors was only 8 feet and floor load limits were restricted, the use of materials-handling equipment for high stacking on these levels was not justified. The principal use these floors would be put to, therefore, would be to hold reserve quantities of merchandise. The merchandise would be stacked on pallets and moved to the floors with a handjack and the palletloads would be dropped as a unit to eliminate the handstacking operation.

The estimated cost of conversion to the ammonia system of refrigeration was $20,000 and the estimated cost of racks was $4,000. Total conversion cost was $39,000, and depreciation over a 12-year period totaled $3,250 annually. It was estimated that with the palletized system, a warehouse crew of four men would be required, compared to the six men required for the unconverted warehouse. Estimated costs of a new ammonia cooling system are compared with the costs of an older salt-brine system in table 14.

An estimated annual saving of $5,100 in warehousing costs would be possible with the installation of the ammonia refrigeration system (table 14) and $8,725 with construction of a one-floor warehouse (see table 13). Despite the lower annual saving, the wholesaler decided to install an ammonia refrigeration system in the existing warehouse for the following reasons: (1) Less capital investment would be required, thus more capital would be available to develop additional retail accounts; and (2) the existing warehouse was in very good condition and would require little additional maintenance cost in the near future.

The ammonia system was installed at a cost of $19,555 or $445 below the estimated cost, hence the initial annual saving with the ammonia system actually totaled more than $5,500. The company now is in the process of developing new frozen food accounts for added business volume and has discontinued its produce business.

TABLE 14.—*Estimated annual warehousing costs with salt-brine cooling system and with ammonia cooling system*

Expense item	Present salt-brine cooling system	Proposed ammonia cooling system
	Dollars	*Dollars*
Maintenance cost	1,100	1,100
Equipment depreciation	----------	3,250
Insurance and taxes [1]	1,012	1,012
Supervision	5,500	5,500
Labor	24,960	16,640
Total expense	32,572	27,502

[1] See appendix table 17 for these computations.

Case B

This wholesaler supplied institutional accounts and a voluntary group of supermarkets and smaller stores in its trading area. Products handled by this wholesaler included dry groceries, frozen food, dairy items, tobacco products, and health and beauty aids. Grocery warehousing space, including shipping and receiving docks, totaled approximately 48,000 square feet, frozen food space totaled 2,200 square feet, and office space totaled 2,500 square feet. Fruits and vegetables and meat were supplied to the firm's accounts by outside distributors. The warehouse, a one-floor structure, was built in 1953 of cinderblock, brick, and steel. Clear stacking height in the grocery warehouse was approximately 14 feet, but was only 8 feet in the area used for the freezer. The company owned the existing building, and total annual business volume, including frozen food, had grown to approximately $6½ million.

By operating with a comparatively large warehouse crew for the business volume handled, the firm was able to operate the warehouse despite many inefficiencies. The practices of continually bringing replenishment stock from reserve storage, of selecting merchandise from reserve storage, and of selecting merchandise without benefit of a warehouse numbering system; the limited aisles of varying widths that hampered use of laborsaving materials-handling equipment; and the frequent rehandling of merchandise made the warehouse operation inefficient from a labor-cost viewpoint.

The company's business volume had shown moderate growth in recent years, but directors of the firm believed considerable growth was possible with good management and hard work. In fact, during the study, negotiations were in progress to buy a locally based wholesale food competitor that had annual sales of approximately $6½ million. Management believed that the possibilities of expanding the warehouse to handle an increased volume were good because the firm had unoccupied land at the warehouse site. However, with a combined annual volume of $13 million, management questioned whether the addition to the building would permit adequate space for future business expansion, since the 8-foot freezer ceiling offered scarcely sufficient space to handle the combined annual frozen food volume of approximately $500,000. Management had to decide whether to remain at its present site and attempt to handle a potential total volume of $15 to $16 million, or to buy land to build a distribution center capable of handling the combined current business and provide for a potential expansion of $18 to $20 million.

