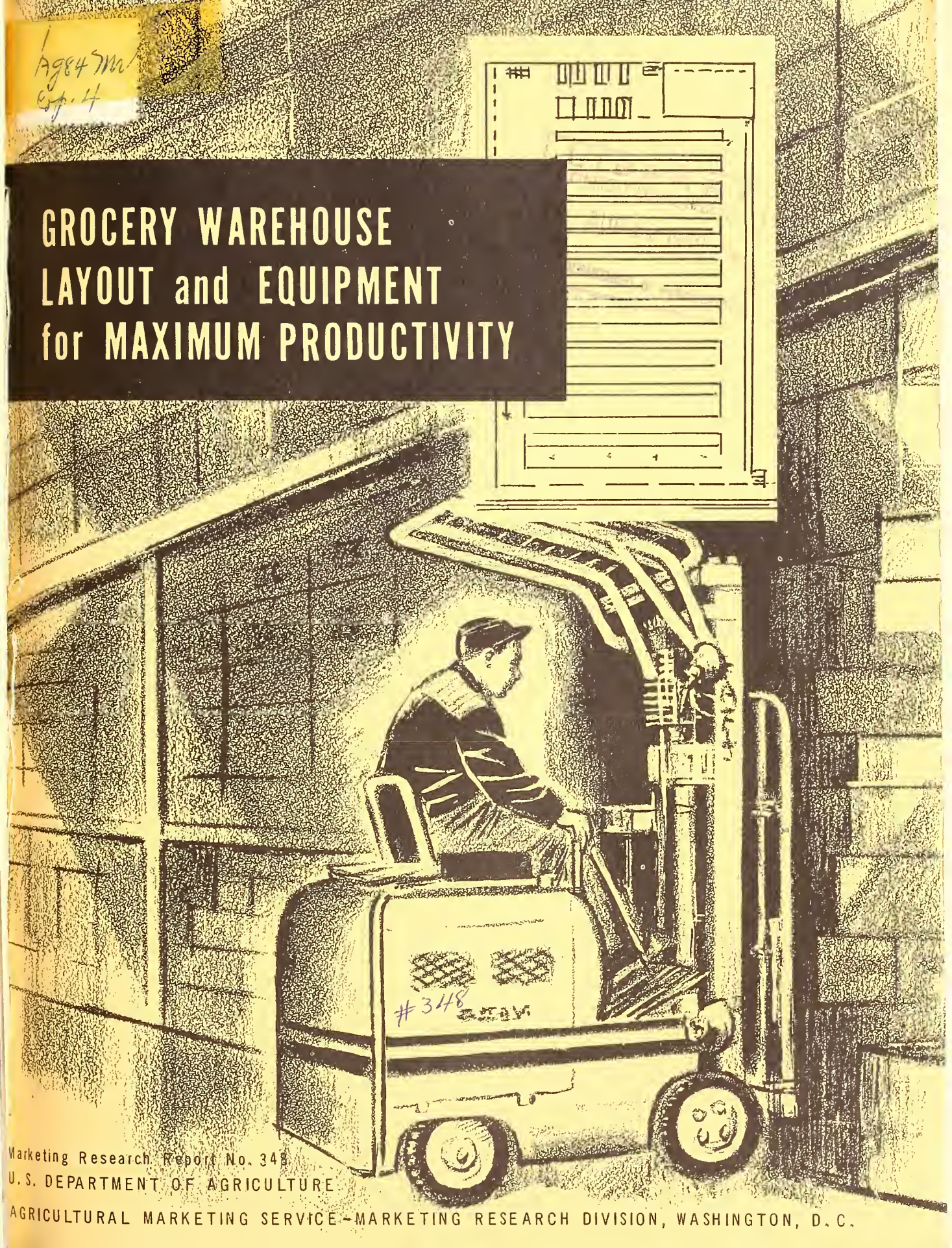
GROCERY WAREHOUSE LAYOUT and EQUIPMENT for MAXIMUM PRODUCTIVITY



Marketing Research Report No. 348
U. S. DEPARTMENT OF AGRICULTURE
AGRICULTURAL MARKETING SERVICE—MARKETING RESEARCH DIVISION, WASHINGTON, D. C.

PREFACE

This is one of a group of reports of research looking to greater efficiency of handling groceries in warehouses. Previous reports were, "Methods of Increasing Productivity in Modern Grocery Warehouses," Marketing Research Report 94; and "Methods of Increasing Labor Productivity in Multistory and Small One-Floor Grocery Warehouses," Marketing Research Report 142. During the previous research, improved work methods were developed; however, in many instances use of improved work methods was limited by the warehouse facility, layout, and equipment.

Many food distributors look to the warehouse as a place to reduce their operating costs. For this reason and because many wholesale food distributors are planning to build new warehouses, remodel older warehouses, and purchase new materials-handling equipment, this research and evaluation of alternative warehouse layouts and equipment was undertaken.

The study on which this report is based is part of a broad program of research aimed at expanding market outlets for food and reducing the cost of marketing farm and food products, through various stages of the marketing system. Because of the competitive nature of the food business, savings accomplished at the warehousing level will either be reflected in lower consumer prices, increased producer returns, or both.

ACKNOWLEDGMENTS

Special credit is due the following companies that made their warehouses available for detailed study: Associated Grocers of New Hampshire, Manchester, N. H.; Giant Food Stores, Inc., Washington, D. C.; Laurans Brothers Co., New Bedford, Mass.; William Montgomery Co., Philadelphia, Pa.; Penn Fruit Co., Philadelphia, Pa.; Roundy's Inc., Milwaukee, Wis.; Super Valu Stores, Inc., Minneapolis, Minn.; and Washington Wholesale Grocery Co., Inc., Washington, D. C. In addition, a number of other chain store and independent grocery warehouse operators were helpful in providing warehouse plans, and furnishing records and facilities for less intensive study.

The work was conducted under the general supervision of R. W. Hoecker, head, Wholesaling and Retailing Section, Transportation and Facilities Branch, Marketing Research Division, Agricultural Marketing Service.

July 1959

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GROCERY WAREHOUSE LAYOUT AND EQUIPMENT FOR MAXIMUM PRODUCTIVITY

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SUMMARY

A grocery warehouse should be designed to obtain the lowest operating costs with due consideration given to construction costs. Square buildings are less costly to construct than rectangular buildings because less wall is necessary. Odd building shapes for grocery warehouses should be avoided because they are hard to organize for efficient use of labor and materials-handling equipment. The grocery warehouse should be planned so it can be expanded when business volume increases.

Bay size should be designed to fit a given number of pallets. A bay size of 40 x 40 feet was found desirable for a pallet size of 32-inch face and 40-inch depth, because with the square dimension it would be possible to change direction of warehouse aisles without the problem of support column spacing. A warehouse aisle either 6½ or 10 feet wide can be used with this spacing.

Modern grocery warehouses should be designed with a minimum of 20 feet of clear stacking height. The receiving dock at the rail siding should be 45 inches over the top of the rail and from 45 to 51 inches above the back-up ramp at the truck dock, depending on motortruck-bed height. The docks should be enclosed in the warehouse, with motortrucks and rail cars located either inside or outside the warehouse, depending on the climate.

The office can be located at low cost over the shipping dock and truck well, over the motortruck receiving dock and packing room, or over the garage. The repack room should be located between the motortruck receiving dock and the shipping dock. Since most repack items are received by truck, this location would keep travel distance to a minimum. Lighting levels of around 25- to 35-foot candles should be provided in warehouse aisles and docks.

Wooden pallets are used in grocery warehouses to provide a platform for stacking merchandise, as well as a base for handling merchandise with forklift trucks and pallet jacks. The straddle-type forklift truck was found better suited in a 6½-foot aisle warehouse while the counterbalanced forklift truck was more efficient in the 10-foot aisle warehouse.

To economically use order selector tow tractors, the warehouse must be more than 50,000 square feet in size. With use of radio-controlled order

selectors, order filler production was 13 percent greater (159 cases compared with 141 cases per man-hour) than use of tractors without radio control. Use of a perimeter towline was less costly than towing orders to the shipping dock with tractors, in warehouses having a business volume in excess of $20 million annually or larger than 125,000 square feet.

Merchandise normally received by rail car should be stored on the side of the warehouse closest to the rail dock. Motortruck docks should be located near pallet racks and the repack room because items received by truck are normally stored in these areas. The docks should have sufficient depth to provide a temporary block or storage area for accumulating merchandise to eliminate the dependence of the palletizing crew on storing operations, and to separate order assembly, checking, and loading. Merchandise should be placed in the grocery warehouse in accordance with quantities received and sales velocity rather than in commodity groupings. Fast moving merchandise should be placed near the shipping dock if order fillers push selector trucks on the selection line.

It is advantageous to use a fixed slot system of merchandise placement, because of the greater efficiency in receiving merchandise, fewer errors in billing and assembly of orders, and better utilization of warehouse cubic space when compared with the floating slot system.

With use of mechanical tow tractors and large retail orders, a long selection line should be used. In warehouses of comparable size, business volume, and with orders larger than 700 cases in size, order selection and equipment cost averaged 0.93 cent per case with use of a long selection line and tow tractors compared with 1.08 cents per case with a short selection line and pushing handtrucks manually. The short selection line was more efficient for the assembly of small orders in warehouses of more than 100,000 square feet size.

Labor costs are of greater importance than cost of land and building.

It is advantageous to use a 10-foot aisle in grocery warehouses having a business volume in excess of $6 million annually. At an annual volume of $6 million, savings with use of a 6½-foot aisle would total more than $2,700 annually if the warehouse were operated during one shift; at an annual business volume of $20 million, savings using a 10-foot aisle would total nearly $13,000 annually; and with a business volume of $35 million, savings using a 10-foot aisle would total more than $28,000 annually.

The use of a master container for assembly and shipping of a 60-unit order of repack room merchandise results in a production of 163 units per man-hour, compared with 113 units per man-hour for assembly of the merchandise and packing it in cardboard boxes. With use of an assembly rack for assembly and packing of 60-carton quantities of 12 brands of cigarettes, the time required was reduced two-thirds from 6.80 to 2.25 minutes.

Merchandise flow and warehouse layout require constant review to meet changing business volumes, items handled, and to avoid delays in handling. The flow of merchandise must be considered in receiving, order assembly, checking and loading of delivery trucks.

Warehouse layouts are presented for small, medium, and large size grocery distributors. The layouts are based on inventories of approximately 3,000 grocery items, use of automatic tabulating equipment in the office, and an annual inventory turnover of 16 to 18. In the layouts, support columns are spaced at 40 feet from center to center. Canopies are shown over the edge of the ramp at the motortruck shipping and receiving docks. The motortruck ramps and rail car siding should be enclosed in the warehouse where climatic conditions are severe. Expansion areas are shown with the warehouse layouts for the addition of perishables departments and additional grocery area.

INTRODUCTION

Efficient warehousing is important in moving food and other grocery store items from producers and processors to the retail store and consumers at the lowest possible cost. It involves unloading and receiving rail car and motortruck lots of merchandise, moving them into the warehouse storage locations, the assembly of items in quantities ordered by retailers, and the loading of delivery trucks. Approximately, 4,000 items are stocked in the typical grocery warehouse, and it is necessary that each of these items be available for the assembly of retailer orders.

The continued rise in labor costs has resulted in many food distributors looking to the warehouse as a place to reduce their operating costs. For this reason, and because many food distributors are planning to build new warehouses, remodel older warehouses, and purchase new materials-handling equipment, this research and evaluation of alternative warehouse layouts and equipment was undertaken.

Previous research reports describe how improved work methods, balanced work crews, and better utilization of equipment would increase labor productivity in modern one-floor, multistory, and small one-floor grocery warehouses. 1/ It is often necessary to design and construct a new warehouse to make full use of the best labor-saving equipment, methods, and flow.

The primary objectives of this study were: (1) To determine the most advantageous place to locate the receiving and shipping docks, repack room, offices, and support columns; (2) to evaluate the basic systems of order selection line length, aisle width, fixed and floating slots, and to describe the procedure for laying out and placing merchandise in the warehouse; (3) to describe and evaluate the materials-handling equipment used in modern grocery warehouses; and (4) to present warehouse layouts for a small, medium, and large size grocery distributor to illustrate research findings.

Detailed studies were made in modern one-floor grocery warehouses ranging from 60,000 to 175,000 square feet in size, having from $6 million to $35 million annual sales volume. In some of these firms a towline was used to move

1/ Bouma, J. C. "Methods of Increasing Productivity in Modern Grocery Warehouses," U. S. Dept. Agr. Mktg. Res. Rpt. 94, 30 pp., June 1955. Bouma, J. C. and Lundquist, A. L. "Methods of Increasing Labor Productivity in Multistory and Small One-Floor Grocery Warehouses" U. S. Dept. Agr. Mktg. Res. Rpt. 142, 42 pp., November 1946.

assembled orders to the shipping dock, in other firms order fillers pushed assembled orders manually on 4-wheel trucks or used tow-tractors to pull trains of 4-wheel warehouse trucks to the shipping dock. In addition to the detailed studies conducted in modern one-floor grocery warehouses, many comments in this report are based on general observations made of warehousing operations in numerous grocery warehouses located in various sections of the country.

Comparisons of different equipment and layouts in this report are based on practices accepted and used by the trade. All comparisons of labor costs are based on an assumed uniform wage rate of $2.01 per hour 2/ for warehousemen and an annual salary of $7,000 for warehouse superintendents.

WAREHOUSE DESIGN

The design of a grocery warehouse includes the shape of the building, support column spacing, ceiling heights, location and height of receiving and shipping docks, location of the office and repack room, and adequate lighting. A food distributor planning to build, remodel, or change his grocery warehousing operation will obtain greater warehousing efficiency through extensive planning of all details. Some food distributors have found it beneficial to tour new warehouses and to discuss operating problems with the management of the firms visited to obtain suggestions for planning. If all of the plans are made for the building, merchandise placement, and equipment ahead of actual construction, many operational problems in the new warehouse can be avoided.

Shape of Building

A new warehouse should be designed on the basis of using good materials-handling principles and so it can be expanded without interfering with the use of these principles or changing the basic building shape. Square buildings are less costly to construct than rectangular buildings covering the same area because the perimeter is shorter and therefore less wall is necessary for a given square footage and cubic area.

Odd building shapes such as the "U" and the "L" should be avoided for grocery warehouses. These buildings are hard to organize for efficient use of labor and materials-handling equipment. A building site that is too narrow should be avoided because the building can only be expanded in one direction. This would increase the ratio of length to width, and thus increase operating costs.

Examples of an "L"- and "U"-shaped, and a long narrow warehouse are given to show how these shapes result in increased materials-handling cost. Figure 1 illustrates an L-shaped grocery warehouse. With the shipping dock on

2/ Weighted composite earnings in food processing, wholesale trade, and retail food stores, calculated from data of Department of Labor. "Average Hourly Earnings of Food Marketing Employees," The Marketing and Transportation Situation, MTS-132, USDA, January 1959.

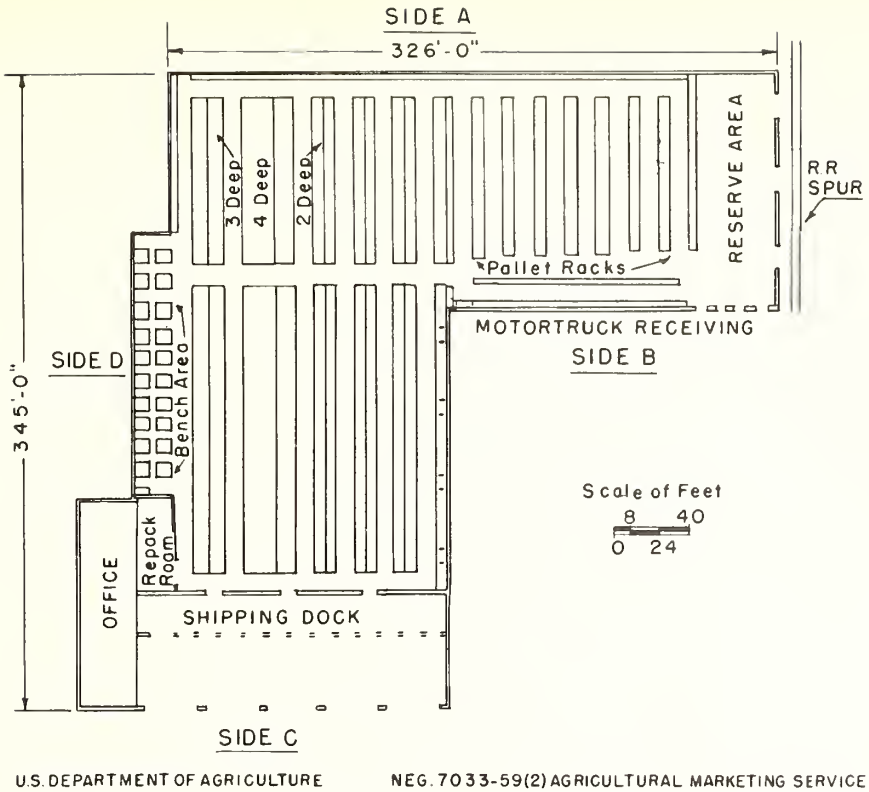

Figure 1.--An L-shaped warehouse.

building side "C", a long travel distance is required with merchandise selected from pallet racks on side "B" near the rail receiving dock. Also, with this layout a long travel distance is required to move merchandise received by rail car to the two or three deep slots where such merchandise is normally stored.

Figure 2 shows a U-shaped warehouse building with truck receiving and shipping docks located in the open end of the "U". The grocery selection area is 65 by 208 feet, and it is necessary to move repacked items and frozen food a considerable distance for composite loading.

The original measurements of the long narrow warehouse shown in figure 3 were 300 by 60 feet or a ratio of 5 to 1. Six additions have been made to the original warehouse and present dimensions are 740 by 60 feet. A total of 29 warehousemen working two shifts handle the merchandise into and out of the warehouse on conveyor lines. The annual grocery business volume totals $10 million, but warehousing cost has become almost prohibitive. With use of a single conveyor line system it was nearly impossible to move all of the merchandise into and out of the warehouse within a 24-hour period on heavy volume days. The firm had reached the saturation point for its single conveyor line and the building was of little value for future needs of the company. It was not properly planned for expansion or for use with other materials-handling equipment.

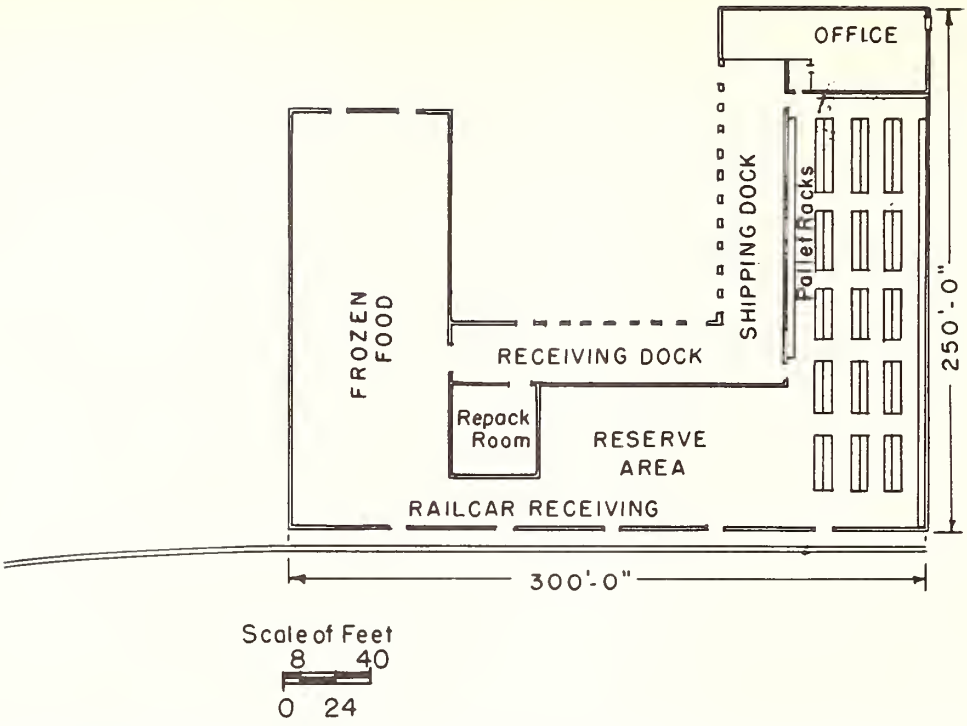

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Figure 2.--A U-shaped warehouse.

