DESIGNING A PUBLIC WAREHOUSE for Storing Flat Bales of Cotton

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Preface

The study on which this interim report is based is part of a larger research project, covering improved layouts and designs for cotton warehouses and compresses, conducted by the Handling and Facilities Research Section, Transportation and Facilities Branch, Marketing Research Division, Agricultural Marketing Service.

The authors wish to express their appreciation to the cotton warehousemen who made their facilities available for layout and design studies, furnished construction cost data, and offered helpful suggestions, criticisms, and other assistance.

Special credit is due to Frederick C. Winter, associate professor of industrial engineering, Columbia University, and consultant to the Branch, and Leo E. Holman, supervisory project leader, for their guidance and many helpful suggestions in the preparation of this report. Also to the "Automatic" Sprinkler Corporation of America, Pacific Fire Rating Bureau, Cotton Warehouse Inspection Service, and the Texas State Board of Insurance for suggestions for fire protective features for the compartments described in this report and for providing basic rates for calculating insurance costs on building and contents.

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Designing a Public Warehouse for Storing Flat Bales of Cotton

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Summary

Few of the 1,400 cotton warehouses in use in 1958 were designed for the efficient use of machines for handling bales of cotton. Consequently, operators of public warehouses are concerned about the costs of constructing new storage compartments.

When planning such facilities, operators can save money if they remember that the basic principle of a layout for a cotton storage compartment is to move bales of cotton as easily as possible, over the shortest distance, while at the same time providing a natural sequence of operations, and consider such factors as:

1. Spacing of poles or columns. Poles can be spaced so that the bales can be stacked around them and so that they do not block the aisles.
2. Storage patterns for bales.
3. Width and length of main and cross aisles. Aisles must be wide enough for the efficient use of the handling equipment but not so wide that space is wasted.

An operator can save money if, when deciding on the type of construction, he considers not only construction costs but also insurance, and other annual costs. Maintenance costs may be kept down by putting guards on walls, doors, and columns to prevent costly damage by machines.

This report contains designs and costs for four different types of compartments and a warehouse consisting of six separated compartments. The warehouse is designed for storing 40,000 to 50,000 bales and is suitable for areas of low rainfall, such as the Southwest.

The factors mentioned, as well as insurance rates and other items, were considered in designing the compartments and the warehouse. Estimated construction costs are based on labor rates and material prices for the first quarter of 1958 in the Dallas, Tex., area.

Compartment design A is of pole-frame construction with corrugated metal siding and roofing and hot-mix bituminous concrete floor. Dimensions of the compartment are 177 by 234 feet, and its storage capacity is roughly 7,500 flat bales when they are stacked three high on head. The estimated cost of constructing this compartment in 1958 was $72,000, the lowest of the four designs. This cost is roughly $1.74 per square foot of floor space or $9.60 per bale of storage capacity. On the basis of straight-line depreciation over an estimated useful life of 25 years, annual *building* costs for the compartment would total $2,880 or roughly $0.38 per bale. Total annual *facility* costs, including annual building costs, 5 percent on the average investment for interest, and 2.3 percent on the total investment for taxes, insurance, and maintenance, would approximate $6,340 or $0.85 per bale of capacity.

Compartment design B is of heavy wood beam and girder construction with heavier gage metal siding and roofing than design A. It has the same dimensions and the same storage capacity as design A, but is of a higher quality construction. The estimated cost of constructing this compartment in 1958 was $81,000. The cost is roughly $1.98 per square foot of floor space or $10.80 per bale of storage capacity. On the basis of straight-line depreciation over an estimated useful life of 30 years, annual *building* costs for the compartment would total $2,700 or roughly $0.36 per bale. Total annual *facility* costs, including annual building costs, 5 percent on the average investment for interest, and 2.3 percent on the total investment for taxes, insurance, and maintenance, would approximate $6,660 or about $0.88 per bale of capacity.

Compartment design C is of tilt-up concrete wall construction with steel roof joists and girders, pipe columns, built-up roofing, and hot-mix bituminous concrete floor. Dimensions of the compartment are 151 by 261 feet, and its storage capacity is roughly 7,200 flat bales

when they are stacked three high on head. The estimated cost of constructing this compartment in 1958 was $112,500, the highest cost of the four compartment designs. This cost is roughly $2.86 per square foot of floor space, or $15.63 per bale of storage capacity. On the basis of straight-line depreciation over an estimated useful life of 60 years, annual *building* costs for the compartment would total $1,875 or roughly $0.26 per bale. Total annual *facility* costs, including annual building costs, 5 percent on the average investment for interest, and 1.32 percent on the total investment for taxes, insurance, and maintenance, would approximate $6,177 or about $0.86 per bale of capacity.

Compartment design D is of long-span, timber truss construction with built-up roofing, wood girts covered with aluminum siding, hot-mix bituminous concrete floor and wood columns. The columns are 50 feet on centers, the widest spacing used in any of the 4 compartment designs. Dimensions of the compartment are 151 by 251 feet, and its storage capacity is roughly 7,000 flat bales when stacked three high on head. The estimated cost in 1958 for constructing this compartment was $101,000. The cost is roughly $2.66 per square foot of floor space, or $14.43 per bale of storage capacity. On the basis of straight-line depreciation over an estimated useful life of 35 years, annual *building* costs for the compartment would total $2,886, or roughly $0.41 per bale. Total annual *facility* costs, including annual building costs, 5 percent on the average investment for interest, and 1.8 percent on the total investment for taxes, insurance, and maintenance, would approximate $7,234 or about $1.03 per bale of capacity.

A warehouse facility was designed which consisted of six compartments of pole-frame construction. Its storage capacity was roughly 45,000 flat bales stacked three high on head. The estimated cost of constructing this warehouse in 1958, including the necessary roads, fences, utilities, rail sidings, and loading and unloading areas, was $671,000, roughly $14.90 per bale of storage capacity. On the basis of straight-line depreciation over an estimated useful life of 25 years, annual *building* costs for the warehouse would total $26,800 or roughly $0.59 per bale. Total annual *facility* costs, including annual building costs, 5 percent on the average investment for interest, and 2.3 percent on the total investment for taxes, insurance, and maintenance, would approximate $59,048 or about $1.31 per bale. If we assume that this warehouse will receive and ship approximately 65,000 bales per year, other annual costs would include $8,256 for direct labor, $4,877 for equipment, and $7,740 for insurance of stored cotton. These specified annual costs would total approximately $79,921, or about $1.23 per bale handled yearly.

Six men would be required during the peak of the cotton season, and two of these six men would be retained as a permanent crew. One man would weigh bales; three men would sample bales and assist in other operations; and two men would operate clamp trucks. The six men would work a total of about 6,648 man-hours during the year.

Five machines and eight attachments would be used in performing the handling operations:

3—3-bale clamp trucks
2—4-bale clamp trucks
1—beam scale mounted on a boom attachment
2—Breakout devices
3—3-bale clamps
2—4-bale clamps

Background and Objectives

Storage facilities for baled cotton in the United States in 1958 consisted of approximately 1,400 warehouses, 300 combined compresses and warehouses, and perhaps 100 open storage yards around or close to warehouses.

Most warehousemen use storage arrangements that minimize the number of times bales are handled except when storage space is at a premium, or when other considerations require changes. However, few of the warehouses were designed for the efficient use of such equipment as 3-, 4-, and 6-bale industrial lift trucks, and bale-breakout and scale attachments. Common defects of existing structures are (1) weak floors, (2) improper spacing of columns, (3) ceilings too low, (4) narrow platforms of improper height, and (5) inadequate protection of walls, floors, doors, and columns from damage by clamp trucks.

Improved design principles are needed as a guide for new warehouse construction as well as for modifying old warehouses, so that the most efficient methods and equipment consistent with adequate fire protection can be used. Research on improved floor layouts and building designs of warehouses for flat bales was undertaken first because warehouses comprise the largest component of the industry. Further research will be conducted on compartments for storing compressed bales and on compress compartments.[1]

[1] A *compartment* is a section of a warehouse and serves as a fire division. The purpose of the compartment is to confine any fire to the compartment and prevent its spread by suitable barriers such as firewalls or clear space between the compartments.

A *facility*, as used in this report, refers to the building structure and its accessories.

The *warehouse* consists of the compartments and other facilities for storing bales of cotton. It includes the roadways, rail sidings, utilities, and other improvements.

The main objective of this study was the development of improved floor layouts and building designs for cotton warehouses which would help to reduce the costs of handling bales of cotton and to minimize losses from fire and weather damage. This report is intended as a guide for planning public warehouses for storing cotton; it will not replace the services of engineers, architects, or builders.

There are several prefabricated buildings available, usually of steel frame and steel siding and of standardized design. This type of building was not discussed in this report. However, warehousemen can obtain plans, specifications, and cost estimates for these types of buildings from manufacturers' representatives.

In this study engineering designs and specifications for materials for cotton warehouses were developed which will (1) permit the most efficient use of modern handling equipment, (2) provide for the most efficient use of storage space, (3) minimize construction and maintenance costs, and (4) provide adequate fire protection at minimum insurance costs.

The principles of layout discussed in this report are applicable to any location where cotton is stored. However, the layouts and building designs are for a cotton warehouse suitable for the Southwestern States and other areas of low rainfall where separated compartments can be used satisfactorily.

This warehouse is designed to store 40,000 to 50,000 flat bales, does not have a compress, and is intended for receiving, storing, and shipping flat bales only. Bales are usually shipped on an in-transit basis to a compress for pressing to standard or high density and then forwarded to their destination. It is assumed that all bales will be received by road truck, and that 75 percent will be shipped by rail and 25 percent by truck. Handling operations are to be performed at ground level, with the exception of loading rail cars. Rail cars will be loaded from platforms level with the car floor. Storage compartments were designed for the most efficient type of materials-handling equipment and the least labor. The operations, equipment, methods, labor, and costs were developed from data in "Handling Bales of Cotton in Public Warehouses" (*3, 15*).[2]

Cotton warehouses for storing flat bales in the southwestern sections of the Cotton Belt were studied. These studies covered the type of construction, construction materials, height of walls, spacing of columns, type of roofs and walls, handling operations, fire prevention methods and equipment, and layout and size of warehouses and compartments.

Data from Government reports and information furnished by insurance rating bureaus, insurance underwriters, and various materials associations, as well as engineering principles and experience, were used in designing the storage compartments and warehouses discussed in this report.

The most efficient compartment was selected and the layout and construction features developed in considerable detail. Building and facility costs were computed on all designs. Costs were also computed and layouts made for a warehouse using the most efficient compartment.