Plans were obtained for constructing an addition of approximately 18,300 square feet that would have a clear stacking height of 21 feet. The addition was designed to handle the increased grocery volume. Estimated stock that could be placed in the expanded layout was approximately 175,000 cases with a dollar value of approximately $1 million. With 15 annual stock turnovers,[11] approximately $15 to $16 million in business volume, including frozen food, could be handled.

A major objection to expanding at the present site was that the frozen food facilities could be enlarged only by taking over the truck receiving dock. It was impossible to expand to the east, because the property line abutted on the public sidewalk and the grocery warehouse was on the south and west. However, with the taking over of the two-trailer truck receiving dock to the north, a maximum of 22 feet could be gained, doubling the freezer space to approximately 4,000 square feet. The ceiling height would remain at 8 feet (32,000 cubic feet) and there was no place for a surge area.

Advantages of remaining at the present location were: (1) building and property were owned debt free; and (2) a land expansion area 90 feet by 300 feet, or 27,000 square feet, was available. Disadvantages were: (1) only 14 feet of clear stacking height in the original grocery warehouse building; (2) only two truck spaces for receiving and five truck spaces for loading out; (3) inadequate holding area for receiving from both truck and railcar; and (4) inadequate frozen food space because of low ceiling height and lack of a surge area.

An alternative plan was developed. A 13-acre tract of land with good access to highway and rail lines was found that could be purchased for $35,000, and a new building, with a 21-foot clear ceiling throughout, was designed for this site. The firm planned to handle annually $13 million in dry groceries in 67,200 square feet of modern, one-floor warehouse, $2.5 million in fruits and vegetables in 13,000 square feet, and $1½ million in frozen food in 4,000 square feet (84,000 cubic feet).

[11] See footnote 6, p. 21, for definition of term "stock turnover."

Table 15 compares the approximate annual costs of the remodeled freezer in the older building and a new, modern one-floor frozen food warehouse large enough to allow for expansion and provided with the most efficient materials-handling equipment, good work methods, and optimum warehouse layout. Using 1967 cost estimates, it should be possible to build a new frozen food warehouse of 4,000 square feet at a cost of approximately $75,000. This assumption is made in table 15.

TABLE 15.—*Estimated annual costs (1967) of a remodeled warehouse for frozen food and a modern new structure when each contains 4,000 square feet of space* [1]

Annual expense item	Remodeled building	New building
	Dollars	*Dollars*
Facility cost [2]	2,510	6,276
Maintenance cost [3]	80	80
Equipment depreciation	65	1,266
Insurance and taxes [4]	346	824
Supervision	5,500	5,500
Labor [5]	29,120	16,640
Total	37,621	30,586

[1] Both warehouses are one-floor structures. The older, however, has 8-foot ceilings and only 32,000 cubic feet of space, whereas the newer has 21-foot ceilings and 84,000 cubic feet of space.
[2] (*7, appendix D*).
[3] See p. 25 for this computation.
[4] See appendix table 18 for this computation.
[5] Assuming an annual wage of $4,160 per employee.

Estimated cost of the frozen food part of the new building, including office space, railroad siding, and pallet racks, totaled $75,000. Amortizing a loan of $75,000 for a 20-year period at 5½ percent interest would cost about $6,276 annually. The annual maintenance cost was estimated in the manner described on page 25. Additional equipment needed in the new warehouse would include one forklift truck at an estimated cost of $5,500, 1,000 pallets at $3 each, and 25 four-wheel selector trucks at $65 each. The total cost of this equipment would be about $10,125 and would be depreciated over an 8-year period at the rate of $1,266 annually.[12] Estimated annual cost of insurance and taxes in the new warehouse would be approximately $824.

Estimated cost of the remodeled frozen food part of the old warehouse would total $30,000 based on a cost of $15 per square foot for 1,800 square feet, or $27,000, and $3,000 for racks. Amortizing $30,000 for 20 years at 5½ percent interest would cost about $2,510 annually. Equipment needed would include 10 four-wheel selector trucks at $65 each, or $650. With an 8-foot ceiling, all merchandise would be handstacked. Equipment cost would be depreciated over a 10-year period at a rate of $65 annually in accordance with established Federal guidelines. Estimated annual insurance and taxes cost would be approximately $346.