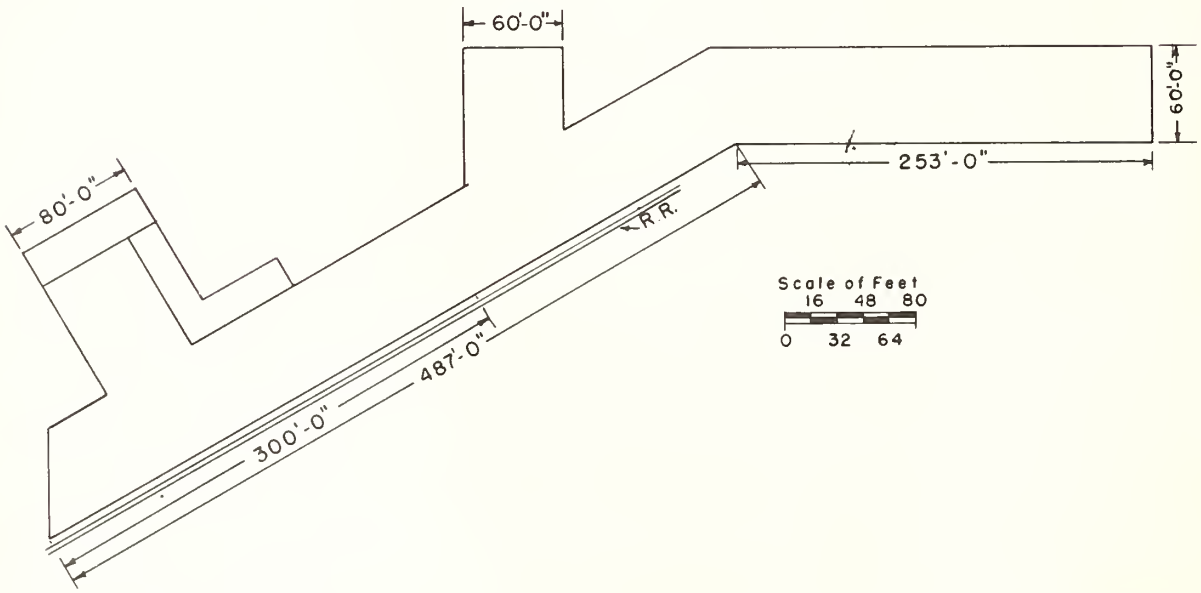

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Figure 3.--A long-narrow grocery warehouse.

With the present building shape and the low ceiling height it would not be practical to use this warehouse with any materials-handling equipment other than conveyor lines. If the company had properly planned facility requirements several years ago, the initial construction and the numerous additions to the warehouse could have been made to contribute to the warehousing needs of the company when other materials-handling equipment is needed.

Support Column Spacing

Warehouse support column spacing is influenced by the following factors: Minimizing interference in aisles and storage areas; construction costs; pallet size; the direction of warehouse aisles and storage areas; and aisle width.

The support columns should be spaced so as to interfere as little as possible with the storing of merchandise or use of aisles. While many warehouse operators would prefer to have no support columns in the warehouse, construction costs without support columns are too expensive for food distribution enterprises. Figure 4 shows a warehouse layout with support columns spaced 40 by 40 feet. With the standard pallet size of 32-inch face (side of pallet boarding the aisle) and 40-inch depth, the column spacing parallel to the aisles would be some multiple of 3 feet, plus 1 foot. Assuming 13 pallet spacings are desired between support columns, a space of 40 feet would be provided (table 1). A larger or smaller number of pallet facings (the number of pallets bordering the aisle) can be provided between the support columns by adding to or subtracting from the space between columns, 3 feet for each pallet facing.

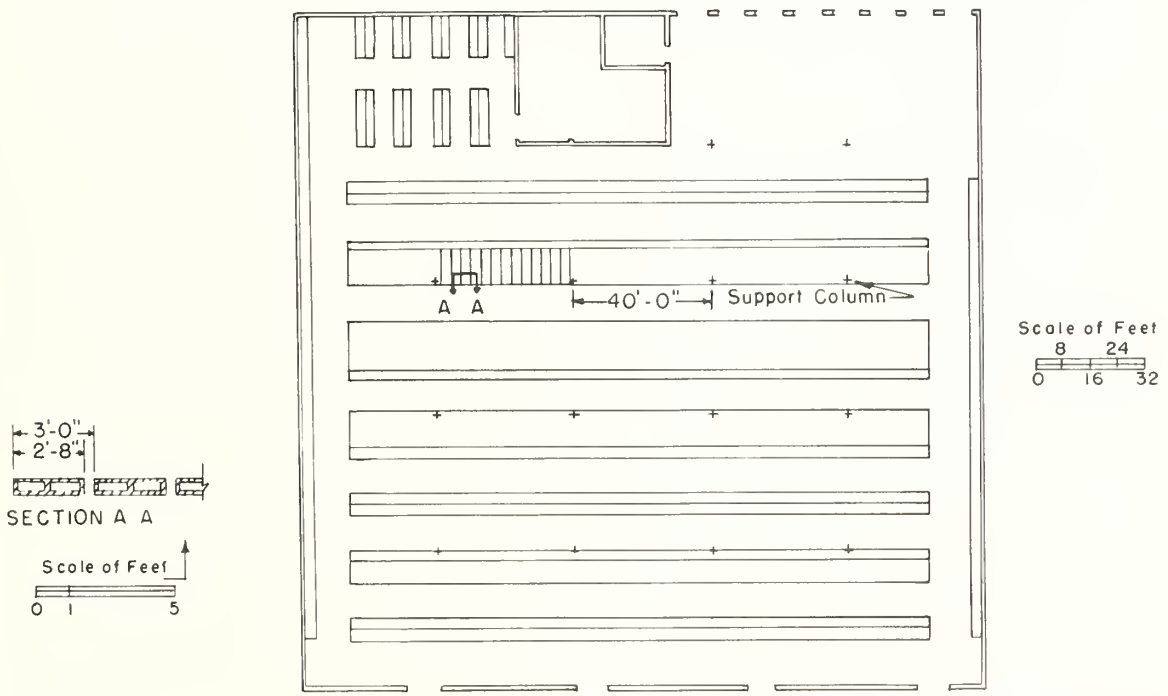

Figure 4.--A warehouse layout with support columns spaced 40 by 40 feet.

Table 1.--A method for computing support column spacing parallel with the aisle with a pallet size of 32 by 40 inches

Item	Allowance	Total
	Inches	Inches
13 pallets	32	416
14 clearances	4	56
1 column	8	8
Total inches		1/ 480

1/ Add or subtract any multiple of 36 inches until the desired dimension is reached.

Pallet sizes other than 32-inch facing and 40-inch depth would require a different dimension than shown in table 1 for spacing column supports. It is advantageous to have support columns in a square pattern so the direction of aisles in the warehouse can be changed without encountering problems of support column spacing. Column spacing perpendicular to the aisle could thus be 40 feet. 3/ With existing forklift trucks two basic aisle widths, either 78 or 120 inches, can be used in the warehouse and either width can be used with a bay size 40 by 40 feet.

In planning support column spacing it would be necessary to review the problem with an architect to determine the relative cost of different support column spacings.

Ceiling Height in the Warehouse

The optimum stacking height for groceries and, thus, the warehouse ceiling height, is limited by two factors: The height that merchandise may be piled before its weight will cause damage to the bottom layers, and the limit to which materials-handling equipment can be used effectively. Most items in the grocery warehouse can be stacked to a height of 20 feet without excessive merchandise damage. The proper materials-handling equipment can effectively stack merchandise to this height.

The grocery warehouse should have 20 feet of clear stacking height with all structural members above that level. Cross bracing at the bottom chord of a roof truss is an illustration of an item that should be above the 20-foot level. If the ceiling height is 20 feet and the truss takes 18 inches, cross bracing reduces the effective stacking height to only 18½ feet. Since a typical pallet load of merchandise is 4 feet high, a clear stacking height of 18½ feet could be of little more value than a clear stacking height of 16 feet.

3/ Use of a 40- by 40-foot column spacing is satisfactory as shown in the layouts, figs. 4, 36, 37, and 38.

Vertical expansion of the warehousing facility is usually less expensive than horizontal expansion. The cost of additional concrete flooring and roofing for horizontal expansion is more expensive than placing merchandise higher in the building. The term "vertical expansion" as used here refers to the addition of stacking height to a modern one-story warehouse and not to the addition of more floors to the existing structure.

To make efficient use of the area available with 20 feet of clear stacking height, it is essential to use forklift trucks capable of servicing the top pallet of merchandise. This requires a forklift with approximately 200 inches of reach in a warehouse having a clear stacking height of 20 feet. Failure to use a forklift truck with sufficient reach will cause double handling of merchandise in storing and removing merchandise from storage.

Receiving and Shipping Docks

The height of the receiving and shipping docks should be approximately the same as the height of the floor of the rail car and truck. If the difference between the two levels is not too great it can be safely bridged with a dockboard. The dock slab height should be adjusted to loaded truck height, so when the truck is empty its floor will be slightly higher than the dock. This is desirable because in ramping down into a truck the dockboard has to extend well into the body of the truck, thus taking up space needed for placing the merchandise. The platform height for trucks will range from 45 to 51 inches above the back-up ramp floor level, depending on the type of truck used.

Figure 5 shows a delivery trailer at the dock ready for loading. The trailer floor is about one inch higher than the dock, and warehouse selector trucks can be pushed into the trailer without difficulty. The dockboard covers very little of the trailer floor space.

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Figure 5.--A delivery trailer at a dock built at the proper level.

The same principle applies to the rail car siding. The rail dock should be about 45 inches over the top of the rail and have 102 inches between the center line of the track and the edge of the dock. A dock in this position will be level with the floor of freight cars and with proper dockboards will accommodate refrigerator cars. When double rail sidings are necessary, the two rail centers should be kept far enough apart, about 12 feet, to allow the doors of the two cars to be opened. In this way the off car can be worked through the near one.

Docks should have sufficient depth to provide a "temporary block" or a temporary holding area between palletizing and forklift storage and between

order assembly and loading operations. Sufficient temporary block area would be provided with a dock 50 feet deep for shipping and 40 feet deep for motortruck receiving. Sufficient room also should be provided on the shipping dock for moving between warehouse trucks for checking the merchandise before it is loaded on delivery trucks.

With warehouse selector trucks measuring 3 by 5 feet, approximately 5 by 6 feet should be provided per truck to provide room for checking the merchandise. A motortruck trailer could be serviced by two lines of 4-wheel warehouse trucks. With a dock depth of 50 feet and an average 4-wheel selector truckload of 35 cases of merchandise, this 2-line arrangement could hold up fourteen 4-wheel warehouse trucks or 490 cases of merchandise at one time and, since not all delivery trucks are loaded simultaneously, adequate temporary block area would be provided.

For motortruck receiving, the same area 40 feet deep could hold three rows of 12-deep 32- by 40-inch pallets. Assuming that each pallet holds 25 cases of merchandise, the temporary block area would hold up to 675 cases and would provide sufficient temporary block area. Since the dock at the rail siding runs with the length of the cars, a dock approximately 15 feet wide usually provide sufficient temporary block and transportation area.

The type of dock to be used depends primarily on climatic conditions. Where quality of product may be affected adversely by subfreezing temperatures, the dock and siding should be enclosed in the warehouse (fig. 6) with pull-down type doors to permit access for rail cars and trucks. With a mild climate and limited building funds, it is preferable to enclose the docks with trucks and rail cars spotted at the doors on the warehouse exterior. Some warehousemen locate the truck or rail car at the doors on the warehouse exterior and extend a canopy out from the roof of the building to provide partial protection from inclement weather when unloading. This type of protection can be furnished at a cost lower than enclosing docks and ramp areas within the warehouse building. In some warehouses the dock was on the exterior of the building and had a roof extending to the edge of the dock (fig.7). Observations made during the studies indicated a dock of this type is not entirely satisfactory in many areas of the United States because: (1) Wide temperature fluctuations influence labor productivity in the cars, trucks, and on the dock; (2) moisture accumulation on the dock may result in hazardous working conditions; (3) doors remaining open at the dock add to the expense of heating the warehouse; and (4) temperature and humidity may cause damage to the product. At the same time, with a dock on the warehouse exterior it is not necessary to spot rail cars at particular doors, and more rail cars could be positioned at the dock.

The enclosed dock has the following advantages over an outside dock: (1)It may be used for temporary storage of merchandise regardless of weather conditions; (2) it protects warehouse merchandise from extremes of temperature and precipitation; (3) it will not be necessary to clear the dock of all merchandise at the end of the day to avoid pilferage; (4) dunnage and trash will not be as likely to accumulate inside the building; and (5) employee health and productivity will be improved when working inside the building at a fairly constant temperature. These advantages, however, must be weighed against

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Figure 6.--A rail receiving dock and siding within the warehouse.

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Figure 7.--A rail receiving dock and siding outside the warehouse.

increased building costs for enclosing the rail siding in the warehouse or the difficulty of getting cars spotted at the proper doors if the rail siding is outside the building.

Locating the Office

The office area normally includes a reception room, administrative and buying offices, tabulating equipment room, general office space, a lunchroom or cafeteria, and space for the advertising, store engineering, and sales departments.

The office can be located above the shipping dock and truck well, over the motortruck receiving dock, repack room, or over the warehouse garage. It should be located for easy access by employees and have outside light. These locations would not interfere with the movement of groceries, since 20 feet of stacking height is not needed in these locations and would probably be the lowest cost location.

The tabulating department should have convenient access to the warehouse shipping and receiving offices for transmission of store orders and receiving records. Since the tabulating department cannot be physically located for immediate access for both receiving and shipping, these locations are usually connected by telephone and vacuum tubes for transmitting invoices, bills of lading, and other records.

Location for the Repack Room

Merchandise handled in the repack room usually includes those items delivered to retail stores in smaller quantities than the unit packed by processors or manufacturers, items packed in small cases, and items of relatively high unit value. Typical items handled in the repack room are spices, candy, health and beauty aids, school supplies, and tobacco.

It is usually advantageous to locate the repack room between the motortruck receiving dock and shipping dock to keep travel distance to a minimum since most of the repack items are received by truck. Warehouse transportation for repack merchandise is usually by perimeter towline or by tow tractors that move assembled repack orders to the dock along with regular orders.

The repack room is usually enclosed for security because the items handled have a high unit value, are small, are stored in less than case lots and are susceptible to pilferage. One man should be responsible for security of the packing room. A wire-mesh screen is frequently used to separate the repack room from the other parts of the warehouse (fig. 8). Merchandise in the repack room is usually hand piled on shelves to a height of 8 to 10 feet, no pallets are used, and the area above the height of 10 feet can be used for offices.

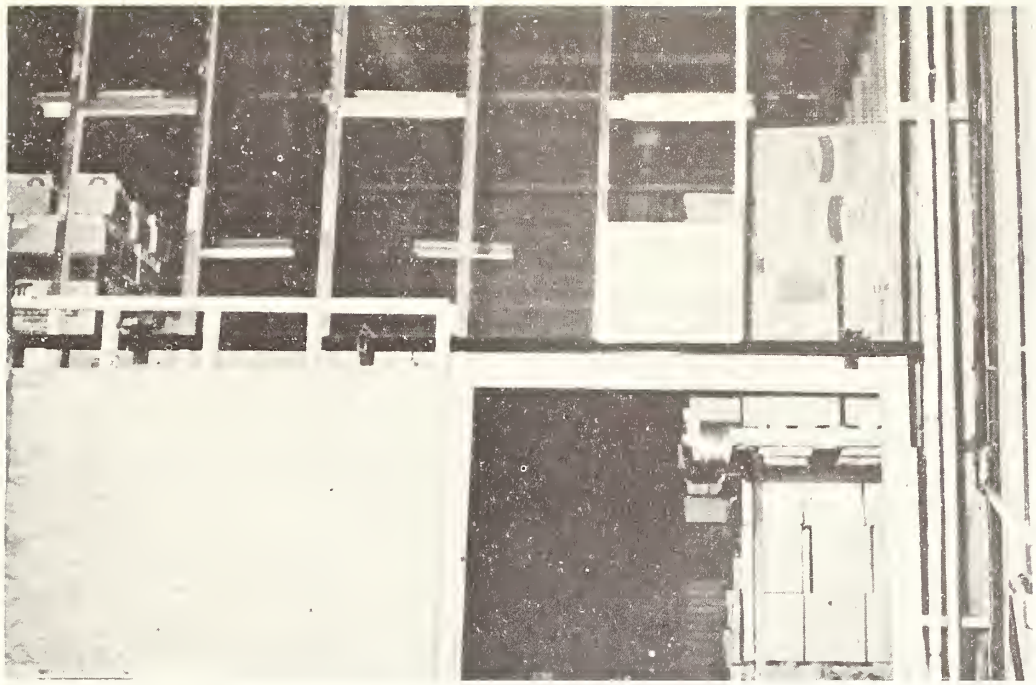

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Figure 8.--A repack room enclosed for security.

Lighting 4/

Adequate lighting in the grocery warehouse permits easy seeing in storage areas, faster location of merchandise and quick and accurate checking of paperwork associated with merchandise handling. Good lighting also contributes to safety of pedestrians and materials-handling equipment in aisles by quickly making visible moving elements that enter aisles from behind rows of merchandise. Experience also shows that well-lighted storage and work areas are usually kept neater by employees, resulting in improved employee morale and greater pride in the warehouse.

Lighting engineers recommend lighting levels of 25- to 35-foot candles for seeing tasks. The illumination should be as uniform as possible, since the seeing tasks are spread over the entire warehouse area. In traffic areas, similar illumination levels are adequate to assure quick seeing and identification of obstacles. In shipping and receiving areas, the seeing tasks are similar to those in storage areas; identification of merchandise and checking of shipping orders and bills of lading. Therefore, 25- or 35-foot candles of illumination are also desirable in these areas. In addition, some provision should be made to get light into the interiors of trucks and railroad cars at docks and sidings.

Fluorescent lamps, rather than incandescent filament lamps, are used more extensively for warehouse lighting because they can be installed at lower mounting heights, and their linear form conforms well to the desired pattern

4/ This section is based on data developed by General Electric Company, Cleveland, Ohio.

of light distribution. For equal illumination levels, fluorescent lighting systems usually cost more to install than incandescent systems, but their high efficiency and long life offset this with lower operating costs.

The major factor in determining layout of fluorescent lighting equipment in a warehouse is the layout of aisles and the storage areas. When the location of aisles has been determined, the lighting systems can be located with comparative simplicity. The height of the fixtures should be sufficient to comfortably clear the highest reach of loaded materials-handling equipment used in the warehouse, or 20 feet high.