Data for computing annual labor and equipment costs were obtained from "Handling Bales of Cotton in Public Warehouses" (*15,* p. 3).[3] Data for computing annual costs of compartments were obtained from trade associations, various suppliers of building materials, building service agencies, warehousemen, and published information. Annual building cost includes only depreciation (25 to 60 years of useful life depending on type of construction). Total annual facility costs include depreciation, taxes at 1 percent, insurance 0.22 to 0.30 percent, interest on average investment at 5 percent, and maintenance at 0.5 to 1.0 percent depending on type of building material. (See page 22 for further discussion of annual facility costs.)

Shortcomings in Existing Cotton Storage Compartments and Warehouses

During the field studies several shortcomings were noted in layouts, building designs, and building maintenance programs.

Improper spacing of columns or posts in a warehouse can cost the warehouseman storage space and storage revenue. Because of this, many warehouses in use in 1958 were not suited for current machine operations or storage patterns. It was not unusual to find a column located in the center of a cross aisle (fig. 1). In some compartments the spacing of columns was responsible for cross aisles being 2 or 3 feet wider than necessary for handling operations.

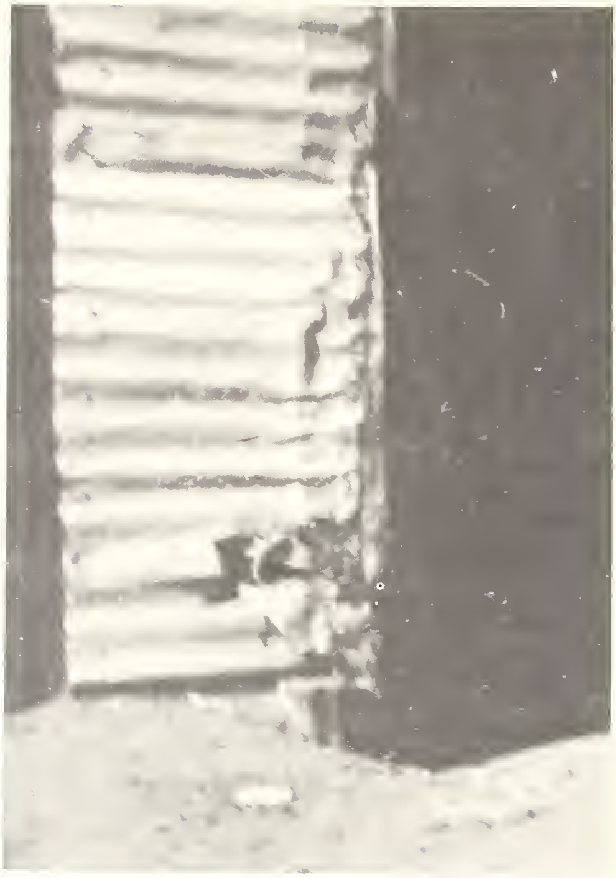
Most warehouses do not have door-, wall-, and column-guards to prevent damage by heavy and powerful clamp trucks (figs. 2–4). Columns located in aisles and along the edge of aisles are frequently damaged or broken and often require replacing each season (fig. 5).

In many existing compartments the ceilings are so low that bales can be stored only two high on head (fig. 6). Sprinkler systems have

[2] Italic numbers in parentheses refer to Literature Cited, p. 37.

[3] See appendix C.

NEG. PN-689
FIGURE 1.—Column located in cross aisle.



NEG. PN-688
FIGURE 2.—Damaged door frame.

been installed in some warehouses so that bales can be stored only two high under the main supply and drainage pipes. Sometimes bales can be stored only two high around the columns because of knee braces (fig. 7). In many compartments up to 25 percent of the storage space is wasted because of these shortcomings.

Many existing warehouses were not designed with an adequate safety factor against structural failure. For example, some warehouses were not properly designed for wind uplift on the roof and for the outward pressure of wind on the walls. In contrast, a few warehouses were designed with more than the necessary amount of structural strength.

Some warehousemen do not have a program for keeping storage facilities repaired. This lack of a systematic program is reflected in broken windows, unpatched holes and cracks in floors, doors hanging by one roller and splintered at the bottom, and walls broken loose from the structural members.

Layouts for Cotton Storage Compartments and Warehouses

Principles

A layout, as used in this report, is the division of space for different activities in handling and storing bales of cotton. The basic principle of a good layout is this: Men, material, and equipment must be integrated so as to move material as easily as possible over the shortest distance, while providing a natural sequence of operations, in a safe manner and under good working conditions (appendix A).

A diagram of a layout presents a visual plan of the proposed facilities as a basis for design, construction, and operation. The preparation of layouts involves consideration of such factors as: (1) Handling equipment being constantly improved; (2) new handling methods growing out of the use of new equipment; and (3) new construction methods and materials.

The major function of a warehouse is to provide space for storing bales of cotton, and a warehouseman performs the service necessary

NEG. PN–679
FIGURE 3.—Wall damaged by clamp trucks.

to carry out this function. The speed of this service is determined by the adequacy of handling methods and equipment and of the layout and building design of the compartment and

NEG. PN–680
FIGURE 4.—Column damaged by clamp trucks.

NEG PN–682
FIGURE 5.—Column and improperly constructed concrete column guard damaged by clamp trucks.

warehouse facilities. A good layout is needed for an economical arrangement of facilities, efficient handling, and utilization of storage area.

NEG. PN–686
FIGURE 6.—Structural framing and sprinkler pipes limit stacking of bales to 2 high on head.

NEG. PN-687
FIGURE 7.—Column knee braces using bale storage space.

Factors Affecting Layouts

Providing for the most storage space at the least cost is paramount in planning a layout for a storage compartment or a warehouse. To obtain maximum utilization of storage space, consideration should be given to (1) size of compartment, (2) column spacing, (3) number, width, and layout of cross aisles and main aisles, (4) storage pattern, (5) locating systems for bales in storage, (6) type and location of receiving and shipping courts and platforms, (7) fire protection, (8) lighting, and (9) handling operations.

Some of the more important types of equipment used for handling bales are: (1) 2-, 3-, 4-, and 6-bale clamp trucks; (2) breakout devices, booms, and rotating clamp attachments; (3) mobile beam scales, portable platform scales, and a beam or electronic scale on industrial lift trucks; (4) portable magnesium ramps; and (5) tractor-trailer trains. The work and storage space that can be used in a warehouse compartment, or in a group of compartments, varies considerably between equipment combinations. Some pieces of equipment require more operating space than others.

Size of Compartment

Insurance standards limit the maximum capacity and size of a storage compartment to 7,500 bales of cotton and 75,000 square feet of floor space, when the compartment is equipped with sprinklers. Insurance standards on sprinkler installations also have a bearing on the size of a compartment. The number of sprinkler heads used and the space each head serves in one or more fire divisions depends on the size of the dry valve and riser and the material used in constructing a compartment (*4*, p. 8).

Proper storage methods are extremely important for handling bales efficiently; also important is the distance bales are moved and the size of equipment used. By using proper storage patterns and handling methods a warehouseman is often able to store the maximum number of bales in much less floor space. Using clamp trucks for transporting and stacking operations, the warehouseman can stack flat bales 3 high on head in considerably less floor space than that required for stacking them one or two high on head. As an example, a compartment can be constructed of a material for which insurance regulations permit the use of one sprinkler system to cover 30,000 square feet. A warehouseman generally can store from 5,500 to 6,000 flat bales three high on head in a compartment of this size. To store the maximum number of bales (7,500) permitted by insurance regulations, and to stack them three high on head, generally requires a compartment having approximately 40,000 square feet of floor area. A compartment with this amount of floor area, using the same type of construction used in the smaller compartment, would require an additional sprinkler system.

Spacing of Columns

The arrangement of columns or posts influences the flow of bales, the amount of usable floor space, and the use of handling methods and equipment and of fire-fighting equipment. Usually 5 square feet or more of floor space is lost per column for storage purposes when the columns are improperly spaced. Column spacing determines the size of the storage section (the area located between two rows of columns and extending from the main aisle to the warehouse wall) and, to a considerable extent, the layout. The trend toward spacing columns farther apart, 25 to 100 feet, offers less difficulty in performing mechanized handling operations and more flexible use of space for storage stacks and aisles. It is often possible to reduce the size of a storage compartment when wider column spacing is used.

Aisles

The size of loads handled by different types of equipment is an important factor in determining aisle widths and materials-handling methods (*16*, p. 49). Usually aisles are nonproductive areas and each square foot of floor area used for aisles is lost for storage. Most aisles in cotton warehouses are used more for cotton handling operations than for traffic arteries.

The following are guides which should be considered when laying out aisles in cotton warehouses: (1) Keep aisles straight, (2) use both sides of working aisles, (aisles located along a blank wall serve only one side, or half of their potential usefulness), (3) length and width of aisles should be such that storage space is not wasted and handling costs not excessive, and (4) one-way traffic should be used if practicable.

Factors to be considered when deciding on the size and location of the aisles are (1) handling methods (present and future); (2) type, size, and speed of handling equipment; (3) size of unit load; (4) size and shape of the compartment; (5) size and location of doors; (6) local insurance and State fire regulations; (7) space required for fire-fighting equipment; and (8) number, kind, and space requirements of operations to be performed in main aisles.

Mechanized operations do not require the wide aisles recommended by some insurance associations, State rating bureaus, warehouse inspection services, and plant operators. Under actual operating conditions most warehouse managers will adjust aisle widths slightly to obtain maximum storage capacity and still remain within the rules or regulations of the State in which they operate. Table 1 shows the suggested width of aisles for specified types of materials-handling equipment.

Storage Patterns

The following two storage patterns are used by warehousemen in storing flat bales: (1) On-head stacks in solid blocks or rows, 1 bale or 2 or 3 bales high and (2) cordwood stacks 5 bales high or more. In warehouses consisting of one compartment with a capacity of less than 5,000 bales, bales are generally stacked on head in solid blocks 1 or 2 bales high. When a warehouse has more than a 5,000-bale capacity, bales are usually stacked in rows 2 bales wide and 1 bale or 2 or 3 bales high. A few warehousemen stack bales in 5 high cordwood stacks.

Bale Locating Systems

Three basic systems are used for storing bales of cotton so that individual bales can be found: (1) Numerical sequence of warehouse tag, (2) locator system, and (3) stacking in any available space.

Numerical sequence of warehouse tag.—A warehouseman using this plan does not fill vacancies in a storage row where bales have been broken out, but rather to gain storage space he moves together (tightens up) the remaining bales in a row. Warehousemen operating country warehouses with a storage capacity of 3,000 to 50,000 bales and storing bales in more than one compartment often use this plan.