In the remodeled freezer the total annual labor requirement was estimated to be 14,560 man-hours (seven men) to handle inbound and outbound merchandise. Assuming an hourly wage rate of $2, annual labor in the frozen food warehouse amounted to $29,120. In the proposed new warehouse where more modern materials-handling equipment could be used, plans called for all merchandise being palletized; thus, the travel time of personnel would be faster and the total annual labor requirement would be only 8,320 man-hours (four men). At $2 per hour, the estimated annual warehouse labor cost would total $16,640.

In this case example, potential saving in operating costs of approximately $7,000 can be realized by building a modern structure instead of remodeling the older one. Additional advantages of a new frozen food warehouse would include: (1) Facilities for handling a potential of $1½ million annual volume, three times the current volume; (2) increased efficiency and control in warehousing and office procedures; (3) increasingly efficient labor as business increased (in the remodeled building, the 8-foot ceiling and subsequent necessity for handstacking all merchandise on racks would cause labor efficiency to decrease as business volume increased); (4) accomplishment of the receiving and shipping operations in the same work shift; (5) additional space for taking on new items of merchandise; and (6) additional prestige with customers and the general public.

Because of the potential savings offered by a new freezer facility and because management believed similar savings could be realized for the dry grocery, dairy, tobacco, and drug warehousing operations, the firm decided to build a completely new distribution center.

[12] This computation reflects the higher risk of obsolescence and normally accelerating maintenance cost of electric-powered forklift trucks mentioned in footnote 3, p. 4.

APPLICATION OF IMPROVED METHODS AND LAYOUT IN NINE FROZEN FOOD WAREHOUSES

An average reduction of 22 percent in the man-hours required for the frozen food operation was made with improved handling methods and layout in nine warehouses. Total savings ranged from 12 percent to 26 percent in individual firms. Table 16 presents a comparison of man-hours required weekly for former methods and for improved methods.

Labor requirements for the *receiving operation* were reduced over 18 percent, from 764 to 620 man-hours weekly, a saving of 144 man-hours. This saving was accomplished by using one man to palletize all items and by using warehouse space to best advantage. Some maintenance and cleaning labor is included in receiving time because the crews were used for this work during slack receiving periods.

Forklift truck time was reduced over 31 percent with improved methods. This saving was accomplished mainly by having the forklift truck operator in the general receiving dock place the receipts directly in the freezer and by transporting full palletloads on each trip between the receiving dock and the frozen food warehouse. Full palletload transport at slot-replenishment time also helped reduce forklift truck time.

Order selection required 20.5 percent less time using improved methods; man-hours were reduced from 1,671 to 1,329. Most important in reducing order-selection time were (1) slotting and numbering warehouse location to coincide with merchandise listing on the invoice, and (2) improving job scheduling. Order-selector productivity was influenced by the type of order-assembly system and the size of the order. Productivity averaged 101 cases per man-hour when individual orders were assembled on a four-wheel handtruck, and 140 cases per man-hour when individual orders were assembled with the use of a battery-powered pallet jack and two pallets. When the order selector used a four-wheel handtruck in selecting an individual order, productivity averaged 56 cases per man-hour for orders of one to five cases and 181 cases per man-hour

TABLE 16.—*Man-hours required weekly in nine frozen food warehouses with former methods and with improved handling methods*