Since individually spaced fixtures require a separate outlet for each fixture, it is usually more economical in installation labor costs to have continuous rows of fixtures mounted end-to-end. The continuous wiring thus allows one outlet to supply all fixtures in the row and produces more illumination of greater uniformity, which is desirable in producing better seeing conditions.

At docks and sidings, sealed flood lamps mounted on the walls are used to light the interiors of trucks and railroad cars. Figure 9 shows wall-mounted flood lamps used at the loading dock to light the interior of delivery trucks. Standard outdoor flood lights might also be used for this purpose. Trouble light fixtures on retractable cords can be used to hang inside the trucks or rail cars; however, care should be taken to remove the lights before the vehicles leave the dock.

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Figure 9.--Wall-mounted flood lamps used to light the interior of delivery trucks.

Maintenance plans should be included in considering the lighting system, since lamp changing and fixture cleaning involve considerable labor costs. A regular cleaning schedule should be established, and consideration should be given to group relamping. Group relamping is the practice of changing all lamps at once at about 80 to 90 percent of rated life, which greatly reduces the labor cost in lamp replacement. The mounting height for fixtures should be such that the cleaning and relamping of the fixtures can be done from platforms placed on forklift trucks.

MATERIALS-HANDLING EQUIPMENT USED IN MODERN WAREHOUSES

An important part of the overall warehousing operation when planning for maximum productivity in a new warehouse is the materials-handling equipment to use. This includes pallets, pallet racks, forklift trucks, pallet jacks, order-selector trucks, order-selector tractors, towlines, dock boards, and conveyor lines. The choice of equipment will depend upon cost and the advantages to be gained with use of the equipment in conjunction with a particular warehouse design and aisle width.

Pallets

Wooden pallets used in grocery warehouses provide a platform for stacking merchandise, as well as a base for handling merchandise with forklift trucks and pallet jacks. Merchandise stacked on pallets is usually placed in interlocking patterns to make the load stable for handling and high stacking. Pallets are usually constructed with hardwood lumber held together with special cement coated screw-type nails. Pallet classifications include: Reversible or nonreversible; 2-way or 4-way entry; and wing type or flush type. These pallet types are shown in figure 10.

A reversible pallet is one with sufficient cross members for stacking merchandise on either side. A nonreversible pallet is one with cross members close together on the top for stacking merchandise and with a wider space between cross members on the bottom to allow entry for wheels of pallet jacks. Two-way entry means that the pallet may be engaged by the forklift or pallet jack only from the ends, whereas 4-way entry means that the pallet can be entered from the ends and sides.

The wing type pallet is designed for 2-way entry with either forklift or pallet jack. Cross members of the pallet extend out over the edges of the stringers on the top, and are usually used with the straddle-type forklift trucks. The flush-type pallet has the cross members ending flush with the outside edge of the stringers, may have either 2-way or 4-way entry, and is usually used with counter-balanced and reach-type forklift trucks.

The standard pallet sizes for use in grocery warehousing are 32-inch face by 40-inch depth and 48-inch face by 40-inch depth. They have the same depth and since the facing of the larger size pallet is $1\frac{1}{2}$ times that of the smaller size pallet, the two sizes can be used interchangeably. The 48- by 40-inch pallet is used for handling and storing the bulky fast moving merchandise, such as paper products and breakfast cereals.

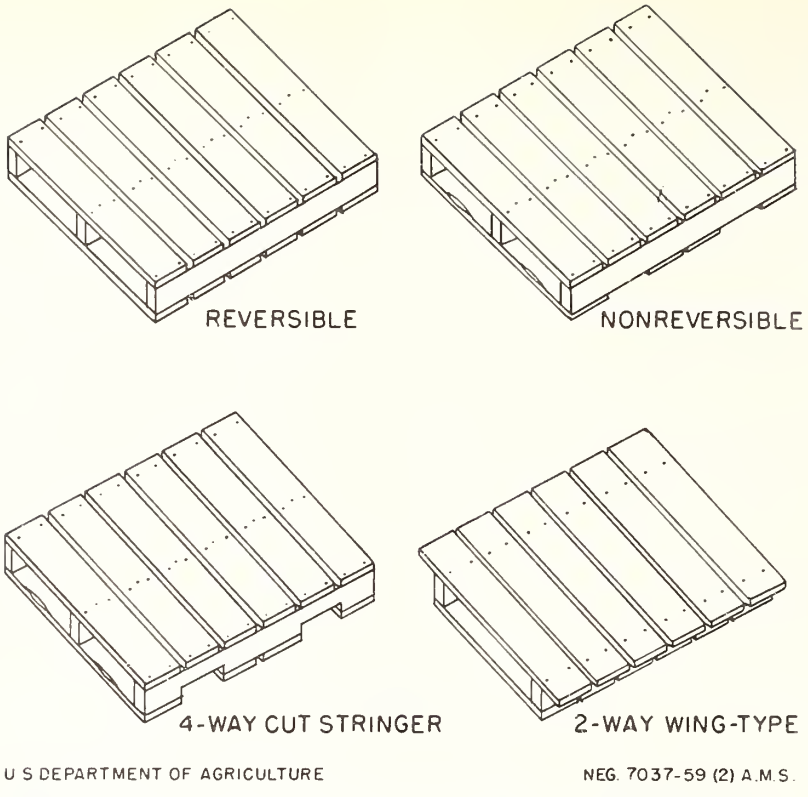

Figure 10.--Types of pallets used in grocery warehouses.

Pallet Racks

Pallet racks are used to increase the number of selection fronts on the assembly line. Merchandise placed in pallet racks is usually received into the warehouse in quantities of three pallets or less with order selection made from either two or three levels. Merchandise for reserve storage is usually placed on top of the racks and the quantity that can be placed on reserve storage is dependent upon the clear stacking height available on top of the racks, the load limit of the racks, and the mast height on forklift trucks used.

Most pallet racks are constructed of steel sections with either two or three pallet facings to the section. They can be dismantled and moved easily to fit changes in warehouse layout. Steel racks provide a stable base upon which palletized merchandise can be placed.

Steel pallet racks for grocery warehousing are manufactured for either 2- or 3-tier assemblies. Figure 11 shows an order filler making a selection in a 2-tier pallet rack. The 2-tier rack usually provides 47 inches of clear stacking height per tier. The 3-tier rack provides from 22 to 29 inches clear stacking height on the top tier. The bed level of the third tier of a 3-tier pallet rack is from 67 to 75 inches above the floor level, making it difficult for order selectors to reach the merchandise (fig. 12). A 5-high block of palletized cases of #303 merchandise requires a stacking height of 45 inches, hence the clearance in a 3-tier rack is not enough to handle the normal pallet load of merchandise.

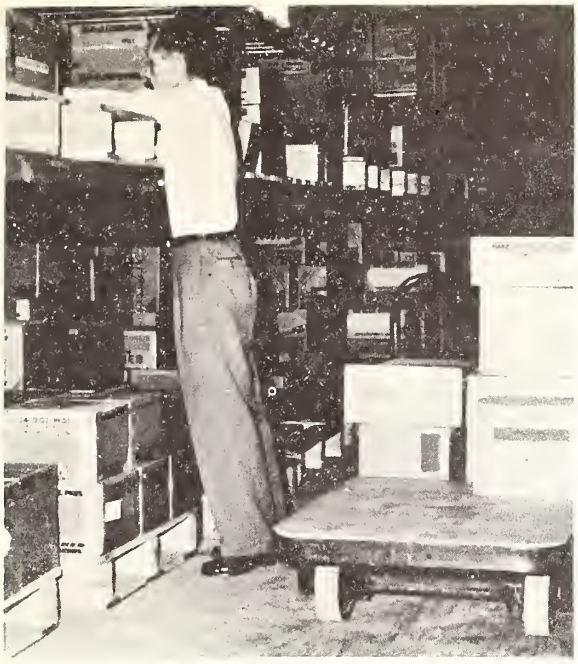

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Figure 11.--Selecting merchandise from the upper tier of a 2-tier pallet rack by a man of medium height.

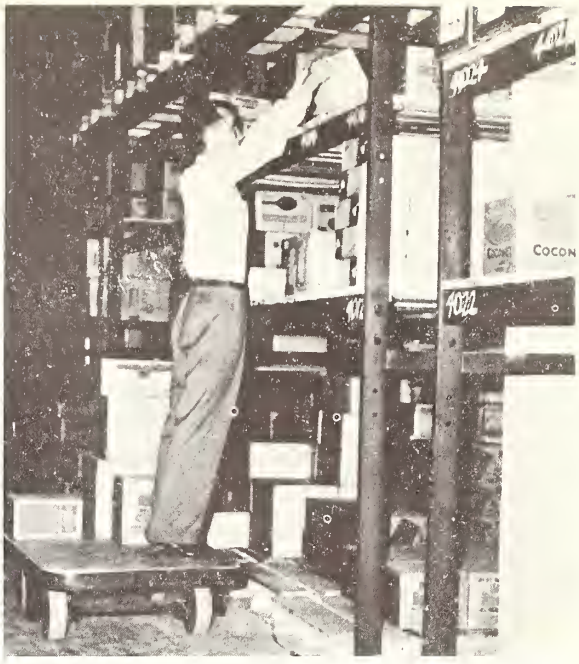

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Figure 12.--Selecting merchandise from the third tier of a 3-tier pallet rack by a man of medium height.

Forklift Trucks

Forklift trucks are used to move palletized merchandise from one location to another and to high stack merchandise in the warehouse. They are classified as counter-balanced and straddle types. Use of forklift trucks is generally limited to modern, 1-floor warehouses with concrete floors, although some multi-story buildings have floors that will support the weight of a forklift truck.

The counter-balanced fork (fig. 13) is heavier than the straddle-type (fig. 13), and requires an aisle of from 9 to 10 feet wide for right angle stacking because it has a wider turning radius than the straddle-type forklift. The mast on the counter-balanced forks can be tilted backwards 10 degrees and forward as much as 5 degrees.

The straddle-type forklift can operate in a warehouse aisle 6 to 7 feet wide because it has a shorter length than the counter-balanced machine. The operator on a straddle-type forklift usually works in a standing position. It is necessary to use either a wing-type pallet or provide a 6-inch space between each pallet of the flush type for entry of the front wheels of the forklift.

A variation of the straddle-type forklift is the reach-type forklift truck which will operate with a flush-type pallet. The reach-type fork has a short wheel base and a scissor-type extender fork for reaching into the stack to pick up or deposit a pallet load of merchandise. Hence, the reach-type fork

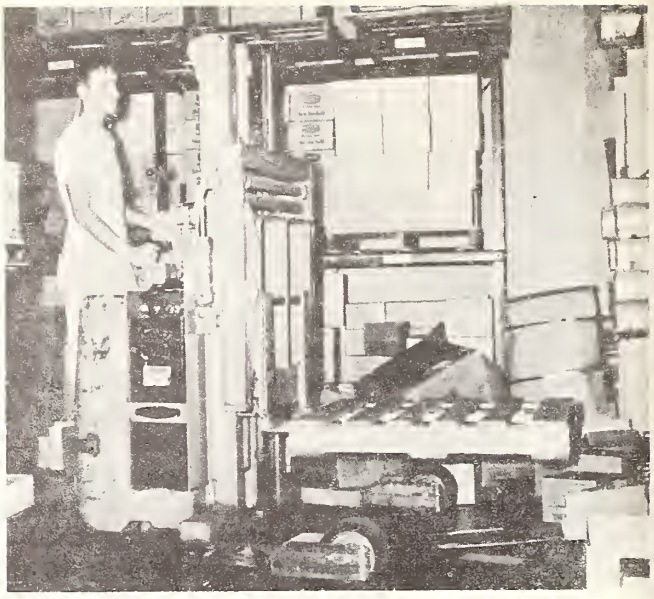

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Figure 13.--A counter-balanced forklift truck (left) and a straddle-type forklift truck (right).

operates from the aisle and does not require the placing of pallets as far apart or the use of wing-type pallets as is required with the straddle fork.

Forklift trucks are designed to handle pallet loads up to 4,000 pounds and pallet sizes up to 48 by 48 inches. Forks will elevate merchandise as high as 210 inches above floor level. The trucks can travel at a speed of more than 5 miles per hour. Forklift trucks of 2,000-pound capacity are used by most wholesale food distributors.

Forklift trucks can also be classified by the kind of fuel used. Counter-balanced forklifts will operate with any one of the following: Gasoline, liquefied petroleum gas, or electric storage battery. The straddle and reach-type forklifts usually operate with electric storage batteries. Forklift trucks built with internal combustion engines have a lower initial cost than comparable units operating with electric batteries (table 5). While counter-balanced forklift trucks operating with internal combustion engines have lower initial cost than comparable units operating from electric storage batteries, they have the disadvantage of producing fumes in the warehouse. With use of either gasoline or liquefied petroleum gas it is necessary to provide adequate ventilation in the warehouse. Widespread use of liquefied petroleum or "bottle gas" as fuel for forklift trucks has become prevalent in the past few years.

Forklift trucks operating with gasoline can be converted to operate with liquefied petroleum gas with installation of a relatively inexpensive conversion kit. Warehouse operators using liquefied petroleum gas report the following advantages in comparison with gasoline: (1) Reduced engine maintenance because there is less carbon deposited in the engine, (2) decreased smoke and odor in the warehouse, and (3) lower operating cost.

Among the advantages of forklift trucks operating with internal combustion engines compared with electrically operated machines are: (1) Lower initial cost, (2) less time required for refueling with a possible continuous use of 24 hours per day, and (3) greater speed for horizontal movement and lifting.

Some advantages of electrically operated forklift trucks are: (1) No exhaust fumes, (2) less mechanical maintenance, and (3) lower fuel cost (table 5). Electrically powered equipment is normally used in areas with little outside air circulation such as in coolers and freezers. Greater initial cost is experienced with battery-powered forklift trucks because of the cost of electric storage batteries and charging units necessary with the forklift. If electric forklift trucks are to be used for more than 8 hours of continuous running, it is necessary to have extra storage batteries that can be transferred into the forklifts when the batteries in use become weak. Figure 14 shows a number of battery racks with spare storage batteries being charged on them. The battery racks are built with roller conveyors on the bottom to facilitate transfer of the batteries into the forklift, which also has roller conveyors on the bottom of the battery compartment.

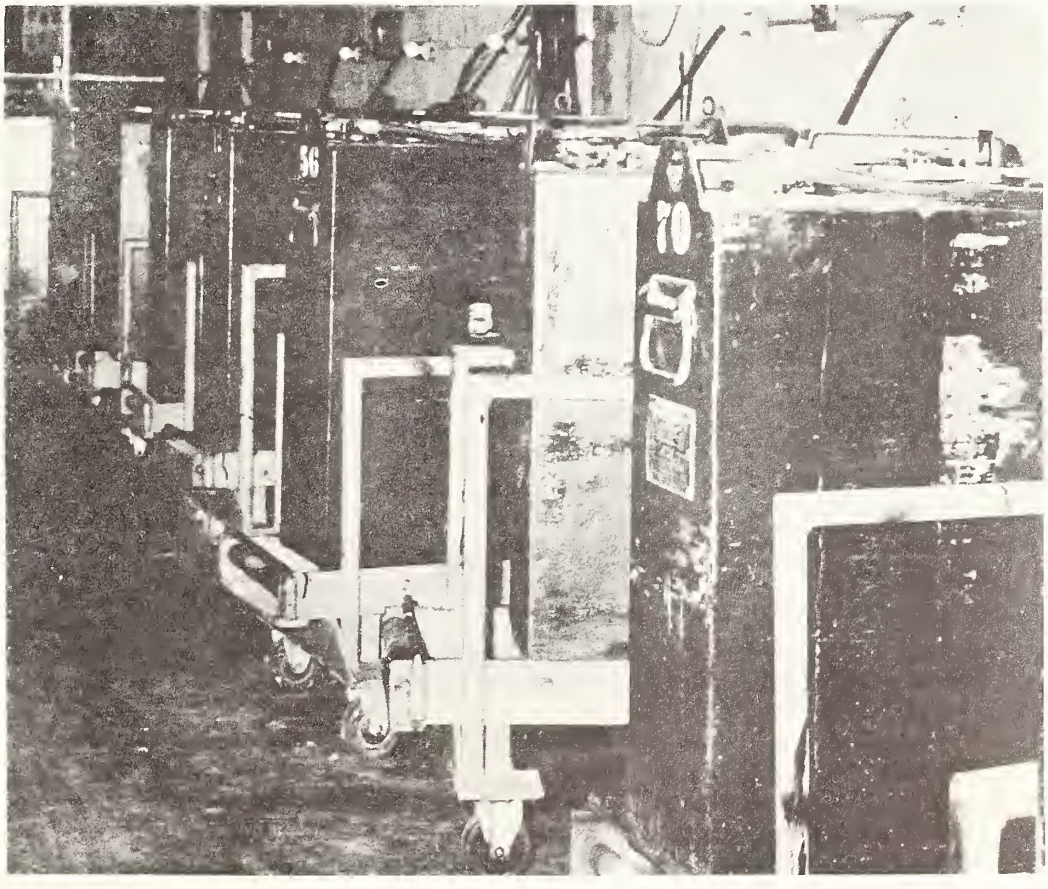

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Figure 14.--Battery racks equipped with roller conveyors to facilitate battery transfer in forklift trucks.

Pallet Jacks

Pallet jacks supplement work done with forklift trucks. They are used to move merchandise horizontally for short distances, as in receiving, where pallet loads of merchandise are moved from the rail car or truck to the temporary holding area on the dock.

Pallet jacks are operated manually or with electric power and electrically-powered jacks are either walkie- or rider-type. They are used by men palletizing merchandise, thus eliminating dependence of the unloading crew on the forklift truck. 5/ Movement of a pallet load of merchandise is accomplished by lifting it approximately 4 inches with the pallet jack to clear the floor. Figure 15 shows an electrically-powered walkie-type pallet jack with a pallet load of merchandise in the raised position.

BN-8186-X

Figure 15.--An electrically operated pallet jack.

In one of the firms studied, the receiving clerk moved palletized merchandise into the warehouse loadline with a walkie-type electric pallet jack, but he was not busy all of the time. Analysis of the operation led to the decision to try a walkie-type electrically-powered forklift truck to place

5/ Bouma, J. C., "Methods of Increasing Productivity in Modern Grocery Warehouses," USDA, Mktg. Res. Rpt. 94, June 1955, p. 3.

merchandise in the loadline two pallets high. A walkie-type electrically-powered forklift truck was obtained on a trial basis for comparison with the low-lift pallet jack. The results of this comparison are shown in table 2.

Table 2.--Time required to move merchandise into a loadline with an electric pallet jack and a walkie-type forklift

Item	Electric pallet jack and regular forklift truck	Walkie-type forklift truck
	Man-minutes 1/	Man-minutes 1/
Get pallet load of merchandise in truck, place in loadline, and return to truck for next pallet load	0.72	1.18
Get pallet load of merchandise and place 2-high in loadline	1.19	2.11
Average time required to place every other pallet load 2-high in loadline	.96	1.64

1/ Includes a 15 percent personal and fatigue allowance.

A counter-balanced forklift truck placed one pallet above another on the receiving dock in 0.47 minute, as compared with 0.93 minute with the walkie-type forklift truck, although the receiving clerk would be doing this job rather than the forklift driver, who was storing the merchandise. The walkie-type electrically-powered forklift truck was not found practical for use on the receiving dock because it was too heavy for entering the smaller motortrucks and was too slow in moving from the truck to the dock and for lifting one pallet above another when compared with use of other equipment.

Order Selector Trucks

Order selector trucks used in modern grocery warehouses may be pushed manually or may be part of a tractor train. A pallet may be placed on a 4-wheel handtruck for assembly of merchandise on the pallet as was done at two of the warehouses studied. Figure 16 shows order selector trucks with pallet loads of merchandise assembled on them.