TABLE 1.—*Suggested aisle widths for equipment transporting bales of cotton*

Equipment	Maximum width of load or equipment	Suggested safety clearance	Suggested aisle widths
	Feet	*Feet*	*Feet*
2-wheel hand truck, loaded, one-way traffic	4	2	6
Lift truck with breakout device, loaded, one-way traffic [1]	3	1½	4½
2-bale clamp truck, loaded, one-way traffic [2]	5	3	8
2-bale clamp truck, loaded, two-way traffic [2]	10	6	16
3-bale clamp truck, loaded, one-way traffic [3]	7	3	10
3-bale clamp truck, loaded, two-way traffic [3]	14	6	20
4-bale clamp truck, loaded 4-bales wide, one-way traffic	9	3	12
4-bale clamp truck, loaded 4-bales wide, two-way traffic	18	6	24
Lift truck with beam scale	7	3	10
Tractor-trailer trains, 1 to 4 trailers, loaded, one-way traffic, manual loading and unloading	7	3	10
Tractor-trailer trains, 1 to 4 trailers, loaded, one-way traffic, clamp truck loading and unloading	15	5	20

[1] "Breaking Out Bales of Cotton Stored on Head" (*14*, p. 16).

[2] 4-bale clamp truck loaded 2 bales wide and 2 bales deep use the same width of aisle as 2-bale clamp truck.

[3] 6-bale clamp trucks use same width of aisle as 3-bale clamp truck.

Locator system.—This plan subdivides the warehouse into alphabetically and numerically designated compartments, sections, and rows. As each bale is placed in storage, the location is entered on a card in the warehouse office. In order to find any particular bale it is necessary only to note the location of the bale number on the warehouse locating sheet. A warehouse employee will then go to that location in the warehouse and mark the desired bale for the breakout crew. This plan is generally used in warehouses with a storage capacity of more than 30,000 bales and with 4 or more storage compartments.

Stacking in any available space.—As many bales are stored in a compartment as the insurance rules permit without regard to warehouse tag numbers. Bales are stacked wherever there is available space. This type of storage is generally used in cotton warehouses of less than 3,000-bale capacity.

Receiving and Shipping Platforms

Some plants do not have facilities for receiving and shipping by rail, but all have facilities for receiving and shipping by road trucks. In many locations in the Cotton Belt covered platforms are a necessity because of climatic conditions. The compartment designs in this report are mainly for the Southwest, where climatic conditions do not usually require covered platforms.

Road trucks servicing cotton warehouses generally have a stake body, which can be unloaded and loaded efficiently by clamp truck from ground level (*15*, p. 22). In some warehouses, road trucks are unloaded and loaded from platforms. Such platforms are level with the truck bed, usually about 48 to 54 inches in height. For the compartment designs in this report, it is assumed that all trucks will be unloaded and loaded from ground level.

Rail platforms are usually 44 to 46 inches higher than the top of the rails. Some warehouses have sufficient space for ramps for unloading and loading rail cars from ground level. Ramps are generally used in areas where climatic conditions permit outside handling operations.

Some warehouses require wider platforms than others because of particular receiving and shipping methods. Bales can be stacked in temporary blocks and then weighed and sampled (*13*, p. 3). When the above operations are performed on the platforms additional space should be provided for maneuvering the equipment and for movement of traffic. A platform width of 20 feet is recommended when bales are placed in solid blocks with hand trucks or 2-bale clamp trucks and stationary beam scales or portable platform dial-type scales are used. A platform width of 30 feet or more is recommended when bales are placed in row blocks with 2- or 3-bale clamp trucks, weighed on mobile beam scale, and transported to storage with 2-, 3-, 4-, or 6-bale clamp trucks.

Handling Operations

Methods used in handling bales of cotton in a warehouse have one general objective. That objective is to transport bales from receiving to storage and from storage to shipping with a minimum of temporary stoppage and to deliver them to their appropriate places in a manner to avoid congestion, delays, and unnecessary handling.

To attain this objective, when moving the bales (1) eliminate backtracking, (2) handle them as few times as possible, (3) move them no farther than necessary, (4) use a minimum of physical effort, and (5) reduce the number of trips by moving several bales at a time.

Handling equipment requirements for a cotton warehouse vary according to the operating methods employed and the number and types of bales handled per operation and per year. Other factors for a warehouseman to keep in mind are the weight of the equipment, aisle widths, strength of floor, and the possibility of using a piece of equipment for different operations by changing attachments.

The number of workers needed will depend upon the methods, operations, and rates at which the warehouseman is called upon to perform services for his customers. The most efficient methods require power equipment for most operations. One man and a machine often can do the work of 4 to 10 men, especially if the warehouseman receives and ships flat bales.

Building Designs of Compartments and Warehouses

General Considerations

The building design consists of the plans and specifications for housing the layout. It includes the selection of materials and their arrangement, the dimensions for the walls, floors, roof, structural framing, and the arrangement of lighting, plumbing, and other building components. The layout and building design should be closely integrated to achieve the most economical and efficient facility.

Availability of local contractors, labor, and materials, as well as the building site, local weather conditions, building codes, and design loads, should be considered when storage compartments and warehouses are being designed.[4]

Availability of Local Contractors, Labor, and Materials

If local contractors have not had the construction experience for the design under consideration, they may increase their bid. They usually are familiar with local building regulations and codes, and they generally have the

[4] *Design Loads:* The weight or forces, such as wind and snow, which the building must be designed to safely withstand.

necessary construction equipment readily available. However, in some cases it may be desirable to have outside contractors bid on the job.

Consideration should be given to the availability and costs of building materials. For example, in some areas lumber may be the cheapest and most easily available building material; in others concrete products or sheet metal may be the most reasonable and easily available.

Building Site

A careful analysis must be made of the building site for a cotton warehouse. The site should be fairly level and well drained. Soil conditions should be as stable as possible to eliminate expensive foundation and floor construction. Irregularly shaped sites should be avoided if possible. Water supply, both for drinking purposes and for fire protection, and electrical power should be adequate. The warehouse site should be served by a main highway; rail access and connections to main rail lines are important considerations. The availability of a sufficient labor supply as well as public transportation for the workers must also be studied before site is selected.

Weather Conditions

Weather conditions will affect the building design. For example, the annual rainfall and the rainfall intensity affect the degree of weather tightness of the building structure and the kind of drainage facilities required. The building designs described in this report were developed mainly for the Southwestern States and other areas having a rainfall intensity of less than about 2½ inches per hour and an annual rainfall of less than about 24 inches. Figure 8 shows the rainfall intensity and the normal annual rainfall in the Cotton Belt. Field studies showed that in areas with an annual rainfall of around 24 inches or less that cotton warehouses can be designed with separate compartments, uncovered loading and unloading areas, and with a minimum type of roof construction, with a minimum of gutters, downspouts, flashing, and so forth.

Effects of snow and wind on the structural requirements of the buildings are discussed under Structural Requirements and Design Loads.

Building Codes

In many areas cotton warehouses must be built according to the standards of local building codes. The designs described in this report follow, in general, the requirements of such standard building codes as National Building Code (*9*), Southern Standard Building Code (*11*), Uniform Building Code (*6*), and American Standard Building Code Requirements for Minimum Design Loads in Buildings and Other Structures (*1*). Many local codes are based on these nationally recognized model codes and standards. The builder should make sure that the warehouse plan meets the requirements and conforms to the local building codes.

Structural Requirements and Design Loads

The cotton compartment must be designed to safely withstand the forces imposed upon it, such as wind, snow, earthquakes, weight of stored cotton, weight of construction, and equipment. The values selected for these forces will depend upon geographical locations and local building codes. Of course, it is impossible to select single values for the various types of design loads which will meet the requirements for all locations of the Cotton Belt.

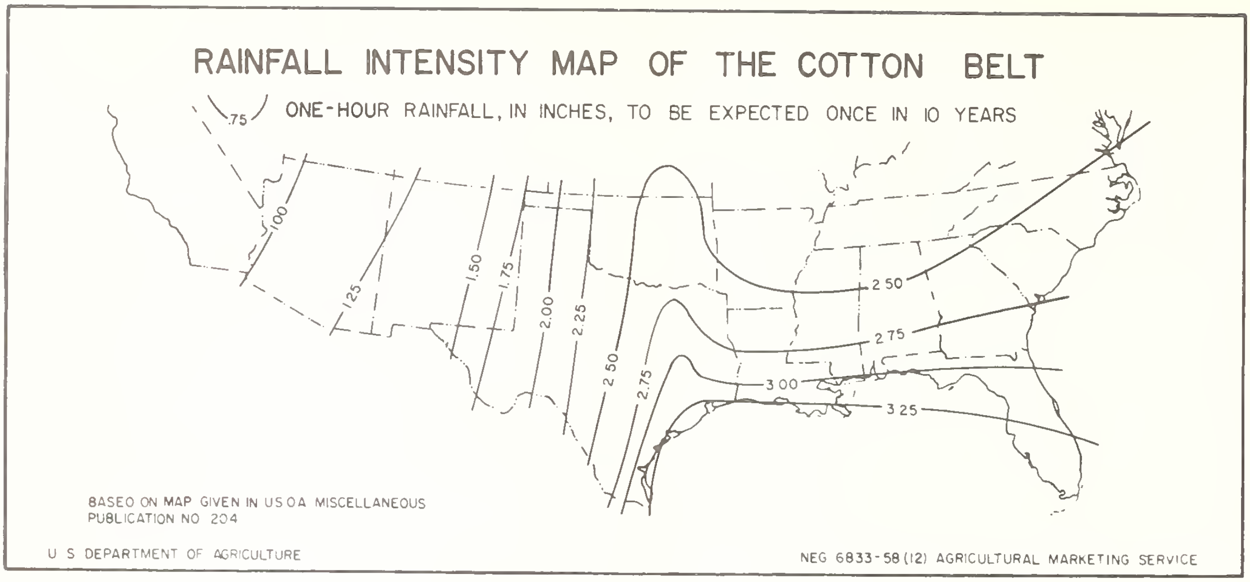
The following discussion of the loads used in preparing the designs illustrated in this report should help in selecting the values required for a particular area.

Roof load.—A basic roof load of 20 pounds per square foot of horizontal projection was used (fig. 9). This is the minimum roof load recommended by the several building codes listed in the previous section. This value covers light snow and miscellaneous construction loads. In the Southwestern States where snow is light and where codes permit, many designers use a smaller load than that given here for compartment designs.