Handling methods	Firm A	Firm B	Firm C	Firm D	Firm E	Firm F	Firm G	Firm H	Firm I	Total of all firms
Former methods	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
Receiving [1]	18	22	80	84	42	120	40	318	40	764
Forklift truck	(2)	10	36	(3)	34	80	80	159	(2)	399
Order selection [4]	25	27	98	156	187	240	240	508	190	1,671
Checking	(5)	(5)	(5)	20	(5)	(5)	(5)	(5)	50	70
Loading	17	23	80	80	89	120	40	191	40	680
Total	60	82	294	340	352	560	400	1,176	320	3,584
Improved methods										
Receiving [1]	11	19	52	80	37	105	40	236	40	620
Forklift truck	(2)	9	20	(3)	27	60	40	118	(2)	274
Order selection [4]	25	23	98	146	144	190	200	376	127	1,329
Checking	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	33	33
Loading	16	20	74	72	70	[6] 80	40	142	40	554
Total	52	71	244	298	278	435	320	872	240	2,810
Savings										
Man-hours	8	11	50	42	74	125	80	304	80	774
Percent	13.3	13.4	17.0	12.4	21.0	22.3	20.0	25.9	25.0	21.6

[1] Some maintenance and cleaning time is included.
[2] A forklift truck was not used.
[3] Receivers operated the forklift truck.
[4] Includes the less-than-full-case selection operation.
[5] Checking was combined with loading.
[6] Based on one-man loading of two trailers.

for orders of 76 or more cases. When the order selector used a battery-powered pallet jack and two pallets in selecting an individual order, productivity averaged 42 cases per man-hour for orders of one to five cases and 251 cases per man-hour for orders of 76 or more cases. Orders were grouped into six sizes for the study. Part of the order-selection saving was accomplished by using a master container for assembling and packing less-than-full-case orders.

Checking was usually combined with loading in most of the warehouses, although five firms did not check orders. For those who continued to check, man-hours were reduced over 52 percent by using one man to check orders arranged on four-wheel handtrucks. To arrange orders on a four-wheel handtruck, order selectors placed the first half of the invoice items on one side of the handtruck and the remaining half on the other side, thus eliminating the need for the checker to search for each item on both sides.

Loading time was reduced 18.5 percent, from 680 to 554 man-hours weekly. This saving of 126 man-hours was accomplished almost entirely by converting to one-man loading instead of loading with two-man teams.

FUTURE DEVELOPMENTS IN FROZEN FOOD WAREHOUSING

Present handling systems in receiving, selecting, and loading frozen food foretell of methods that will be more automated and mechanized. The systems described below tended in those directions. However, the systems' operating procedures were generally not sufficiently advanced, or did not apply adequately enough to all operations in the frozen food warehouse at the time of this study, to warrant inclusion.

AUTOMATED PRACTICES

The order-selection process was accomplished in one firm through an electromagnetic arrangement with an automatic accounting machine. Switches at the end of an inclined metal slide were activated by the accounting machine and the cases dropped onto a conveyor belt. This system appeared to work satisfactorily although it was necessary to place cases manually in the slide for mechanical order selection.

A refinement in the food-handling field is use of the computer to integrate customer order processing with merchandise selection in the warehouse. One firm placed retailers' frozen food orders in the memory drum of a computer for automatic retrieval and transmission to the order-selection area. In the selection area, conventional warehouse labor read an electronically controlled "invoice" board for directions in selecting frozen food cases. The cases were placed directly on a conveyor which transported them to a surge conveyor at the loading dock.

Another atypical system was observed to be in use for order assembly and loading. Order selectors used a two-level powered-belt conveyor hooked into a computer control center on the mezzanine over the loading dock. The computer was coded to a four-color sensing system: red, blue, green, and yellow. A colored box placed on the conveyor line before each order routed the cases on the order over the conveyor lines to the proper loading door at the truck dock. The computer continued to route all cases on the conveyor belt to the same color-coded loading door until the order was fully selected and a box of a different color was placed on the belt to redirect the routing for a new order.

MECHANIZATION

Manufacturing and processing firms have proved that the suction lifter can provide quasi-automatic (1) removal of merchandise from pallets, layer by layer; (2) unscrambling layers of merchandise and sorting of similar items into commodity groups for storing; (3) selection of stored products for filling customer orders; and (4) placement of outgoing merchandise on pallets in complete unit shipments. Suction-lift handling, however, can be applied economically to only a limited number of high-sales-velocity items that can be stored in floor slots in frozen food warehouses. It is not practical to store mixed palletloads of slow movers with this equipment.