The 4-wheel order-selector truck is probably used more in grocery warehouses than any other piece of materials-handling equipment. It has the following advantages when compared with other materials-handling equipment: (1) Low initial cost; (2) low maintenance cost; and (3) flexibility, in that it can be used wherever it is necessary to transport merchandise. The size of the order-selector truck is largely determined by warehouse aisle width so that order selectors may pass each other as well as forklift trucks in the aisle.

The size of order-selector trucks used most frequently in warehouses with aisles 9 to 10 feet wide is 36 inches wide by 60 inches long. Order selector trucks were usually 30 inches wide by 60 inches long in warehouses with aisles 6½ feet wide.

Tires on selector trucks that are pushed manually should be made of plastic rather than rubber or steel. Rubber tires become soft as they age, thus making the selector truck hard to push; however, they work satisfactorily on selector trucks pulled by tractors. Steel wheels on materials-handling equipment will seriously damage a concrete floor.

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Figure 16.--Merchandise assembled on pallets placed on 4-wheel selector trucks.

Order Selector Tractors

Order selector tractors enable the order selection operation in large volume warehouses to be performed more efficiently because the tractor will tow as many as five selector trucks along the order selection route (fig. 17). Equivalent manpower requirements to do the job would require four or five men. 6/ Travel is also faster because the order-selector tractor towing loaded selector trucks has a forward speed of more than 4 miles per hour, as compared with a speed of less than two miles per hour for pushing a loaded 4-wheel hand-truck manually. Order filler travel distances determine when it is more advantageous to use tractors and trains of selector trucks. Usually their use is not justified in warehouses of less than 50,000 square feet in size.

Order-selector tractors can also be used for moving loaded order-filler trucks to the shipping dock if the warehouse facility does not have a towline. They are powered by gasoline, liquefied petroleum gas, or electric batteries. The discussion of the relative advantages and disadvantages of sources of power given in the section on forklift trucks also applies to order selector tractors.

A modification of the battery-operated tractor is a tow tractor developed to operate by radio control. The operation of this machine is described in Marketing Research Report 94.

6/ For production data with use of a tractor and when pushing a 4-wheel handtruck manually in the warehouse order selecting operation, see Bouma, J. C., "Methods of Increasing Productivity in Modern Grocery Warehouses," USDA, MRR 94, 30 pp. June 1955, page 7.

BN-8181-X

Figure 17.--An order-selector tractor with a train of selector trucks for assembling retailer orders.

Since the publication of this report, additional studies have been made of the productivity of order fillers with radio control tow tractors as compared with regular tow tractors and the results are shown in table 3.

Table 3.--Productivity of order fillers in the same (or comparable) warehouses with regular and radio-controlled order filler tractors, by order size

Order size	Regular tow tractors			Radio-controlled tractors		
	No. of orders time studied	Average order size	Production per man-hour	No. of orders time studied	Average order size	Production per man-hour
	No.	Cases	Cases	No.	Cases	Cases
Under 30	6	15	64	6	26	80
30 - 59	7	47	80	3	44	104
60 - 99	11	87	114	7	83	121
100 -149	15	124	129	5	123	135
150 -199	4	169	146	3	161	149
200 -299	5	242	155	5	220	164
300 -399	7	370	162	6	325	186
400 -499	4	440	169	3	452	190
500 -749	11	705	187	4	617	218
750 or more	7	997	212	6	987	248
Total or weighted average	77	314	141	48	308	159

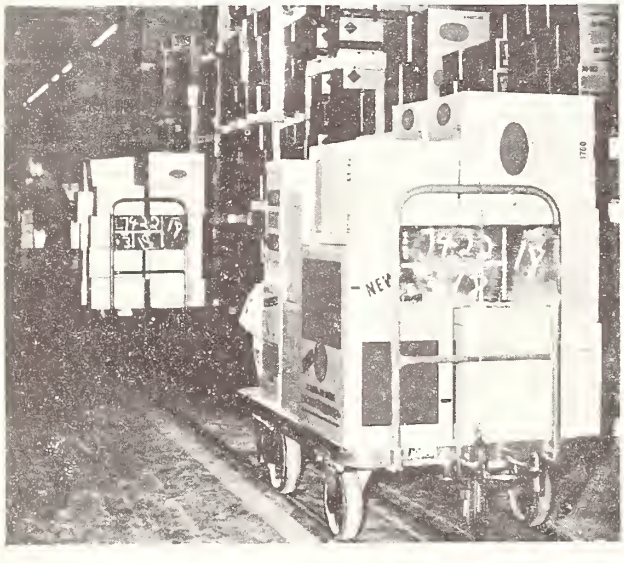
With the radio-control tractors, order filler production is greater because it is not necessary to walk up to the tractor to move it forward and return to select merchandise. The average time required to walk up to the tractor and return to the selection point was 0.06 minute each time the tractor was moved. With use of the radio-control tractor, order filler production averaged 13 percent more (159 cases per hour compared with 141 cases) than when radio-control units were not used. With the radio-control unit an order filler will produce more in an 8-hour day than he would in a 9-hour day with a regular tow tractor.

Towlines

The towline consists of a motor-driven endless chain located either below the floor or overhead to which 4-wheel selector trucks may be attached at regular intervals. The towline overcomes the disadvantage of the relatively small weight and bulk that can be handled with a single 4-wheel handtruck.

Towlines are built to tow the selector trucks through the order assembly area so the order fillers can place merchandise on the selector truck as it passes items ordered; to tow loaded and empty selector trucks from the assembly area to the shipping dock; and to move merchandise received by motortruck and rail car close to the stacking point in the warehouse (fig. 18).

A towline that is routed through the selection area has the following disadvantages: (1) Its speed is too fast for order fillers to select merchandise while the selector truck is attached to it and too slow for moving from one selection point to the next; and (2) the layout of the assembly area cannot be changed without considerable expense because of the towline installation.



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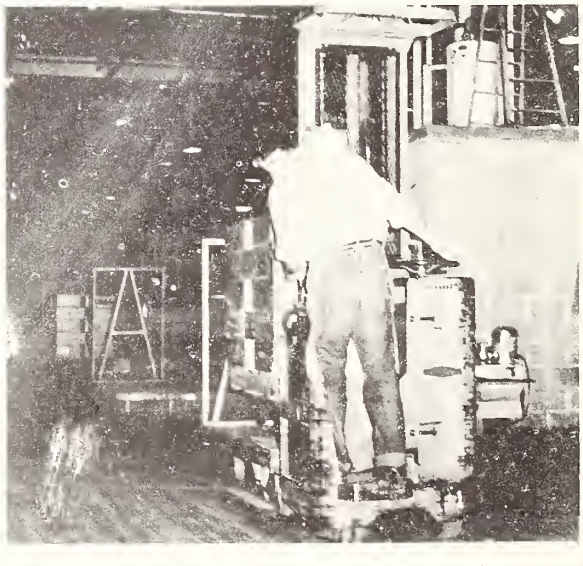

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Figure 18.--A perimeter towline used to move assembled orders to the shipping dock (left) and used for receiving merchandise (right).

The perimeter towline has the advantage that order filler production is not geared to the speed of the towline. Both types of towlines share the following advantages: (1) Elimination of the need for order fillers to travel to the shipping dock with loaded 4-wheel selector trucks and to obtain empty trucks; (2) reduction of confusion and improvement of work flow on the shipping dock; and (3) order fillers can remain in the assembly area at all times. Disadvantages of both types of towline are: (1) Initial cost of the equipment; and (2) required aisle space.

A recent development used as a towline is an electrically-controlled tractor that follows automatically without a physical connection along a guide wire strung overhead, or taped to, or buried in the floor. This is a trackless tractor system with no visible chain overhead or in the floor and moves without an operator. The tractor is capable of towing five loaded selector trucks. The radio waves that control the tractor are transmitted by signal boxes installed throughout the warehouse, or at either end of the route. A tractor is called by pressing a button, and it will come immediately to the station from which the signal originated. These automatic tractors have a lower initial cost than a towline (table 5), and may be set up or rerouted in a comparatively short time if the wire is not buried in a concrete floor. Some distributors are reporting good results with use of these tractors, although they have been available on the market for only a short time.

It is estimated that a perimeter towline saves the equivalent of one man in the shipping department on each shift, compared with moving assembled orders to the shipping dock and bringing empty selector trucks to the selection areas with manually operated tow tractors in warehouses with a $20 million annual business volume or with more than 125,000 square feet of warehouse space. Table 4 shows annual comparative costs of labor and equipment with a perimeter towline, tow tractors, and automatic tractors for moving orders to the shipping dock and bringing empty selector trucks to the selection area. For purposes of making the comparison, the manufacturer's quoted cost of $12,500 for the towline and installation is used; additional warehouse space requirements for the towline are 2,550 square feet; for the operatorless tractor it is 1,275 square feet; and the assumption is made that a 2-shift order assembly operation is used.

Labor cost shown with use of the towline is based on the time required to hook and remove warehouse selector trucks from the towline. With the operatorless tractor, an estimated additional one-fourth man per week shift is required to turn the tractor around and line up the selector trucks at the shipping dock and in the selection area. With the manually operated tow tractor, one man is employed during each shift to obtain the assembled orders and tow them to the shipping dock and to bring the empty selector trucks to the assembly area. Additional labor cost is incurred with the tow tractor for order selectors to obtain the empty selector trucks and this is included in table 4.

Both the towline and the operatorless tractor operate at a speed of from 1½ to 2 miles per hour. This speed has proven to move selector trucks as fast or faster than the manually-operated tow tractor moving at higher speeds because the towline and operatorless tractor follow planned routes. They follow the same routes during each trip down aisles, around corners, through congested

areas, and no time is wasted working through or around tight spots. Also, there is no excessive wear caused by alternate acceleration and deceleration, and starting and stopping.

Table 4.--Annual costs of a perimeter towline, tow tractor, and an operatorless tractor for moving assembled orders to the shipping dock and for bringing empty selector trucks to the selection area in a 125,000 square foot warehouse

Item	Perimeter towline	Tow tractor (manual)	Automatic tractor
	Dollars	Dollars	Dollars
Depreciation	1,250.00	283.38	894.28
Interest	625.00	123.36	428.81
Insurance and taxes	500.00	98.69	343.05
Electricity	180.00	56.16	56.16
Maintenance	1,250.00	74.02	257.28
Total equipment cost 1/	3,805.00	635.61	1,979.58
Labor	3,135.00	10,713.00	5,278.00
Warehouse space 2/	1,227.71	--	613.86
Total cost	8,167.71	11,348.61	7,871.44

1/ See table 5 for the computation of ownership and operating costs.
2/ Additional aisle space is required with the towline and automatic tractor because with the constant movement of warehouse trucks this space must be in addition to the regular aisle. Additional space required for 850 feet of towline, 3 feet wide for the towline, at $6 per square foot, amortized over a 20-year period at 5 percent. With the automatic tractor only one-half the length or 425 feet long by 3 feet wide is used.

The total costs shown in table 4 with use of either the towline or operatorless tractor are less than 72 percent of the cost with use of one man operating a tow tractor to move assembled orders to the shipping dock and to bring empty selector trucks to the selection area in a 125,000 square foot warehouse shipping merchandise during two shifts. When it is necessary to transport orders several hundred feet from the assembly area to the shipping dock, consideration should be given to the use of a perimeter towline or operatorless tractor for this function.

Dockboards

Dockboards are used to bridge the gap between the rail car or motortruck and the dock platform. They facilitate merchandise handling by allowing materials-handling equipment to deliver pallet or case quantities of merchandise either into the common carrier or from the carrier to the receiving

platform. Dockboards are made of a variety of materials, usually steel and aluminum or magnesium alloys. Aluminum or magnesium alloy dockboards weigh only about one-third as much as steel, do not rust, and are used in most of the new warehouses today because of their reduced weight. In one firm studied, the dockboard was hinged in the center with half of the board attached permanently to the shipping dock. When trailers were backed up to the dock, the other half of the board was flipped over to make a secure dockboard. The chief disadvantage with the hinged dockboards was the increased time and skill required to spot trailers within the narrow width at the dock. Because of this disadvantage, extensive use of dockboards of the hinged type is not practical.

Automatic dock levelers were used at the receiving dock in some of the warehouses studied. The dock levelers were used to compensate for different truckbed heights at the receiving dock. The leveler has a counter-balanced weight that is tripped, when the truck backs up to the dock, automatically adjusting the top of the dockboard to the truckbed level (fig. 19).

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Figure 19.--A dock that automatically adjusts to different truckbed heights.

Table 5.--Estimated cost of ownership and operation, per machine, of various types of materials-handling equipment used in selected wholesale grocery warehouses

Type of equipment	Initial cost 1/	Years depreciation 2/	Assumed use per year 3/	Ownership cost per year: Depreciation	Ownership cost per year: Interest at 5 percent	Ownership cost per year: Insurance and taxes at 4 percent	Ownership cost per year: Total	Operation cost per year: Gas, oil, and electricity 4/	Operation cost per year: Maintenance 5/	Operation cost per year: Total	Total ownership and operating cost: Per year	Total ownership and operating cost: Per hour of use
	Dollars	Number	Hours	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Straddle forklift truck (4,000-pound capacity, electric)												
Machine	5,044.00	10	-	504.40	-	-	-	-	-	-	-	-
Battery, 10.45-kwh capacity	983.00	6.3	-	156.03	-	-	-	-	-	-	-	-
Charger	450.00	10	-	45.00	-	-	-	-	-	-	-	-
Total	6,477.00	-	2,000	705.43	323.85	259.08	1,288.36	6/41.80	97.16	138.96	1,147.32	.7137
	7/ 7,460.00	-	4,000	861.46	373.00	289.40	1,532.86	83.60	223.80	307.40	1,840.26	.4601
Straddle forklift truck (3,000-pound capacity, electric)												
Machine	4,687.00	10	-	468.70	-	-	-	-	-	-	-	-
Battery, 9.14-kwh capacity	879.00	6.3	-	139.52	-	-	-	-	-	-	-	-
Charger	450.00	10	-	45.00	-	-	-	-	-	-	-	-
Total	6,016.00	-	2,000	653.22	300.80	240.64	1,194.66	36.56	90.24	126.80	1,321.46	.6607
	7/ 6,895.00	-	4,000	792.75	344.75	275.80	1,413.30	73.12	206.85	279.97	1,693.27	.4233
Straddle forklift truck (2,000-pound capacity, electric)												
Machine	4,437.00	10	-	443.70	-	-	-	-	-	-	-	-
Battery, 7.84-kwh capacity	768.00	6.3	-	121.90	-	-	-	-	-	-	-	-
Charger	450.00	10	-	45.00	-	-	-	-	-	-	-	-
	5,655.00	-	2,000	610.60	282.75	226.20	1,119.55	31.36	84.83	116.19	1,235.74	.6179
	7/ 6,423.00	-	4,000	732.51	321.15	256.92	1,310.58	62.72	192.69	255.41	1,565.99	.3915
Counter-balanced forklift truck (4,000-pound capacity, gasoline)												
Machine	5,230.00	10	2,000	523.00	261.50	209.20	993.70	305.50	261.50	567.00	1,560.70	.7804
	5,230.00	10	4,000	523.00	261.50	209.20	993.70	611.00	523.00	1,134.00	2,127.70	.5319
Counter-balanced forklift truck (3,000-pound capacity, gasoline)												
Machine	5,080.00	10	2,000	508.00	254.00	203.20	965.20	274.75	254.00	528.75	1,493.95	.7470
	5,080.00	10	4,000	508.00	254.00	203.20	965.20	549.50	508.00	1,057.50	2,022.70	.5057
Counter-balanced forklift truck (2,000-pound capacity, gasoline)												
Machine	3,755.00	10	2,000	375.50	187.75	150.20	713.45	244.00	187.75	431.75	1,145.20	.5726
	3,755.00	10	4,000	375.50	187.75	150.20	713.45	488.00	375.50	863.50	1,576.95	.3942
Pallet jack (4,000-pound capacity, electric)												
Machine	1,690.00	10	-	169.00	-	-	-	-	-	-	-	-
Battery, 7.16 kwh capacity	651.00	6.3	-	103.33	-	-	-	-	-	-	-	-
Charger	546.00	10	-	54.60	-	-	-	-	-	-	-	-
Total	2,887.00	-	2,000	326.93	144.35	115.48	586.76	28.64	43.31	71.95	658.71	.3294
Pallet jack (2,000-pound capacity, hydraulic, manual)												
Machine	531.00	10	2,000	53.10	26.55	21.24	100.89	-	26.55	26.55	127.44	.0637
Four-wheel selector truck (1,500-pound capacity, rubber wheels, platform size 36- by 60-inch)												
Machine	68.50	10	2,000	6.85	3.43	2.74	13.02	-	3.43	3.43	16.45	.0082
Towtractor, stand up rider-type (200- to 550-pound draw bar pull, electric)												
Machine	1,478.75	10	-	147.88	-	-	-	-	-	-	-	-
Battery, 7.02-kwh capacity	624.00	6.3	-	99.05	-	-	-	-	-	-	-	-
Charger	364.50	10	-	36.45	-	-	-	-	-	-	-	-
Total	2,467.25	-	2,000	283.38	123.36	98.69	505.43	28.08	37.01	65.09	570.52	.2853
	2,467.25	-	4,000	283.38	123.36	98.69	505.43	56.16	74.02	130.18	635.61	.1589

Continued -

Table 5.--Estimated cost of ownership and operation, per machine, of various types of materials-handling equipment used in selected wholesale grocery warehouses--

Continued

Type of equipment	Initial Cost 1/	Years depreciation 2/	Assumed use per year 3/	Ownership cost per year: Depreciation	Interest at 5 percent	Insurance and taxes at 4 percent	Total	Operation cost per year: Gas, oil, and electricity 4/	Maintenance 5/	Total	Total ownership and operating cost: Per year	Per hour of use
	Dollars	Number	Hours	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Towtractor, radio remote-control (200- to 500-pound draw bar pull, electric)												
Machine	3,476.20	10	-	347.62	-	-	-	-	-	-	-	-
Battery, 7.02-kwh capacity	624.00	6.3	-	99.05	-	-	-	-	-	-	-	-
Charger	364.50	10	-	36.45	-	-	-	-	-	-	-	-
Total	4,464.70	-	2,000	483.12	223.24	178.59	884.95	28.08	66.97	95.05	980.00	.4900
	4,464.70	-	4,000	483.12	223.24	178.59	884.95	56.16	133.94	190.10	1,075.05	.2688
Towtractor, operatorless (200- to 550-pound draw bar pull, electric) 8/												
Machine	7,587.75	10	-	758.78	-	-	-	-	-	-	-	-
Battery, 7.02-kwh capacity	624.00	6.3	-	99.05	-	-	-	-	-	-	-	-
Charger	364.50	10	-	36.45	-	-	-	-	-	-	-	-
Total	8,576.25	-	2,000	894.28	428.81	343.05	1,666.14	28.08	128.64	156.72	1,822.86	.9114
	8,576.25	-	4,000	894.28	428.81	343.05	1,666.14	56.16	257.28	313.44	1,979.58	.4949
Towline, in-the-floor type (length - 850 feet)												
Machine	12,500.00	10	2,000	1,250.00	625.00	500.00	2,375.00	90.00	625.00	715.00	3,090.00	1.5450
	12,500.00	10	4,000	1,250.00	625.00	500.00	2,375.00	180.00	1,250.00	1,430.00	3,805.00	.9513

1/ Obtained from manufacturer of equipment:
Straddle-type forklift trucks, electric, f.o.b. Greene, N. Y.
Counter-balanced forklift trucks, gasoline, f.o.b. Battle Creek, Mich.
Lowlift pallet jacks, electric and hydraulic, f.o.b. Philadelphia, Pa.
Four-wheel selector truck, f.o.b. Cincinnati, Ohio
Towtractors, electric, f.o.b. Northbrook, Ill.
Battery charger for towtractors, f.o.b. Kansas City, Mo.
Towline, f.o.b. Detroit, Mich.