Horizontal wind pressure.—A design wind load of 20 pounds per square foot of exposed wall area was used; this load corresponds to the resultant wind pressure that would accompany a recorded wind speed of about 60 miles per hour (fig. 9–B).[5] The value selected depends mainly on the geographical location of the warehouse. Figure 10 shows the various design wind loads recommended for the Cotton Belt. For a further discussion of wind loads, see sections 5 and A5.1 of the American Standard Building Code Requirements for Minimum Design Loads in Buildings and Other Structures (*1*).

Resultant wind load on roof.—An uplift of 25 pounds per square foot was used. The magnitude and direction of the wind loads on the roof are functions of the horizontal wind pressure, slope of the roof, tightness of the construction, and other considerations. Most codes have simplified those factors and for roof slopes of less than 30° specify an uplift force acting perpendicular to the roof of 1¼ times the horizontal design load (fig. 9–B).

[5] This recorded wind speed (fastest single mile velocity) is sometimes multiplied by 1.3 to obtain a gust velocity.



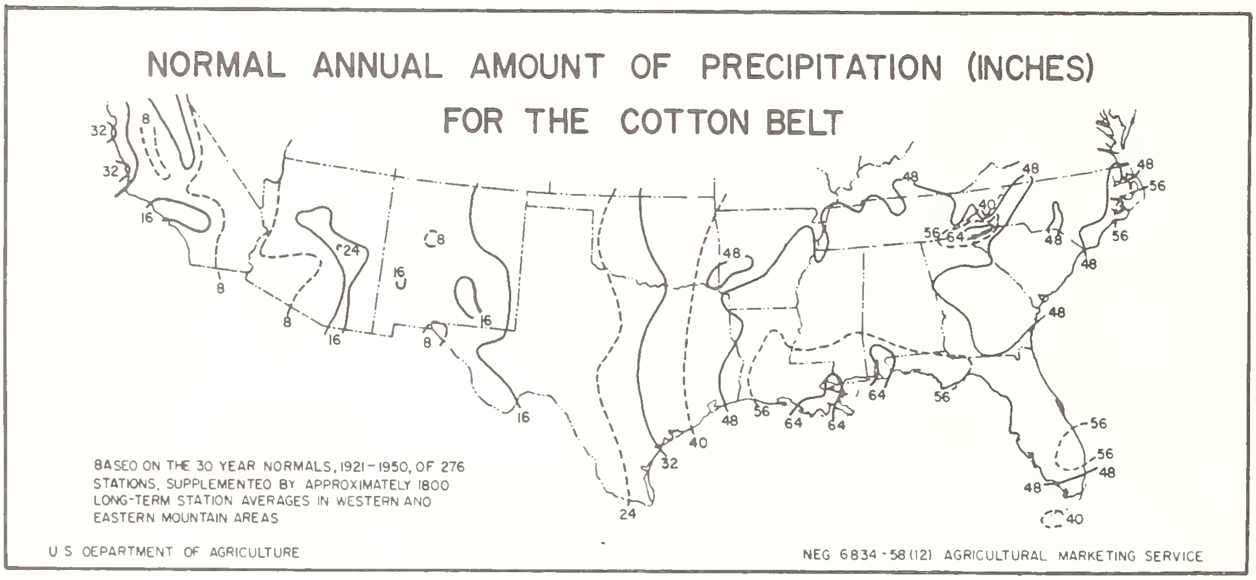


FIGURE 8

Seismic (earthquake) loads.—Figure 11 shows the areas of probable earthquakes for the Cotton Belt. The structures illustrated and discussed in this report were not specifically designed for seismic loads. However, since the seismic loads are proportional to the weight of the building structure, and since most of the designs in this report are for lightweight, one-story construction, they are suitable for earthquake zones. Heavier construction, as represented by design C, tilt-up concrete construction, must be specifically designed to resist the lateral earthquake forces.

Floor loads.—A concentrated wheel load of 3,500 pounds (rubber cushion wheel) was selected. With good soil conditions and a stable base, floors on grade such as shown in these designs can carry heavy uniform loads of 600 pounds or more per square foot.

Bearing capacity of soil.—Fairly stable soil that will support 3,500 pounds per square foot was assumed. Of course, footings should be designed to meet the specific conditions found at the site where the warehouse is to be erected.

Miscellaneous structural requirements.—In general, working stresses as specified in the National Building Code were used for the structural designs. The following miscellaneous structural design criteria were also selected:

For members subject to stresses produced by a combination of wind and other loads, the

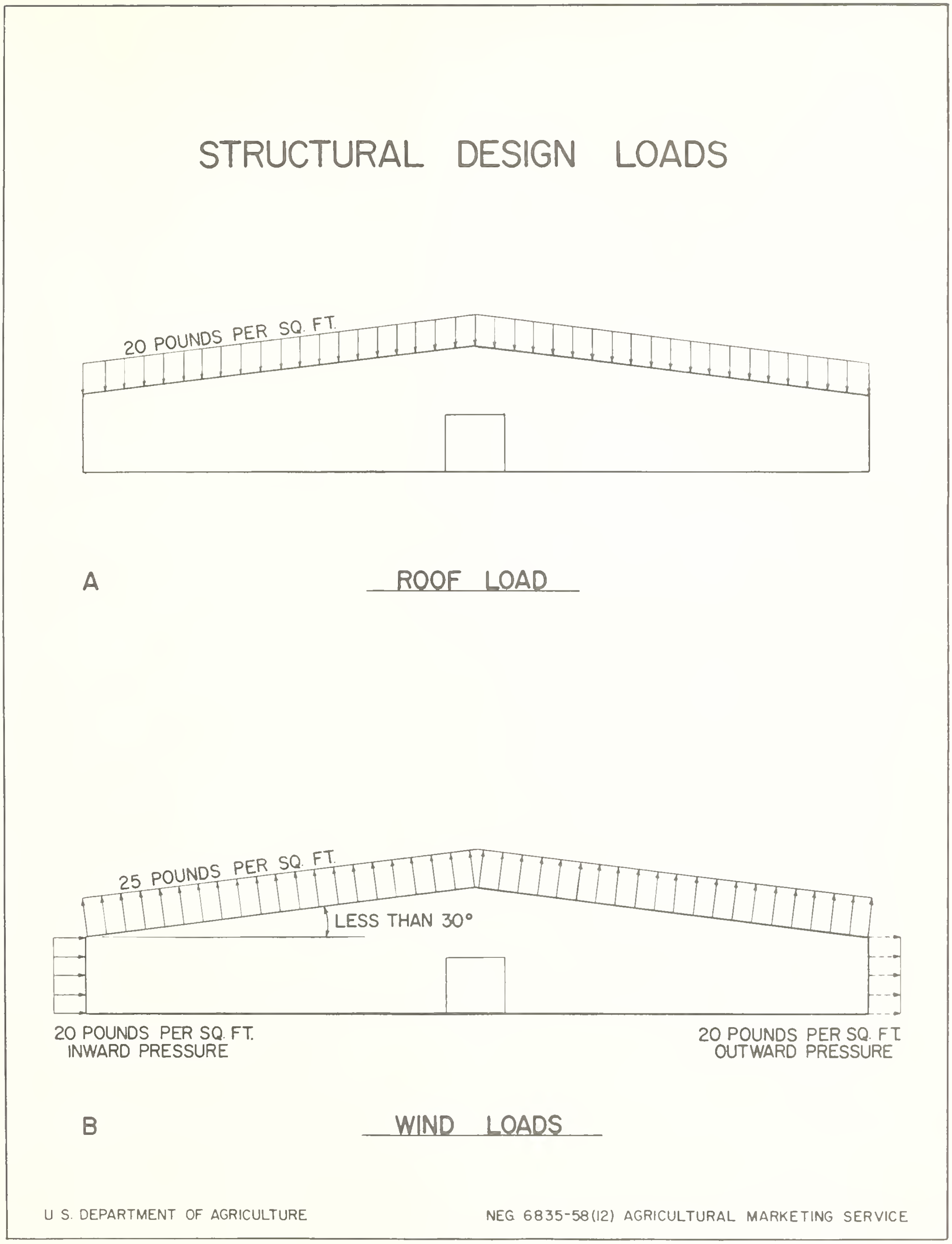


FIGURE 9.—Elevations of a typical compartment showing the direction and magnitude of forces or loads which the building structure must withstand: (A) The roof load includes light snow, sleet, and loads incidental to construction. (B) The walls and roof must also be designed to withstand the forces caused by strong winds.

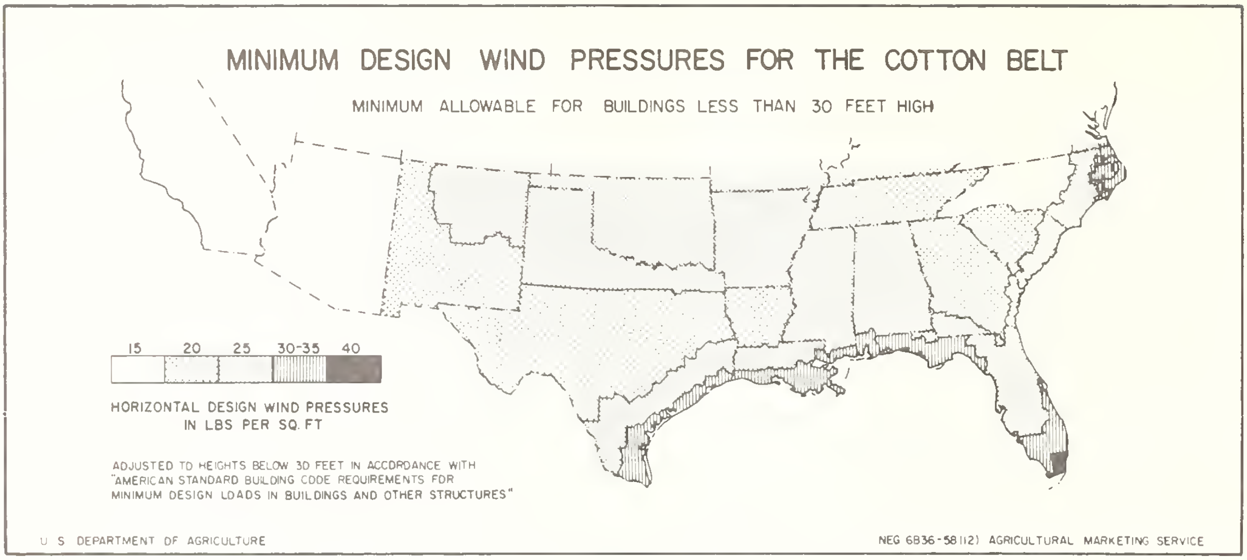


FIGURE 10

normal working stresses may be increased 33⅓ percent.