Another example of materials-handling innovation is found in the system known as "stacker-crane storage," which again is human-mechanical. This system uses a high-rise rack storage (25 to 50 feet high), and an automatically controlled stacker and retrieval unit.

One firm used mechanization to reduce to a minimum time spent by the order selectors in traveling from one selection front (rack) to another. The firm's storage slots faced on a 300-foot powered conveyor. Each order selector was assigned to specific racks and moved only between his racks and the conveyor that received his selections. Items of merchandise were arranged on the racks in the same order that they appeared on the invoices. When a selector finished with one invoice, he did not lose time by returning to the first item listed on his next invoice, but worked his way back in reverse order by selecting from the end to the beginning of the new invoice.

This firm used two-level, custom-built racks that were fed from the rear by a roller conveyor that supplied new stock on pallets fitted with flat bottoms. The pallets moved down a slight incline and into the racks by gravity when the racks were so nearly empty that back cases could be pushed forward by the weight of the incoming stock. The 22-foot-high warehouse ceiling had space for a mezzanine selection area duplicating the selection area beneath it. This freezer stocked over 700 items; pallet size was 40 inches by 32 inches.

Speed of the powered conveyor belt at the selection area was 250 feet per minute. A photoelectric color-sensing system merged the selections from two levels of conveyor to one conveyor and carried the merchandise to the loading dock. When the merchandise reached the loading dock on the conveyor, the belt speed had been slowed to 40 feet per minute. Between the selection and the loading areas, the speed of the conveyor was lowered to 130 feet per minute by a series of U-turns, accumulator areas, and gravity-activated skate-wheel conveyors. As one safety measure, a raised roller was positioned in the conveyor at regular intervals. When this roller was pressured—for example, by excessive weight due to pileup of cases—the conveyor power was cut off and movement of merchandise was stopped until the cause of the pileup was corrected. The console operator in the computer center could stop the operation at once by shifting the control color.

Obviously, modifications of the semiautomatic systems are needed so that order selection can be performed on a case basis and the receiving operation can be wholly mechanized, with incoming merchandise handled entirely in palletload and pallet-layer unit quantities. Automation as well as increased mechanization of materials-handling procedures will undoubtedly greatly reduce the human element in warehousing processes. For example, products will be selected and transported in the order-assembly area with less labor but certainly not without human assistance. With less labor, chances of fluctuating labor productivity and human error will be reduced. When a computer is used in the operation, similar items (commodity groups) will not have to be stored together, since finding and selecting cases of frozen food will not be performed entirely by human labor. Warehouse space utilization will be more fully attained because a whole rack or slot will not have to be allocated to an item that is in little demand.

On the negative side of automation and improved mechanization of equipment is expense and slowness of conversion to the new concepts. Nor will conventional difficulties cease to occur in the −10 degree F. climate of the freezer, such as problems with maintenance of mechanical switches and hydraulic seals on forklift trucks, with oiling procedures on conveyor equipment, with housekeeping practices—such as cleaning the floor—and with such practical details as how to make paint adhere to freezer interior surfaces.

Ideally, concepts for improved handling of frozen food in the future will be flexible enough to adapt themselves to *all* freezer warehousing operations and conditions, so that receiving, storing, order selecting, and loading-out can be accomplished at peak efficiency in the −10 degree temperature. A mixture of old and new systems and equipment will have definite limitations, however, because of difficulties in coordinating the new with the old and problems in reeducating operations personnel. Perhaps a totally new concept or system may overcome these limitations. All concerned with improved frozen food warehouse operating practice must consider the impact of change on the *total* frozen food handling picture; that is, the impact from manufacturer to retailer to consumer. Otherwise, there will be danger of overmechanization or refinement of one part of the system to the detriment of other parts.

LITERATURE CITED

(1) Allegri, T. H., and Bogardus, R. K.
1959. Mechanically processing wholesale frozen food orders. U.S. Dept. Agr. AMS–317, 20 pp., illus.