2/ In accordance with U. S. Internal Revenue Service Bulletin "F" based on reasonable life expectancy.

3/ Based upon 2,000 hours of use per shift per year.

4/ Based on the following assumed costs: Gasoline $.23 gallon, oil $.40 quart, electricity $.01 kilowatt hour.

5/ Maintenance costs computed at following percentages of initial cost when machines are used 2,000 hours per year:
1½ percent - electric forklift trucks, pallet jacks, and towtractors.
5 percent - gas forklift trucks, 4-wheel selector trucks, manual pallet jacks, and electric towline.
Maintenance cost is doubled if the machines are used 4,000 hours per year.

6/ Power costs for battery charging of electric-powered vehicles computed from manufacturers' specifications.
Example:
Battery capacity - 10.45 kwh. Discharge rate per hour - 10 percent of battery capacity.
10.45 kwh. x .10 equals 1.045 kwh capacity per hour battery charging requirement.
1.045 x 2 (50 percent charging efficiency) equals 2.09 kwh charging requirement for each hour of vehicle use.
2.09 x $.01 (electricity cost per kwh) equals charging cost for each hour of vehicle use or $.0209.
$.0209 x 2,000 hours equals $41.80 per year, power cost.

7/ Electric forklift trucks which are used 4,000 hours per year require 2 batteries.

8/ Estimate based on a simple installation between 2 points and 425 feet in length.

Conveyors

Conveyors can be used effectively in grocery warehouses of less than 40,000 square feet in size or with an annual business volume of $6 million or less. They have the advantage of requiring very little aisle space; however, the ability to utilize height in the warehouse is limited. Access aisles to merchandise require approximately 2½ feet and run at right angles from the conveyor line for a distance of up to 30 feet.

Conveyors may be of the following types: Roller, wheel, and endless belt. With the roller and wheel type conveyor systems, electrically powered belt boosters are used at intervals to provide the necessary elevation of merchandise for the conveyors to operate. The endless belt conveyor system uses a a constantly moving belt on the entire line powered by electric motors. Any one of these conveyor types can be used satisfactorily within certain specified limits in grocery warehouses.

Conveyors are seldom used in new grocery warehouses because the business volume necessary to justify economically a new building is usually greater than can be handled on a single line conveyor system. At a business volume of less than $6 million annually, facility costs are usually lower in an older building than in a new warehouse. In this situation a conveyor system is usually advantageous. A full discussion of conveyor systems may be found in Marketing Research Reports 94 and 142.

MERCHANDISE LAYOUT

Merchandise layout discussed in this section includes the plan of merchandise location throughout the warehouse, and the plan of merchandise placement for order assembly; that is, choice of selection line type, numbering warehouse locations, determining proper warehouse aisle widths, and layout and methods for the repack room. Decisions in respect to these problems for individual warehouse operations depend on many factors, such as volume of business handled, average order size, and type of materials-handling equipment.

Merchandise Location in the Warehouse

The old method of placing items together by commodity groups, such as flour, canned vegetables, canned fruits, and canned soups is not maintained in the modern grocery warehouse. The new concept of departmentalization is built upon such factors as rapidity of turnover, quantity of purchases, and special handling required, a major objective being to minimize warehouse handling costs over the old system.

It is preferable to have merchandise that normally is received by rail stored on the side of the warehouse that is close to the rail dock. Items received by truck are usually received in smaller quantities than rail receipts and the dock facility for truck receipts should be located near the rack area where items normally received by motortruck are stored.

In warehouses where order fillers push handtrucks, the faster moving merchandise is usually placed near the shipping dock so the order filler will not have to push this merchandise any farther than is absolutely necessary. Merchandise placed in the selection line without regard to sales velocity required 1,952 feet of travel for the assembly of a 35-case order, or nearly 59 percent more distance than the 1,231 feet required to assemble the same size order when merchandise was placed on the selection line in accordance with sales velocity (fig. 20).

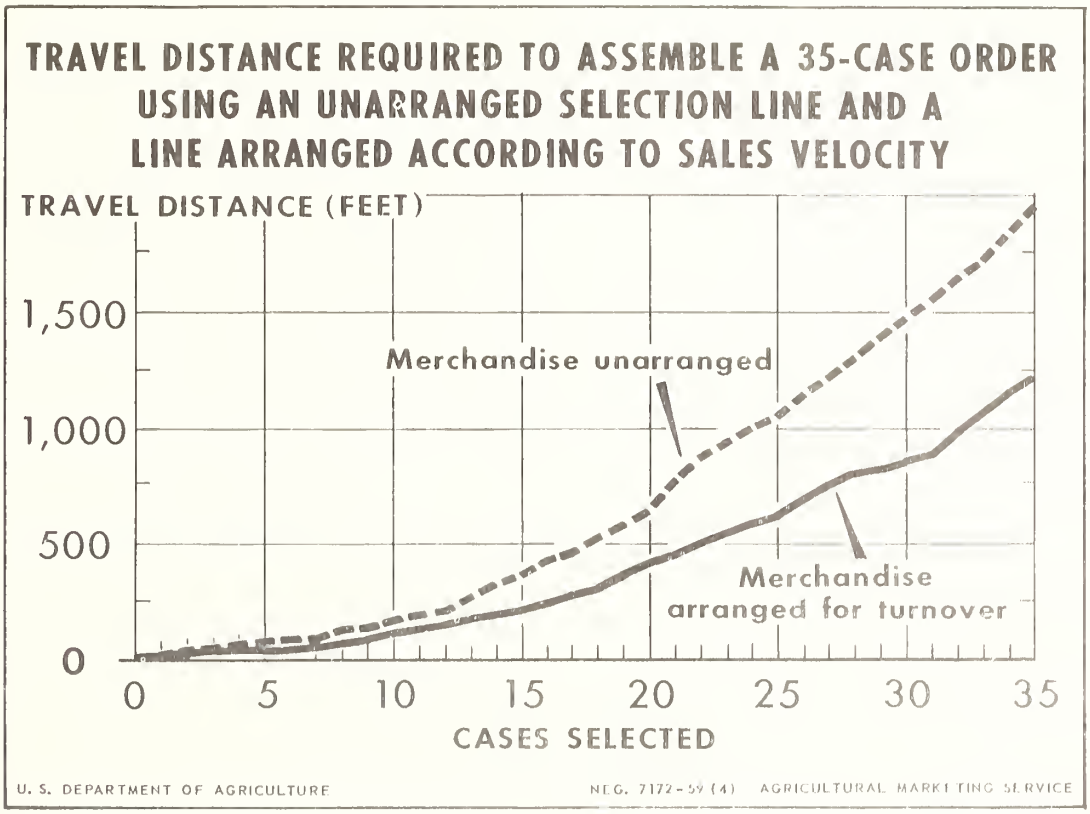
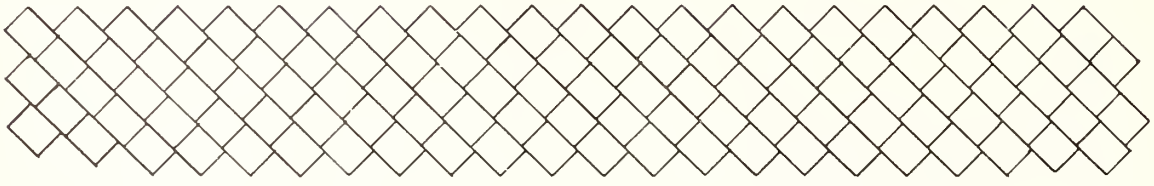


Figure 20

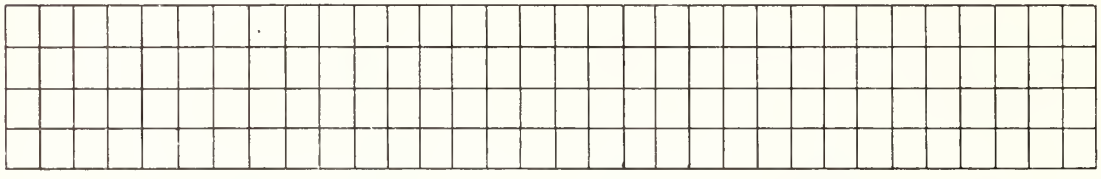
Merchandise is usually placed in warehouse slots at right angles to the aisle because uniform slot depths are achieved and more merchandise can be placed in a given area than with 45° angle storage. There is also more waste space when 45° angle stacking is used, because two full sides of the pallet load are exposed to the order selector, rather than one side.

Figure 21 shows a 90° and 45° angle selection layout utilizing 1,408 square feet of space. With the pallet facings at 90° to the aisle, 64 facings and 128 pallet loads on the floor can be accommodated, while with the 45° layout only 44 facings and 110 pallet loads on the floor can be accommodated. The 90° layout increases storage capacity by more than 15 percent on the floor and provides 45 percent more pallet facings. The chief disadvantage with 45°

stacking is the loss of pallet facings. With continued increases in the number of items handled in the grocery warehouse the need for pallet facings increases.



45° ANGLE STORAGE-44 FACINGS-110 PALLETS ON FLOOR



90° ANGLE STORAGE-64 FACINGS-128 PALLETS ON FLOOR

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Figure 21.--A comparison of space required with 90° angle and 45° angle storage.

Advantages of 45° stacking are that slots may be more easily serviced with a forklift truck and narrower aisles can be used than with 90° stacking. In stacking at 45° the forklift truck is not required to make a full turn to position the pallet load in front of the slot but can make a direct approach. This can be accomplished without a full stop for the turn, and at a faster rate of speed. Figure 22 shows a warehouse with 45° angle stacking being used in the pallet rack area.

Locating reserve merchandise stored over pallet racks is frequently time consuming for the forklift operator. This can be reduced with use of a card maintained for each pallet rack slot by the forklift truck driver moving merchandise into or out of pallet racks. Figure 23 shows a suggested design of the card holder, the card, and information to be placed on it. The card holder is usually attached

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Figure 22.--Pallet racks placed at a 45° angle to the aisle in a grocery warehouse.

to vertical supports on pallet racks in such a position that forklift operators can remove the card to post reserve location numbers while remaining on the forklift. Warehouse pallet locations for both selection and reserve merchandise are serviced by forklift trucks, and these records are easily maintained by the driver. With use of these cards time wasted in searching for merchandise is eliminated, as are false out-of-stock situations when merchandise is actually in stock but lost. One company reported satisfactory results with a decal showing the same information as the card. The decal is less likely to be damaged by forklift trucks hitting the pallet rack supports.

An analysis is required for each item carried in the warehouse to determine where the item should be placed in the building. All packing room items including candy and tobacco should be grouped together and provision made for handling these items in a special area of the warehouse. The remaining items carried in the inventory should be grouped by the size of the item's maximum inventory in terms of pallet quantities to determine the location in the warehouse:

Size of Maximum Inventory	Placement in Warehouse
Less than 1 pallet.....	Group and handstack on benches or racks
1 to 3 pallets.....	Place in pallet racks
4 to 7 pallets.....	Place in floor slots - 2 deep
8 to 12 pallets.....	Place in floor slots - 3 deep
13 to 17 pallets.....	Place in floor slots - 4 deep

The maximum inventory on a particular item is the maximum quantity in the warehouse at any time. Some items have a seasonal movement that must be considered in space assignments. For example, movement of cranberry sauce reaches a peak during the winter months, whereas picnic supplies reach a maximum inventory and movement during the summer months. Such items would probably be in pallet rack slots during the slow movement periods and be in floor slots during periods of peak movement.

Inventory records are usually maintained in case lot quantities, and it will be necessary to define the block to be used, including the number of cases high the merchandise is to be piled, to arrive at the quantity of merchandise per pallet. The maximum inventory for each item should be reviewed by the buying department for accuracy and adequacy and to determine whether or not the item will be handled.

Type of Selection Line

After the maximum inventory for each item has been grouped and assigned by warehouse location, it is necessary to place the merchandise in the warehouse. There are two basic types of selection lines in use--the short selection line, and the long selection line. With the short selection line system, a relatively small quantity of each item carried in the inventory is placed in one area for convenient order assembly. As merchandise on the assembly line becomes low in stock it is replenished from reserve merchandise stored in the remaining warehouse area. The second basic system is the long selection line where merchandise is stored and selected during the order

assembly over the entire warehouse area. Modifications of these two basic systems are used extensively in grocery warehousing.

The short selection line layout is used advantageously for the assembly of small orders in a large warehouse and when selector trucks are pushed by order fillers, because less travel is required.

The short selection line has the disadvantages of requiring one extra handling of merchandise, moving it from the reserve storage area to the selection line as a unit load, and of storing merchandise in more than one location, thus requiring close supervision to insure movement of merchandise to the selection line when it becomes low and presenting more difficulty in taking physical inventory.

The long selection line is usually advantageous for the assembly of large orders if mechanical tow tractors are used. With the long selection line, the handling of merchandise from reserve storage to the selection line is eliminated, although it is still necessary to lower inaccessible merchandise for order fillers.

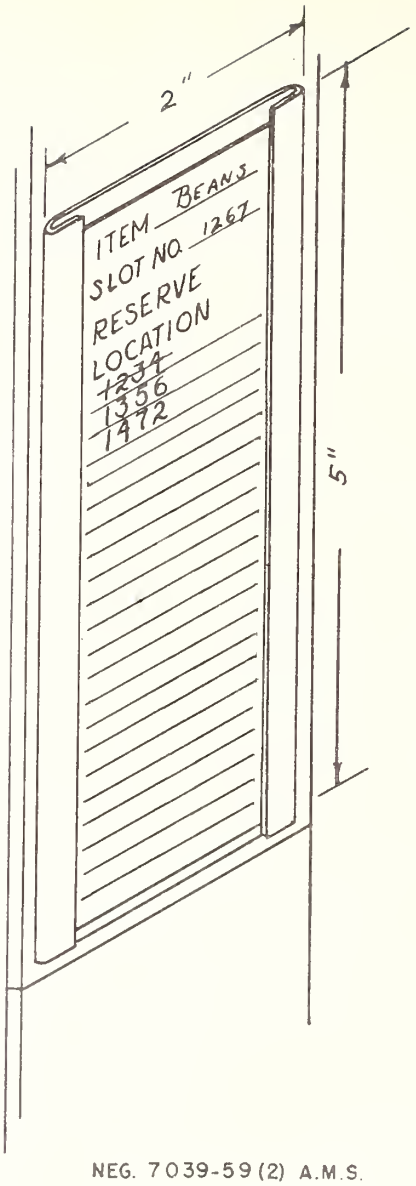

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Figure 23.--A card holder with a card designed to show quantity and location of reserve merchandise stored over pallet racks.

With the long selection line, merchandise may be assigned a fixed location in the warehouse, known as the fixed slot system, or the location may vary with the quantity of merchandise received and the space available, known as the floating slot system. Location of merchandise with the fixed slot system is never changed except when necessitated by changes in seasonal movement or items on sales promotion. With the floating slot system, each time an item is received it is usually placed in a different location.

Some of the advantages of the fixed slot system over the floating slot system are: (1) The storage of merchandise in one location means ease in taking physical inventory; (2) better utilization of warehouse cubic space is obtained on items utilizing multiple floor slots; (3) a more definite inventory in a fixed location can point up weaknesses in buying policy or

warehouse space allocation; (4) greater efficiency in receiving merchandise is obtained because time is not required to search for an empty slot; (5) fewer errors are made in billing and assembly of orders; and (6) there is less possibility of error in writing the location numbers and interpreting the written numbers in the office for items received into the warehouse.

The advantages of the floating slot system are: (1) Automatic stock rotation; (2) quantities of merchandise received for special sales promotion are placed in the warehouse without assignment of a special area for the items; (3) there is little need for location adjustments due to seasonal items; (4) quantities of merchandise received over the maximum that can be stored in a fixed slot are placed in the warehouse automatically with the floating slot system; and (5) automatic check on the inventory between the warehouse and office will take place each time a warehouse slot becomes empty. Based on the advantages and disadvantages, a fixed slot system is preferable for use in most grocery warehouses.

For warehouses of less than 50,000 square feet of floor space, only a relatively short selection line can be used because all of the available pallet fronts are needed to place each item in the inventory on the selection line. Companies with warehouses over 50,000 square feet can determine whether to use a long or short selection line on the basis of order size and warehouse equipment used.

Studies were conducted in two companies, each with an annual business volume of approximately $30 million in groceries, serving the same number of stores, and having similar working conditions. One firm operated a warehouse with a short selection line with order fillers assembling merchandise on 4-wheel trucks pushed by hand. The other firm used a long selection line with orders assembled on trains of three or four selector trucks towed with an electric tractor. Both firms used a fixed slot system of merchandise placement. Order filler productivity in the firm with the short selection line averaged 208 cases per man-hour on orders of more than 700 cases in size. In the firm with the long selection line and use of electric tow tractors, order filler production for the same size orders averaged 247 cases per man-hour, or nearly 19 percent greater (table 6).

An evaluation of the most economical order assembly system must include order filler production, as well as equipment cost, as is shown in table 6. Savings with use of a long selection line totaled 0.146 cent per case or nearly 12 percent. The findings of these two firms indicate a long selection line with tow tractors is more economical in firms servicing large retail orders.

Numbering Warehouse Locations

Merchandise in most grocery warehouses is assigned a warehouse location which is usually designated with a 4 digit number with the lowest number starting at the beginning of the selection line and the highest number located at the end of the selection line or in the packing room. The manner in which numbers are assigned merchandise locations determines the travel routes of order selectors in assembling retail store orders. The placement of incoming

merchandise and selection of retail store orders by warehouse location numbers is more efficient than when these functions are performed with use of item description. 7/

Table 6.--A comparison of order filler productivity and equipment cost with a short selection line and a long selection line in two companies on orders larger than 700 cases

Method	Order filler productivity 1/	Selection labor cost 2/	Equipment and other labor cost 3/	Total labor & equipment cost
	Cases per man-hour	Cents per case	Cents per case	Cents per case
Short selection line hand pushing	208	0.966	0.110	1.076
Long selection line tow tractors	247	0.814	0.116	0.930

1/ Includes a 15 percent personal and fatigue allowance.
2/ Assuming an hourly wage of $2.01.
3/ With the short selection line for each hour of order assembly an additional 1/10-hour use of a forklift truck and operator is included to move merchandise from reserve storage to the selection line. With the long selection line equipment cost includes a manually operated tow tractor. Table 5 shows hourly cost of various kinds of materials-handling equipment.

There are various numbering systems. The conventional numbering system used for floor slots in warehouses with grocery orders averaging less than 700 cases in size is the odd and even system. With the odd and even system warehouse floor locations are numbered with even numbers on one side of the aisle and odd numbers on the other side. Merchandise selection with this numbering system requires a considerable amount of aisle crossing.

With the pivot system of order assembly, cases are selected from a predetermined number of slots on one side of an aisle before crossing (pivoting) to the other side to make selections from the same number of slots there. Initially, when first starting an aisle or when crossing a center aisle, the number of slots to be selected from before a pivot is made will be determined by minimizing the backtrack distance necessary to reach the first selection site on the other side of the aisle. The pivot system (right side) and conventional system (left side) are illustrated in figure 24 with travel routes shown that assume a selection at each slot.

Numbering warehouse floor slots so orders are selected from only one side of the aisle is used in many warehouses handling large orders of more than 700 cases in size with order selectors using relatively high speed tow tractors and a train of 3 or 4 trucks. With this system, a second trip is made through each aisle to select merchandise from the other side.