For members subject to stresses produced by combinations of snow and other loads, the normal working stresses may be increased by 15 percent. (Applies to wood structural members only.)

The maximum deflection of roof members shall not exceed 1/240 of the span.

Warehouse Component Considerations

Requirements for floors, roofs, doors, skylights and windows, structural framing, utilities, and miscellaneous items such as office space, machine shop, sanitation, and parking space should be considered in designing and constructing a cotton storage compartment or warehouse.

Floors

Floors are one of the most abused parts of any warehouse structure. Much attention should be given, therefore, to the type of floor construction and to the floor strength best suited to bale handling in any particular cotton compartment. Earlier warehouses had dirt or wood floors, but in 1958 the most common types of floors were poured concrete or asphalt. Concrete or asphalt floors wear well and are easy to keep clean. Asphalt floors, improperly de-

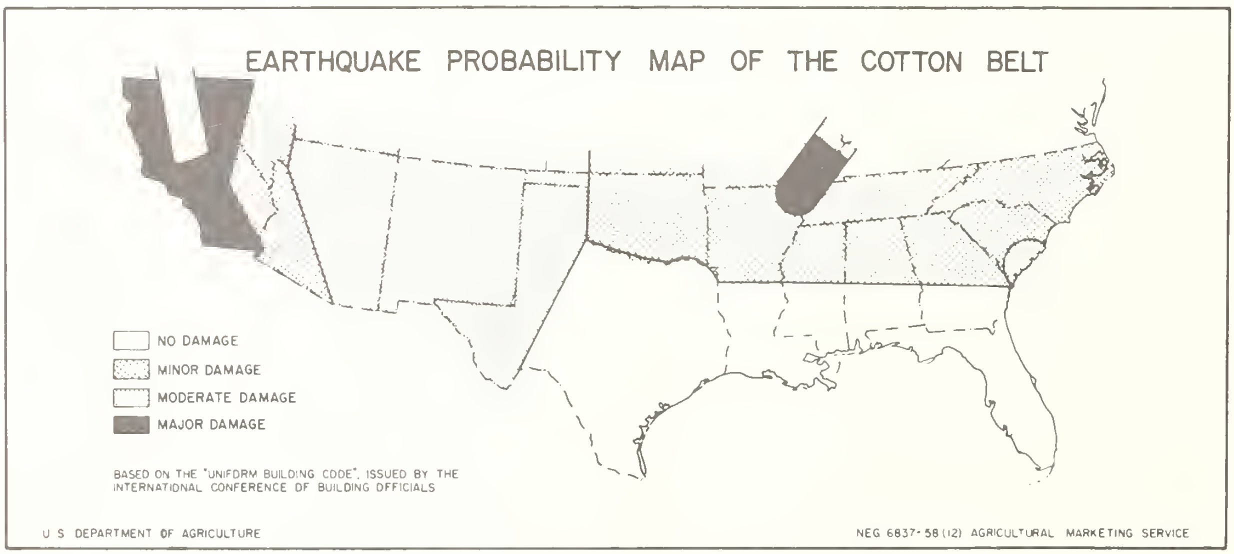


FIGURE 11

signed and constructed, might scale or flake and stain the cotton. But if a densely graded and well compacted hot-mix asphalt paving is used, there should be no problem of staining. There were no reports of the asphalt floors staining the cotton in any of the warehouses visited. A number of characteristics are desired in floors of a cotton warehouse. They should be durable enough to carry the needed handling equipment, skid proof and nonslippery under any conditions, unaffected by change in temperature and humidity, able to dissipate static electricity and be nonsparking, easy to clean; low in maintenance costs by being easily and quickly repaired; and low in initial construction cost.

Walls

Exterior walls.—The exterior walls in some of the older warehouses were thick masonry walls used to carry both wall and roof loads. Modern warehouses are usually constructed to place roof loads on beams and supporting structures, and walls are needed mostly to keep out the elements. Walls are constructed of concrete blocks, brick and block combinations, poured concrete, wood, precast concrete slabs, asbestos cement panels or corrugated metal panels. Since the insulation value and appearance are not considered as important factors, most warehousemen choose a low-cost wall material; in many sections of the Cotton Belt, the compartment walls are of corrugated metal sheets on a wood frame structure.

It is important that the walls be protected from clamp truck damage (fig. 12). Heights of exterior walls in storage compartments are usually determined by the storage pattern used and by insurance limitations.

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FIGURE 12.—Wall guards of 4-inch pipe installed to protect metal wall from clamp-truck damage.

Firewalls.—When two cotton storage compartments are joined, a firewall must be constructed between them. These firewalls are of vital importance in connection with cotton storage, as a single fire may involve thousands of dollars. Generally, the firewall is constructed of brick or reinforced concrete and extends about 5 feet above the roof line (figs. 13 and 14). A firewall is usually 16 inches thick if it is constructed of masonry and 12 inches thick if it is constructed of reinforced concrete.

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FIGURE 13.—Masonry firewall separating two compartments.

Rules and standards for construction, and for the protection and maintenance of cotton warehouses have been issued by cotton insurance associations. A warehouseman contemplating building a cotton storage compartment requiring firewalls should communicate with his State rating bureau or other insurance agencies for complete details.

Instead of using firewalls, the storage compartments may be separated by a clear space (usually 100 feet) to provide the necessary fire division. The separated compartments are usually cheaper to construct, and most warehouses in the Southwest are made up of compartments of this type.

Figure 14 illustrates a firewall and separated compartments and shows the comparative costs of the two types. The reinforced concrete firewall is compared with the two sheet metal end walls of separated compartments plus the extra piping, roadway, and land (computed at $1,000 an acre) required for separate compartments. This type of firewall is the one most often found in existing warehouses and is accepted by most insurance underwriters.

Some insurance underwriters will accept an 8-inch firewall of lightweight concrete. If acceptable, the suggested 8-inch firewall as described in design C (p. 25) can usually be con-

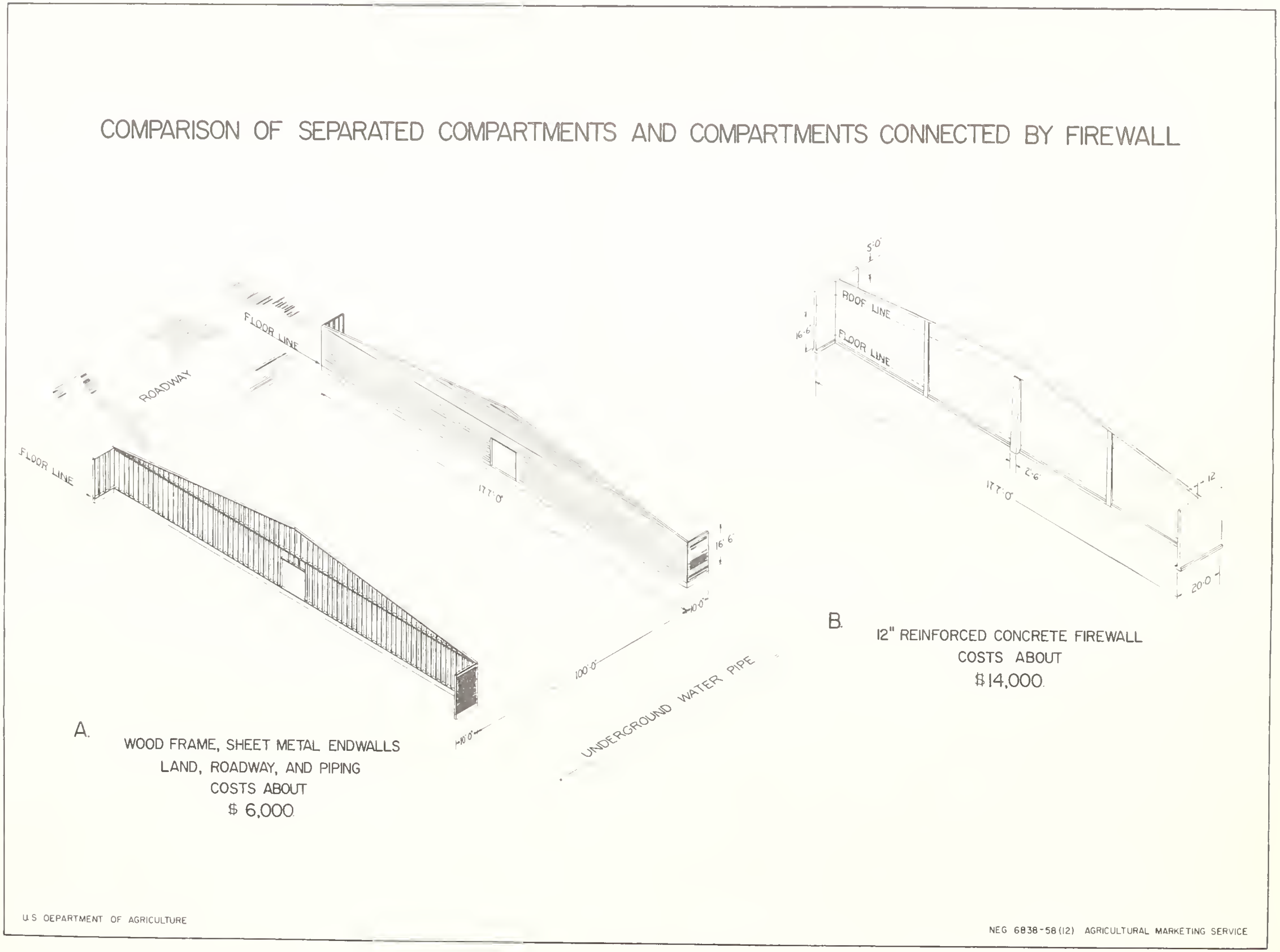

FIGURE 14.—(A) End walls of two compartments separated by 100 feet to provide the necessary fire division. (B) Two compartments connected by a common firewall.

structed at a price competitive with the price of separated compartments.

Roofs

Roofs are often a maintenance problem and careful consideration should be given to the pitch of the roof and the materials used. Rain leakage is not as great a problem in the Southwest as in other areas, but it must be considered. In areas subject to high winds, metal roofs must be securely fastened in place. In certain areas such as west Texas, hail damage is a problem. Metal roofs are commonly used for cotton warehouses in the Southwest; builtup roofs of felt, tar, and gravel on wooden or precast concrete roof decks are also used. Some warehouses have asphalt roll roofing on wood decking.