(2) ——— and Herrick, J. F., Jr.
1957. Materials handling in public refrigerated warehouses. U.S. Dept. Agr. Mktg. Res. Rpt. 145, 120 pp., illus.

(3) Bartz, D. J., Catel, J. M., and Bouma, J. C.
1967. Use of adhesive labels for price-marking cases at the grocery warehouse. U.S. Agr. Res. Serv. ARS 52–23, 19 pp., illus.

(4) Bouma, J. C., and Kriesberg, M.
1960. Measures of operating efficiency in wholesale food warehouses. U.S. Dept. Agr. Mktg. Res. Rpt. 399, 32 pp., illus.

(5) ——— and Lundquist, A. L.
1956. Methods of increasing labor productivity in multistory and small one-story grocery warehouses. U.S. Dept. Agr. Mktg. Res. Rpt. 142, 42 pp., illus.

(6) ——— and Lundquist, A. L.
1959. Grocery warehouse layout and equipment for maximum productivity. U.S. Dept. Agr. Mktg. Res. Rpt. 348, 58 pp., illus.

(7) Clowes, H. G., Elliott, W. H., and Crow, W. C.
1957. Wholesale food market facilities: types of ownership and methods of financing. U.S. Dept. Agr. Mktg. Res. Rpt. 160, 96 pp., illus.

(8) Mixon, J. A., and Allegri, T. H.
1955. Some improved methods of handling frozen food in wholesale plants. U.S. Dept. Agr. Mktg. Res. Rpt. 107, 44 pp., illus.

(9) ——— and Larson, J. S.
1952. Planning a wholesale frozen food distribution plant. U.S. Dept. Agr. Mktg. Res. Rpt. 18, 61 pp., illus.

(10) Shaffer, P., Bouma, J. C., Karitas, J. J., and Flynn, G.
1966. Handling groceries from warehouse to retail store shelves. U.S. Dept. Agr. Mktg. Res. Rpt. 473, 47 pp., illus.

(11) U.S. Bureau of the Census.
1961. U.S. census of business: 1958, vol. III, wholesale trade—summary statistics and public warehousing. Washington, D.C.

(12) ———
1966. U.S. census of business: 1963, vol. IV, wholesale trade—summary statistics, part 2, and public warehousing. Washington, D.C.

(13) U.S. Department of Commerce.
1965. Business statistics: a supplement to the survey of current business. (1965 Biennial Edition). 262 pp., Washington, D.C.

(14) U.S. Federal Power Commission.
1967. Typical electric bills, 1966. FPC R–68, 127 pp.

(15) U.S. Internal Revenue Service.
1964. Depreciation guidelines and rules. IRS Revenue Procedure 62–21, 92 pp.

APPENDIX A

RESEARCH METHODS AND TECHNIQUES

A study of a cooperator's frozen food warehouse required a minimum of 2 man-weeks. The first step in conducting a study in a firm is orienting the firm's warehouse personnel to the reasons for, and objectives of, the study. The techniques to be used during the research are explained to the workers. These techniques include stopwatch timing of workers as they perform their assigned jobs, critical observation of warehousing methods, and questioning of personnel about details of their work. The result of stopwatch timing is the setting of a time standard for each job in the warehouse. Standard time is equal to the base time plus allowances for fatigue and personal needs. The fatigue allowance is included in the production rates established by time study to provide time for the worker to rest from fatigue resulting from sustained physical effort. The percentage rate used for the allowance is directly related to physical difficulty and the working conditions associated with an assigned job. A personal allowance of 5 percent is added to the fatigue allowance to provide the total allowance figure. This personal allowance is generally accepted as adequate for worker comfort because it provides 24 minutes in an 8-hour work shift.