7/ Marketing Research Report 94, p. 16.

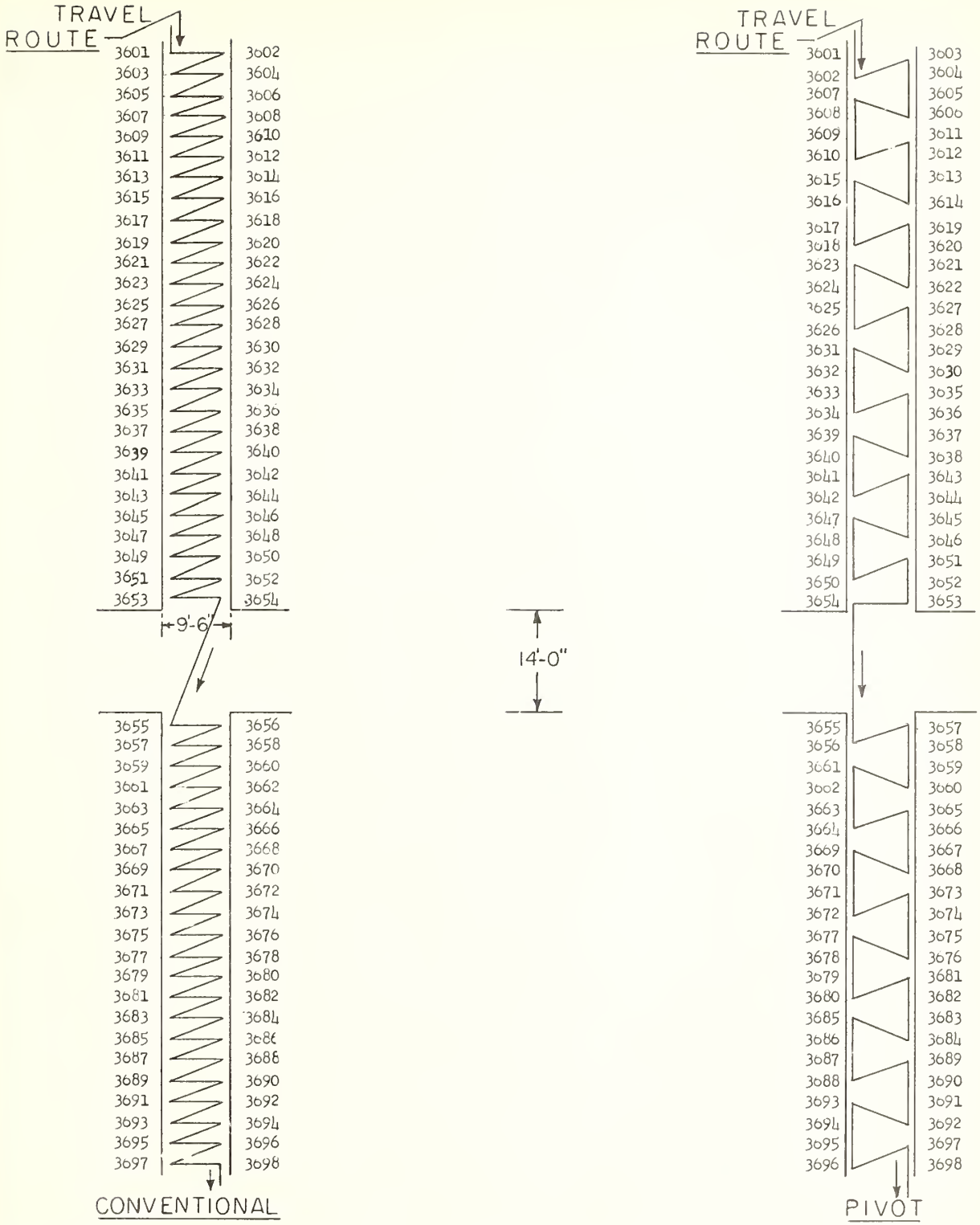

Figure 24.--Conventional and pivot numbering systems and travel routes for floor slots assuming a selection is made at each location.

By increasing the number of items selected from one side of the aisle before crossing the aisle to select additional items as in the pivot system, the travel distance is reduced and an increased order assembly rate should be realized. A study of the pivot system compared with the conventional system was conducted at one grocery warehouse that had wide aisles in a 2-deep slot area and where assembled cases of merchandise were placed on 4-wheel handtrucks. Figure 24 shows the numbering systems used in the study. After a training period order assembly was time-studied for identical days of the week used in the study of the conventional operation.

Table 7 shows order assembly production and distance traveled in the studies based on the number of cases selected per order in the aisle. Productivity was nearly 26 percent greater with the use of the pivot system. Merchandise was selected at the rate of 240 cases per man-hour with the conventional method and 302 cases per man-hour with the pivot system. Order size averaged the same, 8.7 cases in both studies and ranged from 2 to 43 cases per order in the one aisle.

Table 7.--A comparison of cases selected per man-hour and average distance traveled, based on the number of selections per order in the experimental 2-deep slot aisle

Order size	Conventional system			Pivot system		
	Number of orders	Average travel distance	Order filler production per man-hour	Number of orders	Average travel distance	Order filler production per man-hour
Cases	Number	Feet	Cases	Number	Feet	Cases
1 - 3...	7	235	144	7	214	151
4 - 6...	7	267	208	7	238	242
7 - 9...	5	273	228	5	252	271
10 - 12...	3	282	235	3	265	289
13 - 15...	4	331	263	4	309	349
16 and over	2	430	275	2	371	393
Total or wtd. av.	28		240	28		302

The increased labor productivity shown in table 1 is based on the study of 2-deep slots composed of merchandise that would be classified as medium fast movers. Studies of selection patterns were not made in slots larger than 2-deep, pallet racks, bench areas or the repack room. The pivot system of numbering could be applied to these areas and some increase in production could probably be achieved.

Determining the Best Aisle Width

The optimum warehouse aisle width for a particular company depends on construction costs, equipment costs, and labor requirements. Costs for land and building amortized over a period of 20 years usually constitute about 40 percent of the total operating costs in a new warehouse. Labor cost usually

totals 50 percent of the operating cost. The other costs are for equipment, insurance, and taxes.

In this section an examination will be made of the relation of warehouse aisle width and associated handling methods to the major costs of grocery warehouse operations for food distributors having relatively small, medium, and large grocery volumes.

A wholesaler with an annual business volume of $6 million should design the warehouse for a volume of $8 million to allow for expansion. A warehouse designed with aisles 10 feet wide requires about 48,000 square feet to accommodate and handle a 4,000 item inventory, normal for this size business. With use of 6½-foot aisles only about 42,000 square feet would be required. Construction costs for the building at 1958 prices would be about $6 per square foot. The capital necessary to construct the different size warehouses was amortized for a 20-year period at 5 percent interest and equals the rental cost shown in table 8.

Table 8.--Estimated comparative annual costs of two alternate aisle widths for warehouses designed for $6 million annual business volume

Item	10-foot aisle		6½-foot aisle			
	One shift		Two shifts		One shift	
	No.	Dollars	No.	Dollars	No.	Dollars
Annual rental	-	23,110	-	20,221	-	20,221
Total forklift cost 1/	2	2,290	2	2,802	2	2,471
Warehouse labor	8	33,446	8	35,330	8	33,446
Warehouse supervision	1	7,000	2	13,000	1	7,000
Total cost		65,846		70,353		63,138

1/ Table 5 shows detailed cost data for various types of materials-handling equipment.

As shown in table 8, rental cost with the 10-foot aisle warehouse would total $23,110, whereas with the 6½-foot aisle warehouse the rental cost would total only $20,221. With an annual business volume of $6 million, two forklift trucks would be needed with either warehouse layout. With the 10-foot aisle building, counter-balanced forklift trucks operated with gasoline or liquefied petroleum gas would be used. With the 6½-foot aisle building, the straddle-type electric forklift trucks would be used. According to research, in warehouses of this size eight warehousemen would handle the receiving and order assembly with either warehouse layout. In the 10-foot aisle building all receiving and shipping would be done during one shift with eight men at a wage rate of $2.01 per hour. With the 6½-foot aisle building, either all receiving would be done during the daytime with three men at a wage rate of $2.01 per hour and all shipping would be done during a night shift with five men at a wage rate of $2.11 per hour. or all of the receiving and shipping would be done during one shift. The labor cost with the 10-foot aisle and the 6½-foot aisle

operating one shift would total $33,446 and with the 6½-foot aisle operating two shifts would total $35,330. With use of two shifts in the 6½-foot aisle warehouse it would be necessary to provide supervision during both shifts, hence a supervisory cost of $7,000 for the general superintendent during the day shift and $6,000 for a night supervisor for a total supervisory cost of $13,000. In both warehouses orders would be assembled on 4-wheel handtrucks. These costs are assumed to be equal, and so are not shown in table 8.

Some food distributors report they can satisfactorily receive and ship merchandise during one shift with the 6½-foot warehouse aisle layout up to an annual business volume of $6 million; however, as volume increases above $6 million, aisle congestion becomes too great and it is necessary to receive and ship merchandise during different shifts. A review of the cost factors in this situation would indicate that the food distributor should build a warehouse with 6½-foot aisles for his present business volume. As business volume increased he could expand the warehouse and use 10-foot warehouse aisles.

A comparison of actual costs in a 115,000 square foot warehouse with 10-foot aisles was made with estimated costs in a warehouse of comparable volume using 6½-foot aisles. The building was designed to handle a $20 million annual grocery volume. Orders were selected on 4-wheel trucks pulled by electric tractors. With use of a 6½-foot aisle, a saving of 10,336 square feet of warehouse floor space would be realized. With the 6½-foot aisle, 4-wheel trucks would be pushed manually along the selection line. A comparison of estimated annual costs with a 6½-foot aisle with actual costs with a 10-foot aisle is shown in table 9.

Table 9.--Estimated comparative annual costs with two alternate aisle widths for a warehouse designed for $20 million annual business volume

Item	10-foot aisle		6½-foot aisle	
	Number	Dollars	Number	Dollars
Annual rental	-	55,367	-	50,391
Forklift truck cost 1/	4	5,428	4	5,795
Order filler tractor cost 1/	5	3,178	-	-
Warehouse labor	17	72,332	20	86,736
Warehouse supervision	2	13,000	3	19,000
Total annual cost		149,305		161,922

1/ Detailed cost data shown in table 5.

With the 10-foot aisle a 115,000 square foot warehouse is needed to handle the existing inventory and business volume. Rental costs (table 9) are based on $6 per square foot construction cost and the capital necessary to build the warehouse was amortized over a 20-year period at an interest rate of 5 percent. Three counter-balanced forklift trucks of 2,000-pound capacity each and one of 4,000-pound capacity were used. One of the 2,000-pound capacity forklift trucks was used during two shifts to service order filler calls and make letdowns. Five electric tow tractors were used for two shifts each day

by order fillers at a cost of $3,178 annually. A total of 17 warehousemen was needed to handle the receiving and order assembly in the 10-foot aisle warehouse: 5 men receiving merchandise and 6 men assembling merchandise during the daytime at a wage rate of $2.01 per hour; and 6 men assembling merchandise during the night shift at $2.11 per hour. Each shift had a supervisor.

With a 6½-foot aisle layout, a total of 104,664 square feet of warehouse space would be needed at an annual rental of $50,391, or more than $5,000 less than the rental required with the 10-foot aisle layout. It was estimated that four straddle-type forklift trucks would be needed -- three forklifts of 2,000-pound capacity, and one of 4,000-pound capacity. Two 2,000-pound straddle forks would be used for two shifts to move merchandise from reserve storage to the selection line. A total of 20 warehousemen would be needed to handle the receiving and order assembly with the 6½-foot aisle layout: 5 men at $2.01 per hour would receive merchandise during the day shift; and 15 at $2.11 per hour would assemble merchandise during the two night shifts. Eighteen percent more order filler productivity is achieved with the long selection line and tow tractors used in the 10-foot warehouse aisle layout, one additional order filler is needed during each shift in the 6½-foot warehouse aisle and one additional forklift truck driver would be needed to move merchandise from reserve storage to the assembly line for the two shifts. With the warehouse operating three shifts per day it is necessary to provide a supervisor for each shift.

Total annual cost for factors affected by the warehouse layout amounted to $149,305 with the 10-foot aisle and $161,922 with the 6½-foot aisle, or a saving of $12,617 with the 10-foot aisle warehouse.

Studies were conducted in two companies with about $35 million business volume each, with comparable order sizes, and servicing approximately the same number and type of stores. One firm used a perimeter towline to move assembled orders on 4-wheel trucks to the shipping dock and to bring empty trucks to the assembly area. Order selectors pushed 4-wheel handtrucks through a short selection line and attached loaded trucks to the towline. Warehouse aisles were 6½ feet wide and it was necessary to ship merchandise during the night and receive merchandise during the day.

The other firm used electric tow tractors to pull a train of three or four selector trucks through the long selection line and completed orders were taken to the shipping dock by order fillers with the electric tractor. Aisles were 10 feet wide and receiving and shipping were accomplished in one shift. Table 10 shows an annual cost comparison of factors affected by warehouse layout in the two warehouses.

Annual rental in the warehouse with the 10-foot aisle totaled $73,085 for 151,800 square feet. Six counter-balanced forklift trucks are used to handle the business volume, four 2,000-pound capacity and two 4,000-pound capacity forklift trucks. A long selection line with a fixed slot system of warehousing is used with order selectors driving eight electric radio control tow tractors for order assembly. Order filler production on all orders averages 247 cases per man-hour (table 6). All warehousing is conducted during the day shift at

a wage rate of $2.01 per hour with 9 men receiving and 17 men shipping the merchandise. One superintendent is in charge of the warehousing operation.

In the 6½-foot aisle warehouse, annual rental totaled $64,997 for 135,000 square feet. Six straddle-type forklift trucks are used: Four 2,000-pound capacity and two 4,000-pound capacity. Two of the 4,000-pound capacity forklift trucks are used two shifts per day or 4,000 hours per year to move merchandise from reserve storage to the short selection line.

Order fillers push 4-wheel handtrucks in order assembly and average 208 cases per man-hour (table 6), or 84 percent as much as order fillers in the 10-foot aisle warehouse. An in-the-floor towveyor is used to move assembled orders to the shipping dock and to bring empty selector trucks to the order assembly area. Two shifts, with a total of 33 men, are used in the warehouse: 12 men at $2.01 per hour received merchandise during the daytime; and 21 men worked the night shift shipping the merchandise at $2.11 per hour. The general superintendent is in charge of the day shift and a supervisor is in charge of the night shift.

The total annual cost for factors involved with the two systems is $204,328 with the use of the 10-foot aisle and $232,594 with the use of the 6½-foot aisle, or an annual saving of $28,266 in the warehouse with 10-foot aisles.

Table 10.--Comparative annual costs in 2 firms with different warehouse layouts, each having a $35 million business volume

Item	10-foot aisle		6½-foot aisle	
	Number	Dollars	Number	Dollars
Annual rental	-	73,085	-	64,997
Forklift truck cost 1/	6	7,702	6	8,458
Tow tractor cost 1/	8	7,840	-	-
Towveyor cost 1/	-	-	1	3,805
Labor cost	26	108,701	33	142,334
Supervision	1	7,000	2	13,000
Total cost		204,328		232,594

1/ Detailed cost data shown in table 5.

The Repack Room Layout and Methods

Studies conducted in the packing rooms illustrated the importance of layout, workplace arrangement, and product flow. The volume of business done in the repack room of an average size grocery wholesaler is large enough to keep several men fully occupied. This is particularly true if cigarettes are handled because they must be stamped in addition to the usual warehouse handling. Labor expense is a major part of the cost of the repack service.

An analysis was made of the repack room order assembly operation and of the various elements of the job in a number of the firms studied. Flow diagrams were used to plot the movement of merchandise and men in the packing room. In one firm a flow diagram (fig. 25) showed that with the existing layout a nonproductive walking distance of 75 feet requiring 8.6 percent of the total order assembly time could be eliminated by locating the repack bench at the end of the selection line.

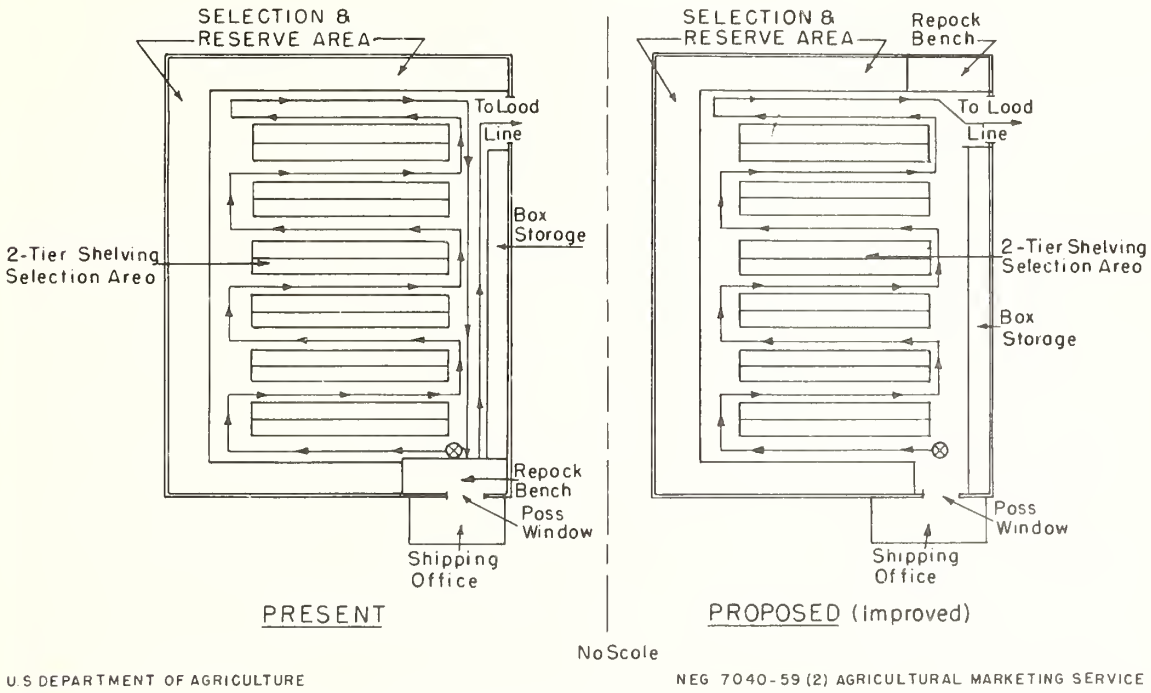

Figure 25.--A packing room layout showing present and proposed (improved) travel routes.

Shelf locations in the packing room should be numbered in the same sequence as items are listed on the retailer order form or invoice. With this procedure the productivity in order assembly will be increased because backtracking and hunting for items will be greatly reduced. This method also reduces the amount of reading time because the items will be listed in selection sequence, eliminating the need for flipping pages and rapid scanning of the invoice.

With the exception of one firm, all the companies studied assembled merchandise in the packing room on small 4-wheel handtrucks, moved the assembled merchandise to a packing table, checked, packed, and sealed it in cardboard boxes. This method required 44 percent more time than orders assembled in master containers as was done in the other firm (table 11). With use of cardboard boxes the merchandise is tightly packed to avoid damage in the delivery truck, whereas with the master container the merchandise is not packed tightly, although the master container is rigid.