Doors

One feature easy to overlook is the size of door openings. Doors that are too low or too narrow will limit the size of handling equipment. Older compartments have sliding doors made of wood, but the newer ones generally have a wood-frame, metal-covered, sliding door, or an overhead, steel or wood, rolling door. Overhead doors are more expensive, but they roll up out of the way and often require less maintenance.

Table 2 shows the recommended widths of doors required for efficient operation of specified types of materials-handling equipment.

TABLE 2.—*Recommended minimum door widths required for mechanical equipment used in handling flat bales of cotton*

Equipment	Width of loaded equipment	Recommended door width	
		One-way traffic	Two-way traffic
		Feet	*Feet*
2-bale clamp truck	4′ 10″	8	14
3-bale clamp truck	7′ 3″	10	18
4-bale clamp truck:			
2 bales wide in tandem	4′ 10″	10	18
4 bales wide	9′ 8″	12	22
6-bale clamp truck	7′ 3″	12	22
Tractor-trailer train	4′ 8″	8	16

In the designs illustrated in this report, 12-foot-wide door openings have been selected which provide adequate clearance for 3- and 4-bale clamp trucks. Warehousemen anticipating the use of larger industrial trucks should use wider openings.

Doors should be high enough to clear materials-handling equipment; a recommended height is 12 feet. Door jambs should have guards to prevent clamp truck damage. In some warehouses, road trucks drive into the compartment for loading and unloading; the recommended minimum door height for this type of operation is 15 feet.

Structural Framing

The structural framing of a cotton warehouse consists of girders, beams, columns, purlins, and other members supporting the roof and wall construction. The framing must resist the wind and other forces acting on the building. Wood frame construction is commonly used in cotton warehouses, but steel frame and concrete frame constructions are also used.

Careful consideration must be given to the type of framing and spacing of columns. For example, where wood framing supports a lightweight roof, spacing columns more than 16 to 20 feet apart will, in general, increase the total construction costs. The advantages of wider column spacings are discussed under the section of Factors Affecting Layout, page 6.

It is important to select columns or posts which can resist the impact and damage from clamp trucks.

Skylights and Windows

Natural daylighting is desirable for the storage compartments, and warehousemen should take advantage of the large number of clear days in the Southwest by providing skylights or windows. Skylights usually give a better lighting pattern than windows but can be a maintenance problem if not properly constructed. The skylights or windows should be weatherproof, comparatively maintenance free, translucent or transparent, and fire resistant. Acceptable materials for cotton warehouses are wired glass, plastic-coated screen, and plastic panels reinforced with glass fiber. Corrugated plastic panels reinforced with glass fiber can be used as skylights and can easily be installed with sheet metal siding or roofing.

Lighting and Electrical System

As a rule most work in cotton warehouses is done in the daytime, and only a minimum of electrical connections and outlets for artificial illumination is needed. Wiring should be provided for outside floodlighting. All wiring and equipment should be installed in accordance with the standards of the National Electrical Code (*10*).

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Heating and Ventilating

It is not necessary to heat the storage compartments. Where dry sprinkler systems are used, the valve house must be heated, usually by an electric heating element. The office area should be heated.

A minimum of ventilation is required for the storage compartments. This is provided by one or more of the following means: Open doorways, louvered openings, air leaks in wall, and roof ventilators. Some fire insurance authorities look with disfavor on roof ventilators. Louvered openings should be covered with wire mesh for fire protection.

Water Supply

Common sources of water supply are public water systems, gravity tanks, pumps obtaining water from rivers, ponds, wells, or cisterns, and private reservoirs. Two or more independent sources of water are usually needed to guard against the crippling or exhaustion of one source during a fire. Some warehouses have constructed reservoirs and obtain an ample supply of water from deep wells. Most of the warehouses having this type of water supply are located outside the city limits. Public water systems are the most desirable source and are more reliable than the other.

Fire Protection

Fire underwriters, inspection services, and State and insurance bureaus can give valuable information about building designs of compartments and warehouses for storing cotton. Also, one or more of these organizations should check the building designs for the warehouseman so that he can obtain the lowest insurance rates.

A warehouseman should consider the following fire protection suggestions when he is building a new compartment or warehouse: (1) Study the fire hazards of baled cotton to be stored or handled; (2) check the local building codes for acceptable fire resistant materials; (3) separate the compartments by an adequate open space or by acceptable firewalls to limit spreading of any fire outbreak; (4) check with fire underwriters for the proper type of fire fighting equipment; (5) provide sprinkler systems, standpipes, and fire hydrants; and (6) consider available water supply for specific operation.

Most cotton warehouses are protected by automatic sprinkler systems. Fire insurance rates for buildings and contents of a warehouse without sprinklers may be as much as 10 times that for one with sprinklers. With the new spray type of sprinkler heads now being used, fire resistive and noncombustible construction is not so important. In fact, in some States, insurance rates on the stored cotton may be actually higher in compartments built of fire resistive materials.

A dry-pipe sprinkler system, which operates with compressed air and a differential dry-pipe valve, is normally used. Some systems also incorporate a thermostatically operated device which is actuated by the rate at which the temperature rises. With this system the fire alarm sounds before the sprinklers open, and thus provides an opportunity for employees to extinguish the fire manually and prevent excessive water damage. Another advantage of this system is that water will not discharge from the pipes or sprinkler heads if they are accidentally broken.

Miscellaneous

Offices.—Offices for a cotton warehouse should be located near the entrance to the warehouse grounds. Offices located in a separate building provide a means of closer control over the working groups, are less expensive to expand, provide better facilities for storing records, and give better control over maintenance and operating supplies. Visitors, sales people, and traffic entering the warehouse grounds can be more easily and closely regulated.

Parking facilities.—While parking facilities for employees and visitors are not usually a part of a storage compartment, they are necessary for every warehouse. These facilities should be located adjacent to the property entrance gate and opposite the maintenance shop and office.

Washroom and locker facilities.—Sanitation conveniences should be located not far from the office building. Involved problems of cleanliness, personnel control, and increased costs for plumbing can thus be avoided.

Maintenance shop.—Handling equipment, compartment doors, water pumps, and other warehouse equipment require attention from time to time. Some specific location is needed to park handling equipment and trucks and to store parts, gasoline, paints, and other miscellaneous supplies. Space is also needed for shop machines used in making equipment parts and repairs. A combination maintenance and machine shop can render this type of service for a warehouseman, usually at less expense than outside services. Maintenance shops should be located away from the storage compartments and parking facilities. Maintenance shops located fairly close to the office building enable the warehouseman to exercise effective control over maintenance supplies and operations.

Improved Storage Compartments

The determination of size for a storage compartment would be much easier if the storage of bales of cotton were only a matter of the number of bales. Insurance regulations place limitations on the number of bales that can be stored in one compartment, height of storage stacks, the floor area, etc. However, storage capacities of compartments of given dimensions can be determined when the size of the unit loads, storage patterns, types of handling equipment, aisle widths, and column spacing are known.

A number of improved features in layout and building design are discussed and illustrated in this report. In the layouts, columns are spaced to leave cross aisles and main aisles clear and are located between rows of bales where the corners of 4 bales come together (fig. 15). The main aisle extends the width of the compartment; this arrangement increases the bale storage capacity as much as 10 percent at no increase in operating costs. Cross aisles are wide enough for machine handling operations, and main aisles are wide enough for machine traffic and for pre-positioning bales for clamp-truck operations. Wall heights permit the stacking of bales three high on head at the eaves.

In the building designs, 20- to 50-foot spans permit use of fewer columns and guards are provided for walls and doors (fig. 16). Spotlights are provided for better lighting; fewer and smaller knee braces on each column permit storage of an additional 4 to 7 bales per column; and materials used in construction minimize maintenance.

Four compartments with about the same floor area are discussed and illustrated in the following sections. These compartments were designed to make the best use of the most efficient handling methods and handling equipment discussed in the report on cotton handling (*15*). They were also designed for the best utilization of space for storing flat bales of cotton. Estimated construction, operation, and maintenance costs are included.

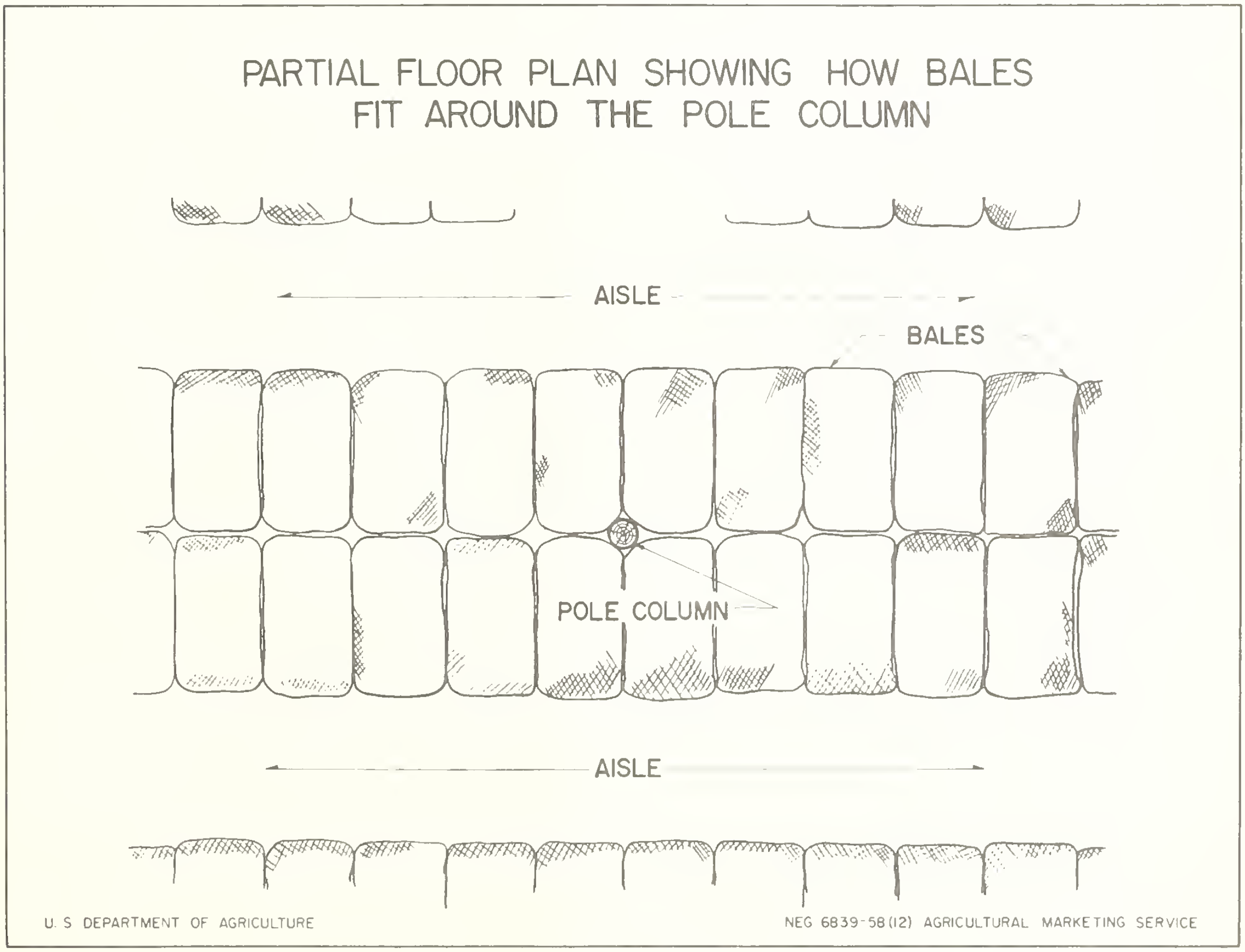

FIGURE 15.—Location of column between rows of bales.