A 30-percent personal and fatigue allowance is used in this study for work inside the freezer and a 15-percent personal and fatigue allowance for work outside the freezer. A 30-percent allowance is used because of the extreme and uncomfortable working conditions inside the freezer and because the allowance provides sufficient time for the frozen food warehouse employee(s) to "suit up" with clothing insulated against cold. Suiting up, or unsuiting, occurs four times per work shift—at the beginning and end of the shift, and at the start and end of the lunch break.

Base time was calculated in cases handled per man-hour. Workers were rated by time-study observers on a scale established for normal performance efficiency. In rating, compensation was made for decreased efficiency caused by the extremity of the working conditions. During the time studies, efficiency of the workers was observed to drop below normal after 15 to 30 minutes in the −10° F. temperature. The effect of the low temperature on the worker (and hence on his output) was apparent in many ways, including fumbling of case selections, slow handling of order (invoice) and pencil (with gloved hands) while checking items selected, stiffness of movement, and distracting nasal drip.

Discussions are also held with management and supervisory personnel about factors related to storing and assembling merchandise and loading delivery trucks, such as delivery schedules, order sizes, buying methods, and order-taking routines. Pictures are taken of warehouse operations while a study is in progress to (1) obtain visual evidence of problem areas to be used in talks with warehouse management; and (2) enable researchers to prepare a more valuable report of findings.

Research personnel, as a second step, inform warehousemen of the desirability of performing their tasks in a normal manner during the study period. Workers are reminded that a research objective is to make warehouse jobs easier. The third step encourages employees to make suggestions and criticisms about warehouse methods.

Researchers present an oral report of findings to management before leaving a firm. Then, when analyses of data are completed at the home office, they forward a written case study with recommendations for improving the operation. Later, when researchers are in the area for other studies or other reasons, the firm is revisited by research personnel to learn whether the recommendations and suggestions have been accepted or rejected. Another means of follow-up is general discussions with cooperators and members of the trade at industrial conventions and other meetings.

APPENDIX B

SUPPORTING STATISTICAL DATA FOR CASE HISTORIES A AND B

TABLE 17.—*Assumed tax and insurance costs for old and new warehouse buildings—Case A*

Cost item	Old building [1]	New building [2]
	Dollars	*Dollars*
Tax [3]	600.00	500.00
Insurance:		
Liability [4]	358.05	17.58
Property damage [5]	16.50	.81
Fire [6]	33.00	27.50
Extended coverage [7]	4.80	4.00
Total insurance	412.35	49.89
Total	1,012.35	549.89

[1] Value: $30,000. Floorspace: 55,000 sq. ft.
[2] Value: $25,000. Floorspace: 2,700 sq. ft.
[3] Rate: $20 per $1,000 of value.
[4] Rate: $0.651 per 100 sq. ft. Indemnity: $300,000 per person/$300,000 per accident.
[5] Rate: $0.030 per 100 sq. ft. Indemnity: $5,000 minimum.
[6] Rate: $0.110 per $100 of value.
[7] Rate: $0.016 per $100 of value.

TABLE 18.—*Assumed tax and insurance costs for remodeled and for new freezer areas in a warehouse complex—Case B*

Cost item	Remodeled building [1]	New building [2]
	Dollars	*Dollars*
Tax [3]	300.00	750.00
Insurance:		
Liability [4]	26.04	26.04
Property damage [5]	1.20	1.20
Fire [6]	16.50	41.25
Extended coverage [7]	2.40	6.00
Total insurance	46.14	74.49
Total	346.14	824.49

[1] Value: $15,000. Floorspace: 40,000 sq. ft.
[2] Value: $37,500. Floorspace: 40,000 sq. ft.
[3] Rate: $20 per $1,000 of value. Based on an assumed apportioned tax rate of $15 per square foot for 4,000 sq. ft. freezer and at 50 percent of appraised value.
[4] Rate: $0.651 per 100 sq. ft. Indemnity: $300,000 per person/$300,000 per accident.
[5] Rate: $0.030 per 100 sq. ft. Indemnity: $5,000 minimum.
[6] Rate: $0.110 per $100 of value.
[7] Rate: $0.016 per $100 of value.

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