Table 11.--Time required to assemble and pack a 60-unit order in the packing room with use of cardboard boxes and master containers

Element	Time required with cardboard boxes	Time required with master containers
	Man-minutes 1/	Man-minutes 1/
Obtain invoice and selector truck	0.47	0.47
Obtain master container	-	.21
Travel	9.51	9.51
Read and write	6.44	6.44
Select merchandise	4.83	4.83
Place merchandise on packing bench	3.45	-
Obtain packing box	.54	-
Check, box, and seal merchandise	6.21	2/ .27
Mark store number on container and dispose	.39	.39
Total time	31.84	22.12
Units assembled per man-hour	113	163

1/ Includes 15 percent personal and fatigue allowance.
2/ Time required to place top on master container.

Productivity with use of a master container for assembly and shipment was 44 percent greater, or 163 units per man-hour, compared with 113 units for assembly, checking, packing, and sealing the merchandise in cardboard boxes. Increased productivity with use of the master container method was primarily due to elimination of the need to pack the merchandise in boxes after selection (table 11). The firm using the master container reported no increase in damage with its use, although it was necessary to sign master containers out to the retail stores in order to assure their return to the warehouse.

The master container, shown in figure 26, is made with a metal frame over which canvas is sewn. The container rests on a wooden base and has a clamp-on type wooden top which is attached before the container is taken to the shipping dock to protect the merchandise during shipment. An additional advantage of this container is that it can be nested when empty by removing the wooden top.

Many wholesalers supply their retail customers with tobacco products in addition to groceries, produce, and frozen foods. The chief tobacco item handled is cigarettes, with from 30 to 40 different brands, sizes, and types stocked by the wholesaler. Carton quantities of each brand of cigarettes ordered by retail stores are selected from full cases, packed in empty cases, sealed with tape, moved to the shipping dock, and delivered to the stores with grocery orders. Some companies limited cigarette sales to a minimum of five cartons of any particular brand, size, or type.

In addition to receiving case-lot quantities, assembling and delivering retail store cigarette orders, many wholesalers must affix a local or State revenue tax stamp and maintain accounting records of this function. In some

instances, separate stocks and assembly areas must be maintained when a wholesaler supplies cigarettes to retailers in areas having different tax laws.

Steps usually followed in handling cigarettes are: (1) Case-lot quantities are received from motortrucks; (2) they are moved to temporary storage, (3) stamped, and (4) moved into reserve storage and assembly areas. Figure 27 shows the travel distance and storage areas used for handling cigarettes through the four steps in one firm studied. By relocating the places where cigarettes were stored, stamped, and selected it was possible to reduce the travel distance nearly 80 percent from 445 feet to 90 feet, as shown in figure 28. Along with this change, delays in waiting for a forklift truck to move pallet quantities of cigarettes from reserve storage were reduced and greater security was gained by having all cigarettes in one location, fenced off from the remainder of the warehouse.

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Figure 26.--A master container used for shipping packing room merchandise to retail stores.

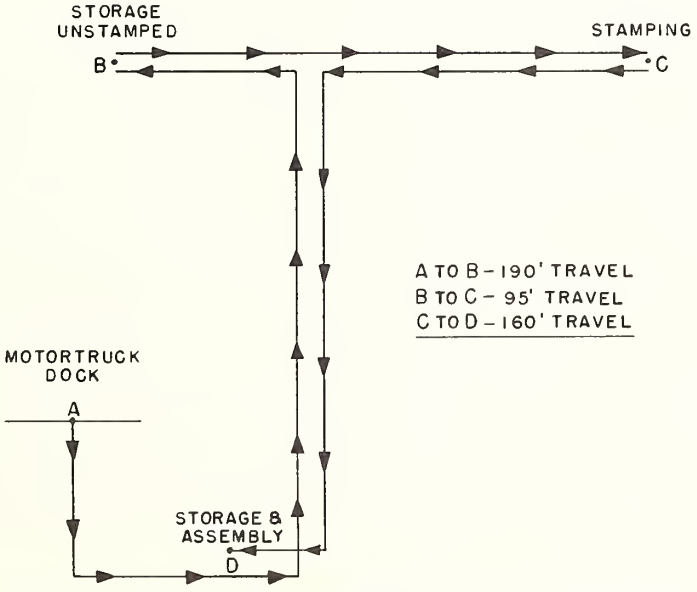

Figure 27.--Flow of cigarettes in a warehouse requiring 445 feet of travel.

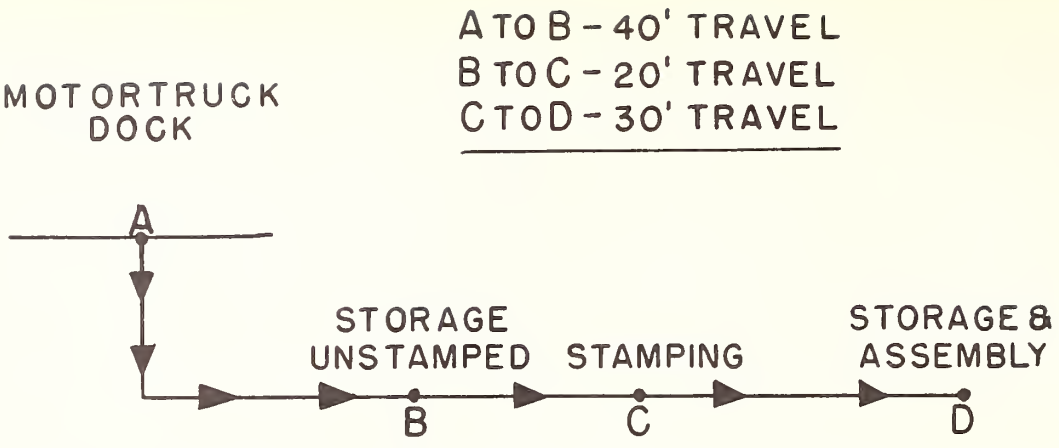

Figure 28.--An improved cigarette flow requiring 90 feet of travel.

In addition to changing the flow and storage areas for cigarettes, an improved method of assembling retailer orders of different brand cigarettes was tested in this firm. Figure 29 shows the former method used in cigarette order assembly. The order filler obtained cartons of cigarettes ordered from

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Figure 29.--Assembling cartons of cigarettes in an 11- by 32-foot room.

stocks of cigarettes scattered around a 32- by 11-foot room requiring a minimum of 80 feet of travel and took them to a table where the order was checked, packed in an empty case, and sealed with tape. Figure 30 shows the travel distance required with this layout. Because cigarettes were not listed on the invoice in accordance with the warehouse location, order fillers frequently made several trips through the area in assembling a particular order. With this system of order assembly a total of 6.8 man-minutes was required to assemble a 60-carton order of 12 brands or types of cigarettes.

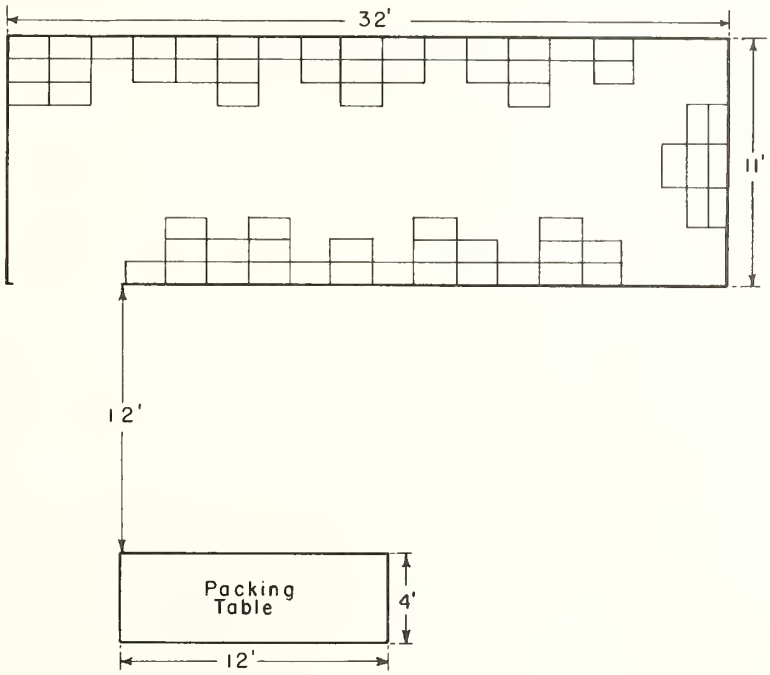

Figure 30.--Travel distance required for order assembly with the former cigarette room layout.

A cigarette assembly rack holding 30 cases of cigarettes and made of 3/4-inch plywood was installed in this firm. The dimensions of the rack are shown in figure 31. With use of this rack and stool built to hold an empty case, only 1/3 as much time or 2.25 man-minutes were required to assemble, check, pack, and seal a 60-carton order of 12 brands. The firm assembled and shipped 6,000 cartons or 100 cases of mixed brand cigarettes each day. With the cigarette assembly rack the number of man-hours required to assemble, check, pack, and seal the cigarettes was reduced nearly 67 percent from 11.3 to 3.75 man-hours per day. Figure 32 shows use of a rack for cigarette assembly.

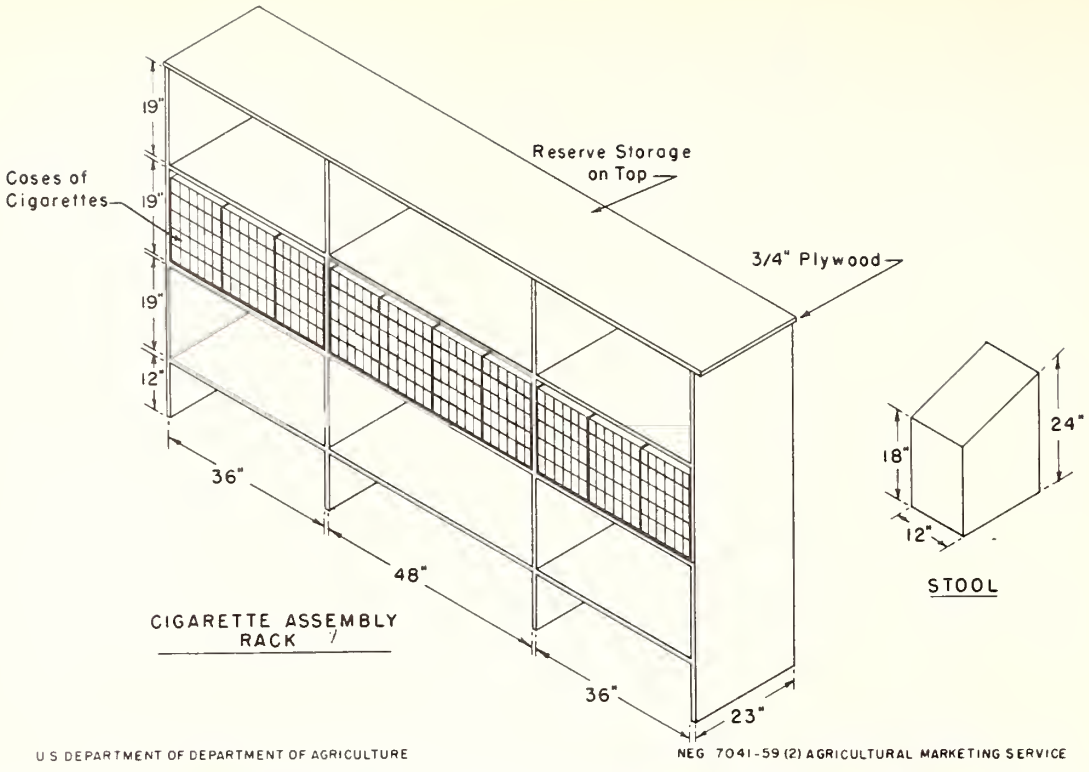

Figure 31.--Dimensions for a cigarette assembly rack and stool for holding 30 brands, types, or sizes of cigarettes.

FLOW OF MERCHANDISE IN THE WAREHOUSE

Management is interested in an efficient flow of merchandise into and out of the warehouse. Flow of merchandise is involved in all of the main segments of the operation: Receiving, order assembly, checking assembled merchandise, and loading delivery trucks. Other parts of the warehousing operation, such as the repack room, tabulating, and accounting departments are affected to a lesser degree by the warehouse layout. The flow of merchandise and warehouse layout requires constant review to meet changing business volumes and items handled.

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Figure 32.--An improved method of cigarette assembly with use of a rack and stool.

Receiving

The receiving of merchandise into the warehouse is usually performed during the day shift. With a warehouse layout having $6\frac{1}{2}$-foot aisles it is not

possible for a 4-wheel warehouse truck and a forklift truck to pass in the narrow aisles; hence, the receiving and shipping operations should not be performed at the same time, particularly if annual business volume is more than $6 million. When a towline is used for receiving and shipping merchandise, it should not be used for both operations simultaneously.

In warehouses having aisles 10 feet wide, the 4-wheel warehouse trucks and forklift trucks can meet or pass in the aisle. This permits the simultaneous receiving and shipping of merchandise in an efficient manner.

Sufficient area on the receiving dock should be provided for a temporary block between the palletizing and storing operation with both the narrow and wide aisle warehouse layout. A temporary block area 40 feet deep is shown in back of the truck receiving area (fig. 33). With use of the temporary block the palletizing and storing of merchandise can be performed separately, and it is not necessary for the palletizing crew to wait for the forklift, or vice-versa.

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Figure 33.--A temporary block area at the truck receiving dock.

Order Assembly

Traffic problems often may be solved by a study of merchandise flow with use of diagrams. Congested areas that slow down the movement of merchandise and transfer points at which merchandise must be double handled can often be eliminated or avoided. For example, in one warehouse studied the chief delay, totaling 5.8 percent of order assembly time, was in waiting for space to put assembled orders on the towline and in waiting for an empty selector truck. Inspection of the shipping dock when this delay occurred showed that the dock was not overcrowded with assembled orders but the checkers were working on particular retailer orders and other orders were left on the towline. With this procedure, the towline soon became loaded with assembled orders while the checkers waited for parts of a specific retailer order. This delay was eliminated by having the checker remove all assembled orders from the towline as they passed the shipping dock. The towline no longer became full of assembled orders, thus eliminating waiting time by order fillers for space on the towline and for empty selector trucks.

Aisle width affects traffic flow considerably because, as previously noted, it is nearly impossible for order selectors and forklift trucks to pass each other in a 6½-foot aisle. It was found impractical during the study to use a selector truck wider than 30 inches in a narrow aisle. It was also found helpful to establish one-way travel in warehouse aisles, particularly when narrow aisles are used.

Figures 34 and 35 show how improved order selection efficiency was obtained through use of flow diagrams. The diagram (fig. 34) shows a nonproductive travel distance of 820 feet in the assembly line to travel from the end of one section to the beginning of the next. This nonproductive travel distance by the order filling crew of 16 men required 3.2 percent of the order assembly time or more than 4 man-hours per day. By rearranging the section's order box locations and order filler travel routes the nonproductive travel distance was reduced to 135 feet (fig. 35) and required only 0.5 percent of the order assembly time.

Loading Assembled Orders

The time required for efficient checking of assembled orders and loading of delivery trucks is dependent on provision of sufficient space on the dock for checking orders and having a dock level with motortruck beds.

In some of the warehouses studied, orders were assembled on pallets that had been placed on 4-wheel handtrucks. The pallets were moved into delivery trucks with a forklift truck. Figure 36 shows a forklift truck entering a delivery trailer with a pallet load of merchandise. In one of the warehouses using this method, time studies showed that trucks were loaded at the rate of 1,875 cases or 56,625 pounds per man-hour. The best manual method for loading trucks is with one man working alone. He loads from a 4-wheel handtruck which he positions inside the delivery truck. With this method production averaged 562 cases or 16,580 pounds per man-hour. 8/ Labor productivity with pallet loading by forklift was approximately 3-1/3 times greater than this manual loading method. One man operated the forklift truck and placed pallet quantities of merchandise in the delivery truck.

8/ Marketing Research Report 94, p. 22.

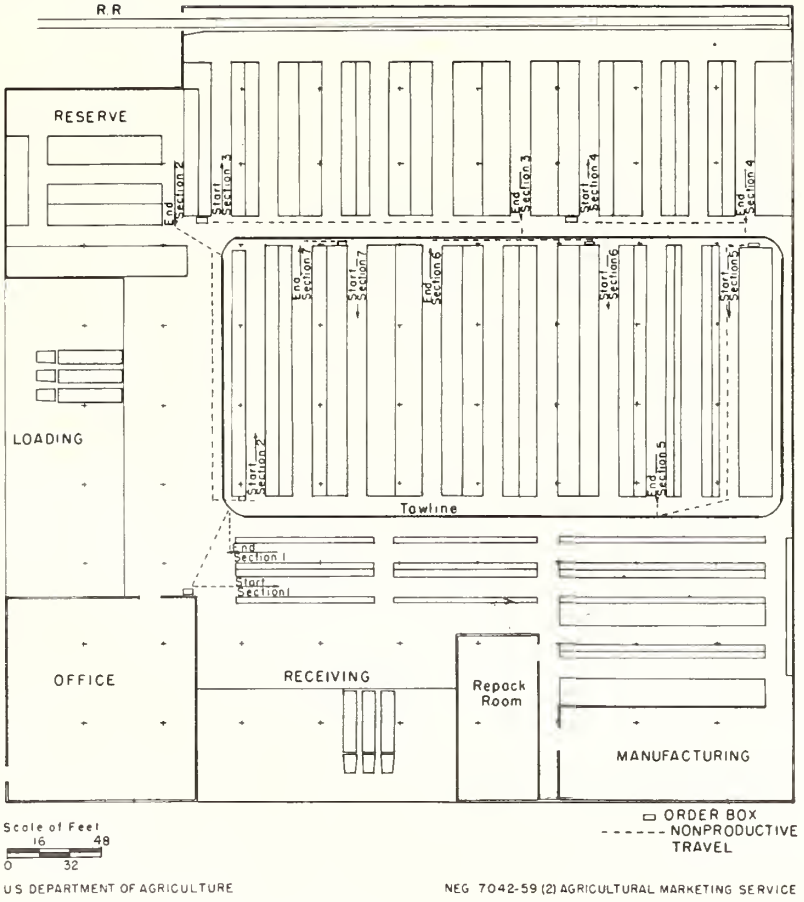

Figure 34.--Order filler travel route with 820 feet of nonproductive travel.

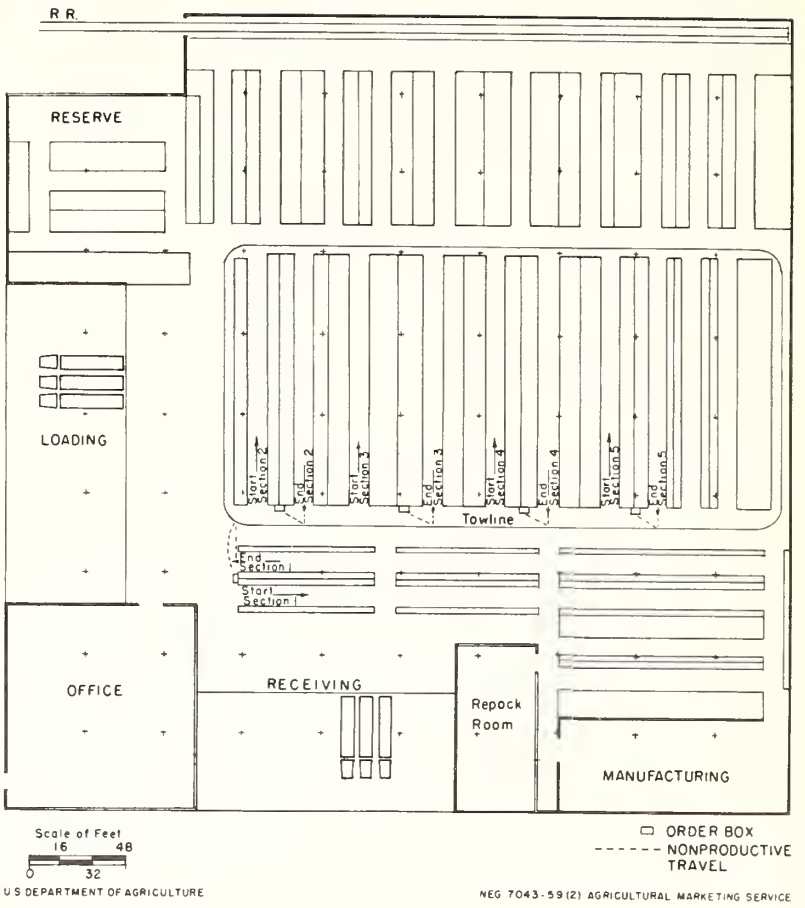

Figure 35.--An improved order filler travel route with only 135 feet of nonproductive travel.