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FIGURE 16.—Door and walls in truck receiving area protected from clamp-truck damage by 4-inch steel pipe.

Storage Compartment of Pole-Frame Construction

The pole-frame design represents the lowest construction cost of the four designs discussed in this report. This design is for a wood-frame structure covered with corrugated metal siding and roofing, and the columns are pressure-treated wooden poles. This compartment is shown in figure 17 and is called design A.

Layout

This storage compartment is 175 by 232 feet (inside dimensions); it provides 40,600 square feet of floor area. Walls are 16 feet 6 inches high at the eaves, and the roof is 27 feet 6 inches high at the ridge. One 12- by 12-foot overhead door is located in each of the two long walls at opposite ends of the main aisle (fig. 17). The walls provide sufficient height for tiering flat bales 3 high on head throughout the compartment plus the required clearance space between the tops of the bales and the sprinkler heads.

Each storage section is 25 feet wide and 99 feet long on one side of the main aisle and 116 feet long on the opposite side (fig. 17.)[6] The main aisle is 17 feet wide and 175 feet long and occupies 2,975 square feet, or about 7 percent of the total floor area. Segregation of bales to be shipped, one-way clamp truck traffic, and weighing and sampling of bales are operations that can be performed in the main aisle.

There are two cross aisles in each storage section extending from the main aisle to the compartment wall. Each cross aisle is 4 feet 6 inches wide and extends the length of the compartment. Excluding 17 feet for the width of the main aisle, the cross aisle is 215 feet long and occupies about 968 square feet of floor space. The total floor space of the 14 cross aisles is 13,545 square feet or 33 percent of the total floor space in the warehouse. Cross aisles are used as working areas for machines to break out bales, as a traffic way to reach the main aisle, and as a work area to tighten up rows or bales to gain storage space (*15*, p. 60).

Machine operations in cross aisles can usually be performed in 4- to 4½-foot-wide aisles, but some insurance rating bureaus require cross aisles 5 feet wide. When changes are made in the 4½-foot aisles specified in the layouts, corresponding changes should be made in the column spacing, which may involve changes in the roof framing. Warehousemen should check with their State rating bureaus and insurance companies before deciding on aisle widths.

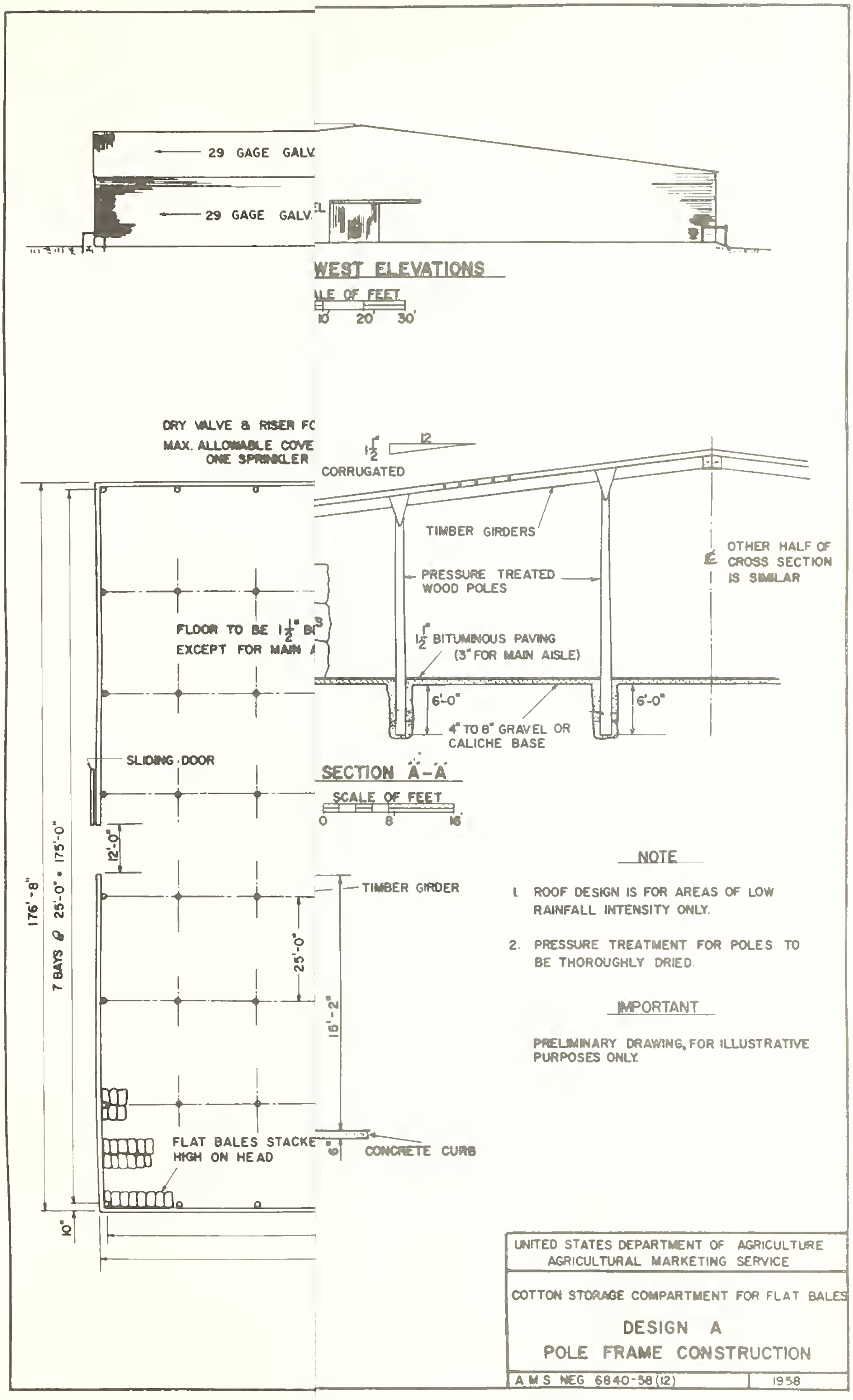
The layout in figure 17 provides for a storage capacity of 7,476 flat bales of cotton, using 24,080 square feet, or 60 percent of the total floor area. Doors located at either end of the main aisle provide ample entrance and exit space for loaded clamp trucks. Columns are spaced on 25- by 19-foot 4-inch centers and are located between two rows of bales so that they are protected from damage by machines. They are spaced for efficient machine operations in storing bales in three-high on-head stacks, in breaking out stacks for shipment, and in transporting bales. No columns are located in cross or main aisles.

The receiving area is located along one side of the compartment and is a part of the asphalt paved strip used by road trucks. This area is usually located 20 to 25 feet from the door leading into the main aisle of the storage compartment. Unloading, weighing, and sampling operations can be performed outside the storage compartment; thus more space can be used for bale storage inside the compartment. Travel distances for the receiving operation, a maximum of 220 feet, permit the use of minimum number of clamp trucks.

Bales can be stacked three high on head in rows two bales wide extending from the wall to the main aisle. Aisles can be marked so that definite space is allocated to the storage row. This storage pattern permits the efficient use of machines for transporting, stacking and breaking out operations, tag inspection, reweighing, resampling, and checking inventory.

The shipping area for rail cars is located on the side of the storage compartment opposite the receiving area (fig. 18). Interference between receiving and shipping crews and machines is thus reduced to a minimum. Provisions are made for rail cars to be loaded from a platform level with the car floor. The rail platform is 30 feet wide and 250 feet long; it is parallel to the storage compartment and is not covered. Road trucks are loaded from a ground-

[6] A section is that area located between two rows of columns and extending from the main aisle to the warehouse wall.