In another warehouse it was evident that there was insufficient surge or holding area for assembled orders on the shipping dock. The 33-foot depth from the edge of the dock to the center of the towline could not hold a line of more than three order-selector trucks behind each trailer; consequently, a very close crew balance had to be maintained between order assembly and loading. Order selectors frequently had to wait for empty selector trucks or loaders had to wait for assembled merchandise to load on delivery trucks, resulting in considerable delay time. It was also necessary to load delivery trucks manually with two men working as a team; principally because of the lack of dock space. Based on studies conducted in other warehouses, it was estimated that with a dock 50 feet deep the number of men loading trucks could be reduced by 1/3 and also the order filler delay in waiting for selector trucks would be reduced.

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Figure 36.--Loading a delivery truck with a pallet load of mixed merchandise.

GROCERY WAREHOUSE LAYOUTS PLANNED FOR MAXIMUM PRODUCTIVITY

The warehouse layouts in this section are presented to illustrate research findings discussed in this report. These layouts are based on inventories of approximately 4,000 grocery items, use of automatic tabulating equipment in the office, and an annual inventory turnover of from 16 to 18. 9/ In the grocery warehouses support columns are spaced 40 feet apart from center of column to center of column. A canopy is shown over the edge of the ramp at the motortruck shipping and receiving docks to prevent rain from entering the warehouse or damaging the merchandise in loading or unloading trucks. The motortruck docks and rail receiving docks are shown on the warehouse interior; however, with minor changes in the interior warehouse layout it would be possible to have the docks on the warehouse exterior. With docks on the warehouse exterior, door openings should be 10½ feet high so high-mast forklift trucks can travel onto the dock. The motortruck ramps and rail car siding, as well as the docks, should be enclosed in the warehouse when climatic conditions are severe.

Many wholesale food distributors have experienced a substantial increase in business volume and a desire to service retail stores with produce and frozen foods after moving into a new warehouse and, because land was not available for expansion, it became necessary to move to another location. For these reasons, expansion areas are shown in the warehouse layouts. The perishables warehouse is connected to the grocery warehouse in the layouts so

9/ Annual sales volume divided by the average sales value of inventory equals inventory turnover.

composite loads of groceries and perishables can be loaded from the grocery shipping dock.

Layout for an Annual Grocery Business Volume of $6 to $8 Million

As shown in figure 37, the basic dimensions of the initial warehouse designed to handle a $6 to $8 million annual volume are 200 by 240 feet, or 48,000 square feet. The design provides 12 doors for shipping and receiving merchandise by motortruck and four rail cars can be spotted at doors for simultaneous loading and unloading. The rail car dock would be 45 inches over the top of the rail and the motortruck dock would be level with the motortruck beds. The aisle at the rail siding is 15 feet wide and throughout the rest of the warehouse aisles are 10 to 11 feet wide. The temporary holding area for shipping and receiving merchandise is 50 feet deep at the motortruck dock. Aisles throughout the warehouse are designated one-way so order selectors and forklift operators will have free movement through the aisles without congestion caused by two-way traffic.

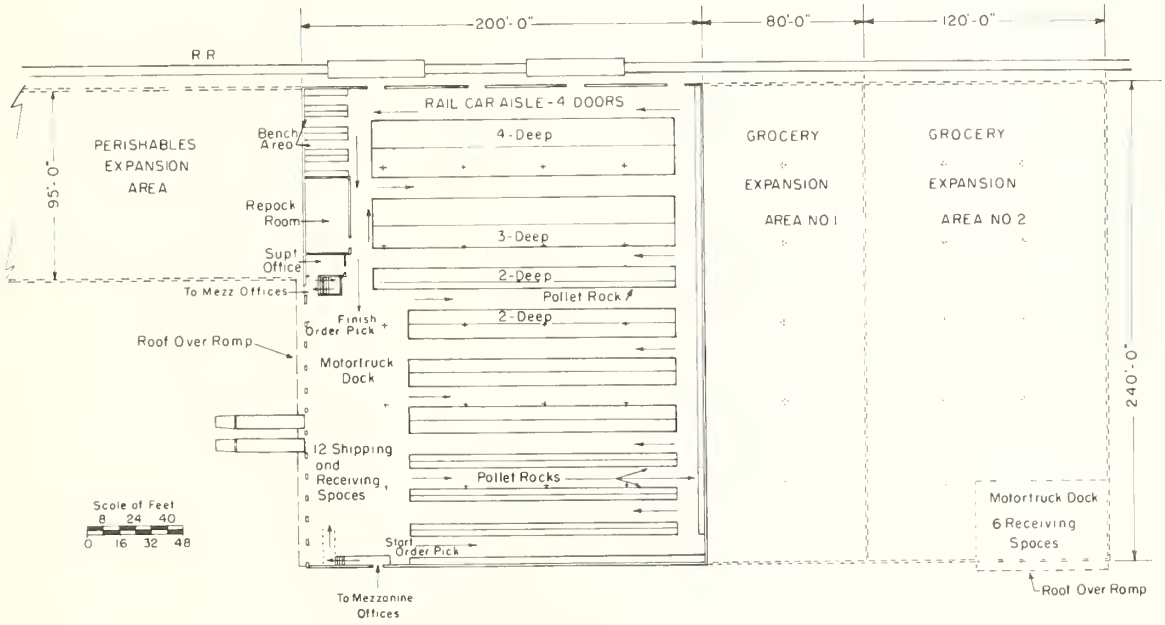

Figure 37.--A suggested warehouse layout designed for a $6 to $8 million annual business volume in groceries with expansion areas.

The fast moving merchandise is located in 4-deep slots near the end of the selection line and near the rail siding (fig. 37). Since order selectors will be pushing selector trucks by hand at this volume of business, it is desirable to locate the fast moving merchandise near the end of the selection line to avoid having order selectors push the bulk of the merchandise through the entire selection line.

The repack room and bench areas (slow moving merchandise handstacked on wooden tables) are also located near the end of the selection line. With this location, items assembled for orders in the repack room may be deposited outside the room for movement to the shipping dock by the regular order selector on his way to the shipping dock or the items may be transported a short distance to the order assembly area.

The general office area for the warehousing operation is located on a mezzanine over the motortruck shipping and receiving dock, packing room, and bench areas, and is reached by two stairways located near the ends of the shipping dock (fig. 37). With this location for the office, it should be possible to reduce construction costs because a ceiling height of not more than 10 feet is needed in the surge area on the dock, in the packing room and bench areas, and the remaining 10 feet of ceiling height can be used for the floor and office above.

Expansion area I (fig. 37) is 240 feet by 80 feet, or 19,200 square feet. With the full use of this expansion area grocery warehouse floor space would total 67,200 square feet and would accommodate an annual volume of approximately $13 million in groceries. With the increased warehouse size it would be necessary to use tow tractors capable of towing five selector trucks to keep the order assembly operation efficient.

Expansion area II (fig. 37) is 240 feet by 120 feet, or 28,800 square feet, and with this addition the grocery warehouse area would total 96,000 square feet. It would be possible to handle approximately $20 million annually in groceries in the enlarged warehouse. A 6-door motortruck receiving dock would be placed in expansion area II to provide sufficient space on the original dock for shipping merchandise and to reduce forklift travel in storing receipts.

An expansion area 95 feet wide is also shown for a perishables department for handling frozen foods and produce. A dock in the perishables department would be provided for handling receipts and shipments by motortrucks and rail cars. If composite loading of perishables and groceries is used the perishables warehouse is located adjacent to the grocery shipping dock for convenient access to the grocery shipping dock.

This warehouse layout incorporates the following features that were found desirable in this research project. Merchandise is placed on the selection line with slow moving items in pallet racks at the beginning of the line and with fast moving merchandise in floor slots at the end of the line to reduce the distance order fillers must push the bulk of the merchandise shipped. Sufficient motortruck and rail dock space is provided for receiving and shipping merchandise. Provision is made for locating the offices in a convenient, relatively low cost location over the motortruck dock, packing room, and bench area. Space is provided in the plan for expansion areas that will accommodate three times the initial volume in groceries and provision is also made for a perishables department. Support columns are placed 40 feet apart, which will allow the interior layout to be changed as the building is expanded without encountering problems with support column spacing.

Layout for an Annual Grocery Business Volume of $15 Million

As shown in figure 38 the basic dimensions of the initial warehouse are 240 feet by 320 feet, or 76,800 square feet. Fourteen doors for shipping merchandise and 8 doors for receiving merchandise by motortruck are provided. The dock at the rail siding would be 45 inches over the top of the rail. Five rail cars can be spotted at doors for simultaneous unloading into the 15-foot wide aisle at the rail siding. Remaining aisles throughout the warehouse are 10 to 11 feet wide. The temporary holding area at the shipping dock is 50 feet deep and is 40 feet deep on the motortruck receiving dock.

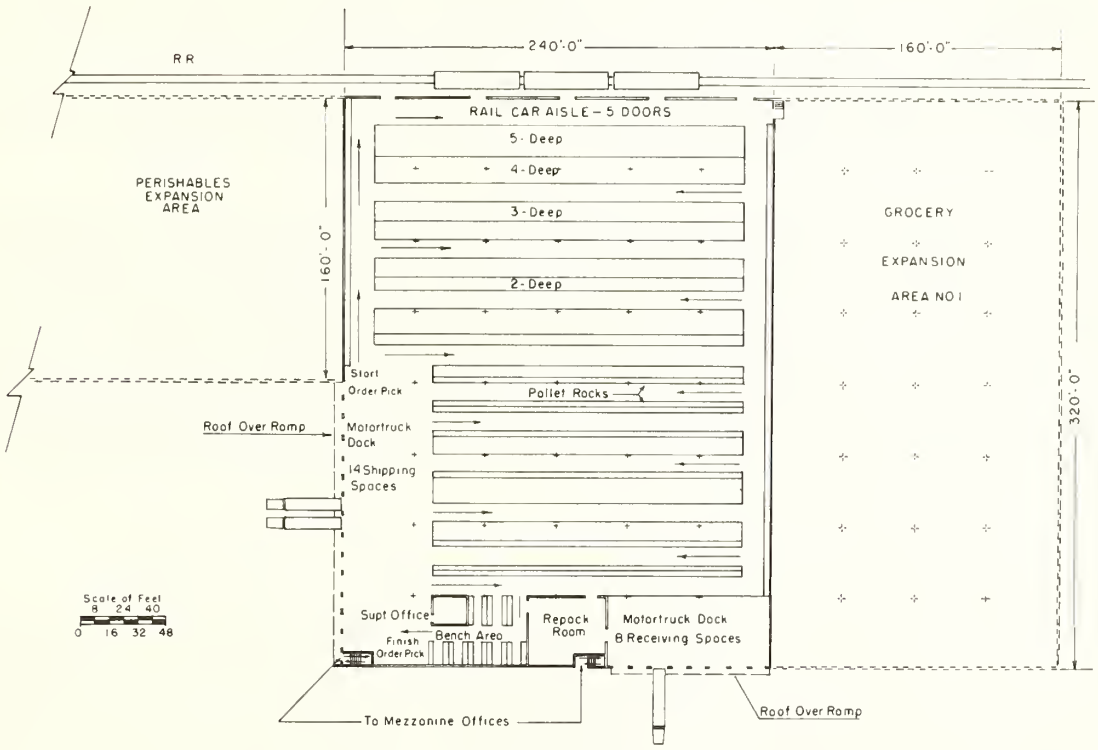

Figure 38.--A suggested warehouse layout designed for a $15 million annual business volume in groceries with expansion areas.

The slots for fast moving items are located near the rail siding and motortruck receiving dock. Since order fillers in this warehouse would use tow tractors during order assembly, it is not necessary to place the fast moving items near the end of the selection line. Aisles throughout the warehouse are designated one-way and lead directly to the shipping dock, where order selectors can leave assembled orders, obtain the next order and return to the selection area without spending an excessive amount of time in travel (fig. 38).

The repack room and bench areas are located near the shipping dock. The general office area is located on a mezzanine over the shipping dock, bench area, packing room, and truck receiving dock, and is reached by two stairways; one located at the end of the shipping dock and the other at the end of the receiving dock. A ceiling height of approximately 10 feet is needed over the docks, bench area, and packing room, leaving approximately 10 feet of height that can be used for office space on the second floor at lower cost than first floor space.

An expansion area is provided for the grocery warehouse measuring 160 by 320 feet, or 51,200 square feet. With this expansion area in use, grocery warehouse space would total 128,000 square feet and an annual grocery volume of approximately $25 million could be handled through the expanded warehouse. Three additional rail car doors would be provided, making a total of eight rail cars that could be unloaded simultaneously in the grocery warehouse. An expansion area 160 feet wide is shown for a perishables department for handling frozen foods and produce. Docks could be provided in the perishables department for handling receipts and shipments by motortruck and rail cars.

This warehouse layout is planned with the following desirable features. The rail receiving dock and motortruck receiving dock are located on opposite sides of the warehouse with merchandise received by the respective carriers located on the side of the warehouse where such merchandise is received. Sufficient dock space is provided for receiving and shipping merchandise. The order filler travel route begins near the shipping dock and ends near the shipping dock, thus eliminating the need to transport assembled merchandise great distances to the shipping dock. Provision is made for an expansion area for the grocery warehouse, as well as the addition of a perishables department.

Layout For An Annual Grocery Business Volume of $25 Million

As shown in figure 39, the basic dimensions of this initial grocery warehouse are 320 by 400 feet, or 128,000 square feet. Sixteen doors for shipping merchandise and 10 doors for receiving merchandise by motortruck are provided. The temporary holding area on the motortruck shipping dock is 50 feet deep and is 40 feet deep on the motortruck receiving dock. Seven rail cars can be spotted at doors for simultaneous unloading into the 15-foot aisle at the rail siding. All other warehouse aisles are 10 to 11 feet wide with the exception of the aisles in which the towline operates.

A perimeter towline circles one-half of the warehouse area (fig. 39) and is used to transport assembled orders on selector trucks to the shipping dock and to bring empty selector trucks to the assembly area. With use of the towline, order selectors would remain in the selection area and store orders would be divided into sections to assure an even flow of merchandise to the shipping dock. With the towline, the possibility of congestion caused by many order fillers coming to the shipping dock and travel time to the shipping dock would be eliminated. The center aisle in the warehouse is 20 feet wide to accommodate the towline and two-way traffic.

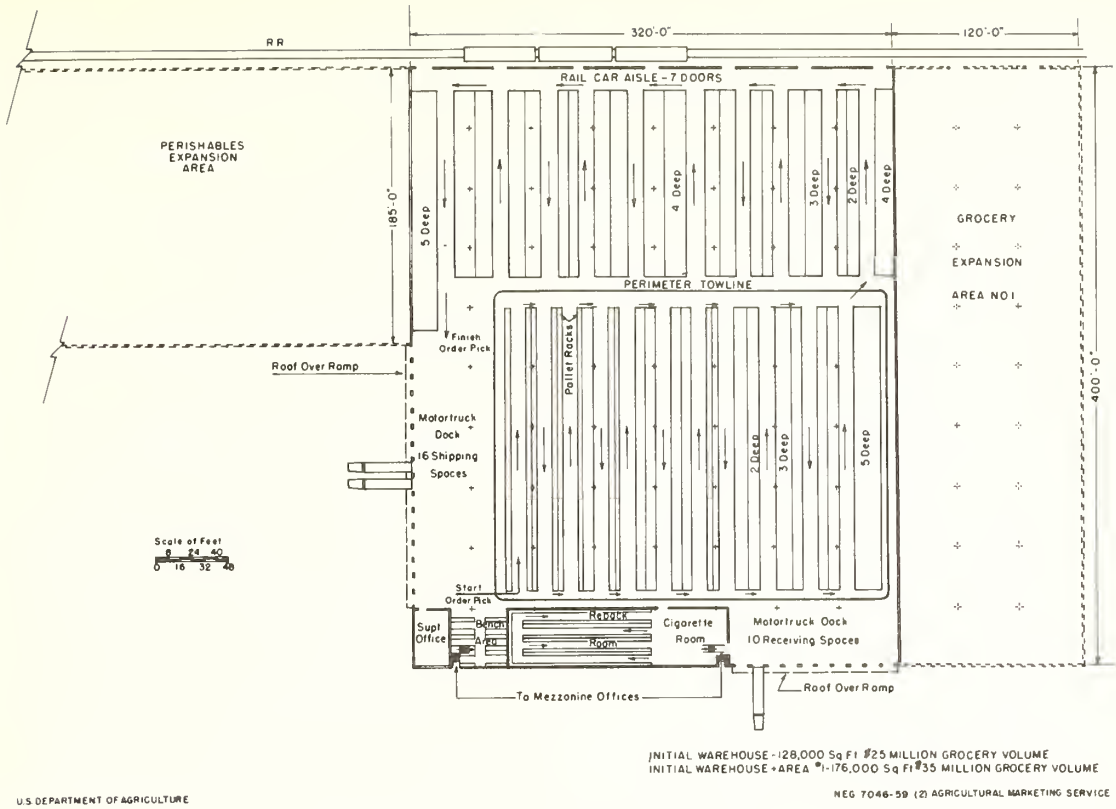

Figure 39.--A suggested warehouse layout designed for a $25 million annual business volume in groceries with expansion areas.

The slots for fast moving items are located principally near the rail siding where most of these items are received (fig. 39). For the fast moving bulky items received by motortruck, several aisles are located near the motortruck receiving docks. It is not necessary to place fast moving items near the end of the selection line with use of towlines and tow tractors. Aisles throughout the warehouse are designated one-way and lead directly to the towline where order selectors can place the assembled orders and obtain empty selector trucks.

The repack room and bench areas are located between the superintendent's office and the motortruck receiving dock (fig. 39). With this location assembled packing room orders can be placed on the towline for transport to the shipping dock. The general office is located on a mezzanine over the motortruck shipping dock, superintendent's office, bench area, packing room, and motortruck receiving dock. The office can be reached by stairways located near the motortruck shipping dock and receiving dock.

An expansion area 120 by 400 feet, or 48,000 square feet, is provided for the grocery warehouse. With the expansion area in use, a total grocery warehouse space of 176,000 square feet would be available and approximately $35 million annual volume in groceries could be handled. A future expansion area 185 feet wide is shown for handling frozen foods and produce. A motortruck dock would be provided for receiving and shipping perishable products. Access to the grocery shipping dock for convenient loading of composite orders of groceries and perishables would be provided.

This warehouse also has the rail receiving dock and motortruck receiving dock on opposite sides of the warehouse. The motortruck docks, packing room, and bench area are on two sides of the warehouse and the office can be located above these areas at comparatively low cost. A perimeter towline is shown to transport assembled orders to the shipping dock and to bring empty selector trucks to the selection area. Expansion areas are provided for additional grocery warehouse space and the addition of a perishables warehouse.

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