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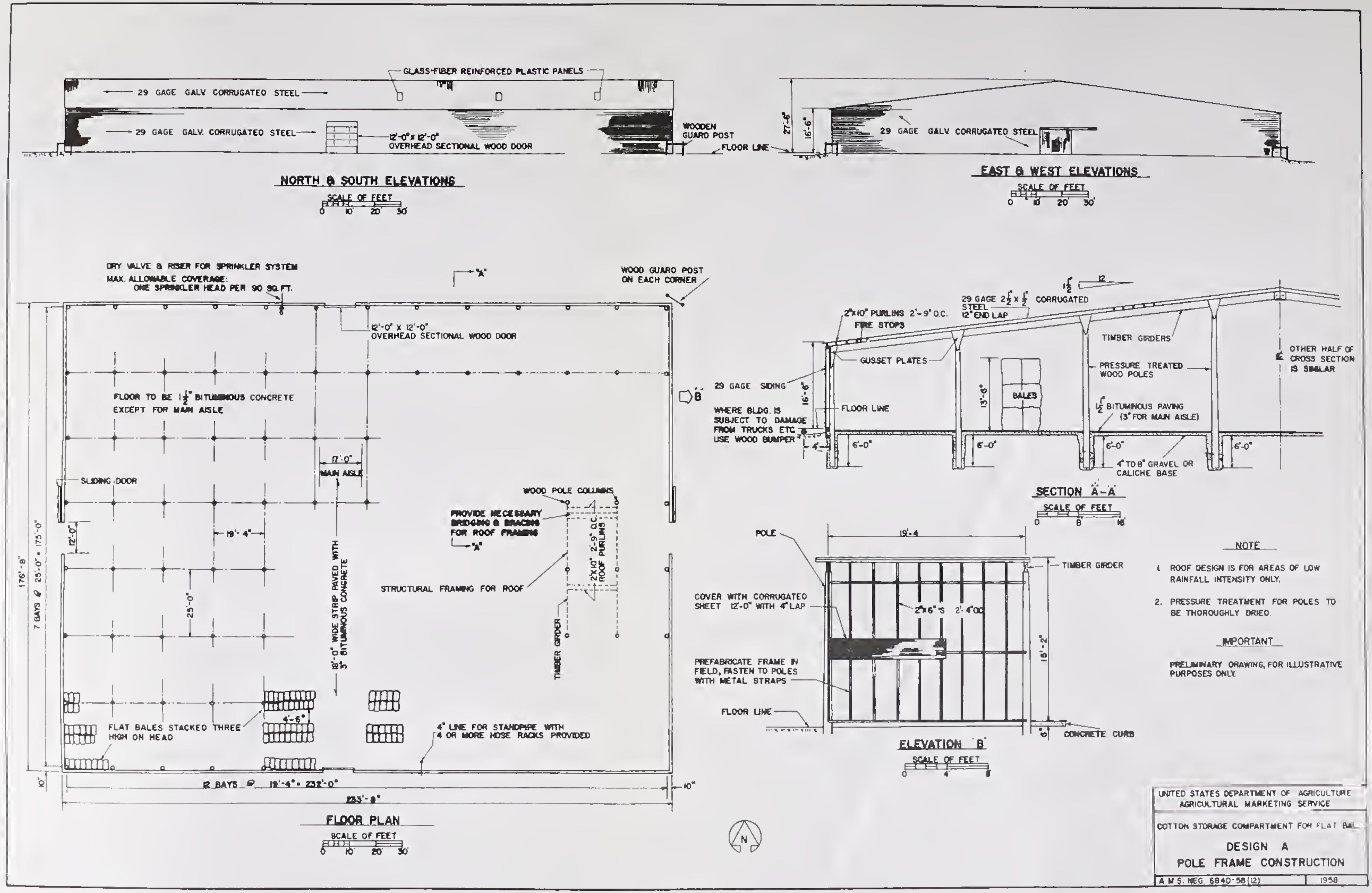
GLASS-FIBER REINFORCED PLASTIC PANELS
29 GAGE GALV CORRUGATED STEEL
29 GAGE GALV. CORRUGATED STEEL
12'-0" x 12'-0" OVERHEAD SECTIONAL WOOD DOOR
WOODEN GUARD POST
FLOOR LINE
NORTH & SOUTH ELEVATIONS
SCALE OF FEET
0 10' 20' 30'
27'-6"
16'-6"
29 GAGE GALV. CORRUGATED STEEL
EAST & WEST ELEVATIONS
SCALE OF FEET
0 10 20' 30'
DRY VALVE & RISER FOR SPRINKLER SYSTEM
MAX. ALLOWABLE COVERAGE:
ONE SPRINKLER HEAD PER 90 SQ. FT.
"A"
WOOD GUARD POST ON EACH CORNER
12'-0" X 12'-0" OVERHEAD SECTIONAL WOOD DOOR
FLOOR TO BE 1½" BITUMINOUS CONCRETE EXCEPT FOR MAIN AISLE
B
17'-0"
MAIN AISLE
SLIDING DOOR
WOOD POLE COLUMNS
PROVIDE NECESSARY BRIDGING & BRACING FOR ROOF FRAMING
"A"
12'-0"
19'-4"
2"x10" 2'-9" O.C. ROOF PURLINS
176'-8"
7 BAYS @ 25'-0" = 175'-0"
25'-0"
18'-0" WIDE STRIP PAVED WITH 3" BITUMINOUS CONCRETE
STRUCTURAL FRAMING FOR ROOF
TIMBER GIRDER
4'-6"
FLAT BALES STACKED THREE HIGH ON HEAD
4" LINE FOR STANDPIPE WITH 4 OR MORE HOSE RACKS PROVIDED
10"
12 BAYS @ 19'-4" = 232'-0"
10"
233'-8"
FLOOR PLAN
SCALE OF FEET
0 10' 20' 30'
N
1½ 12
29 GAGE 2½" x ½" CORRUGATED STEEL
12" END LAP
2"x10" PURLINS 2'-9" O.C.
FIRE STOPS
TIMBER GIRDERS
GUSSET PLATES
PRESSURE TREATED WOOD POLES
OTHER HALF OF CROSS SECTION IS SIMILAR
29 GAGE SIDING
16'-6"
13'-6"
BALES
FLOOR LINE
1½" BITUMINOUS PAVING (3" FOR MAIN AISLE)
WHERE BLDG. IS SUBJECT TO DAMAGE FROM TRUCKS ETC. USE WOOD BUMPER
4'
6'-0"
6'-0"
6'-0"
6'-0"
4" TO 8" GRAVEL OR CALICHE BASE
SECTION A-A
SCALE OF FEET
0 8 16
POLE
19'-4
TIMBER GIRDER
COVER WITH CORRUGATED SHEET 12'-0" WITH 4" LAP
2"x6"'S 2'-4" O.C.
16'-2"
PREFABRICATE FRAME IN FIELD, FASTEN TO POLES WITH METAL STRAPS
FLOOR LINE
6"
CONCRETE CURB
ELEVATION "B"
SCALE OF FEET
0 4 8
NOTE
1. ROOF DESIGN IS FOR AREAS OF LOW RAINFALL INTENSITY ONLY.
2. PRESSURE TREATMENT FOR POLES TO BE THOROUGHLY DRIED.
IMPORTANT
PRELIMINARY DRAWING, FOR ILLUSTRATIVE PURPOSES ONLY.
UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL MARKETING SERVICE
COTTON STORAGE COMPARTMENT FOR FLAT BAL
DESIGN A
POLE FRAME CONSTRUCTION
A.M.S. NEG. 6840-58 (12)
1958

FIGURE 17

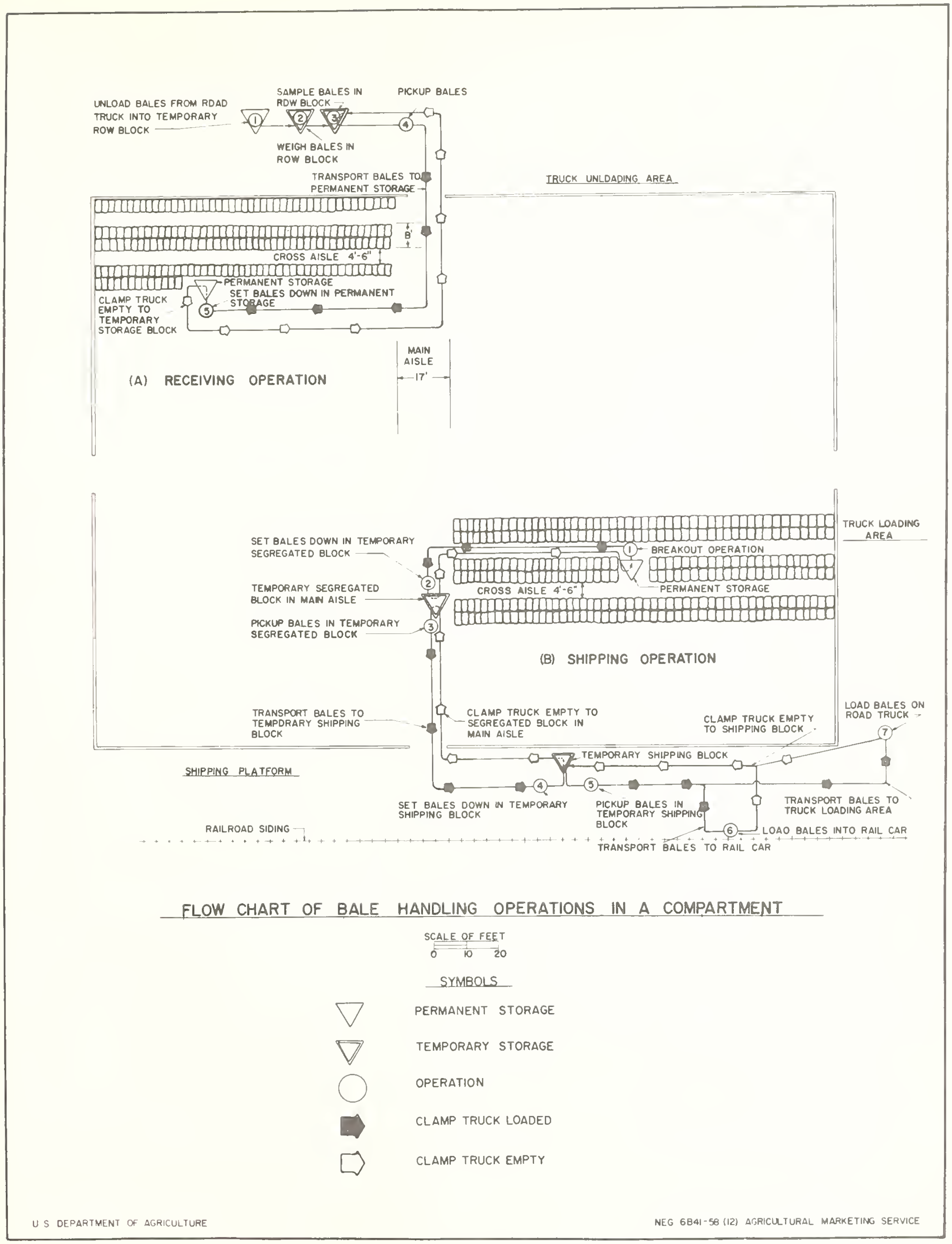

FIGURE 18.—Flow chart of bale handling for (A) receiving and (B) shipping operations in a compartment.

level asphalt court located outside and at one end of the compartment, with the court connected to the end of the rail platform (fig. 18). If desired a canopy can be built over the rail platform so that rail cars can be loaded during bad weather; also, road trucks can back onto the rail platform for loading during inclement weather.

Flow of Bales Into and Out of Compartment

The flow chart in figure 18 represents operations in moving bales into and out of a storage compartment. For an effective flow pattern, the handling operations and movement must remain in the proper sequence.

A recommended flow of movement and sequence of operations for receiving bales is shown in figure 18(A). Receiving operations start with the unloading of bales from road trucks and placing in temporary blocks outside the compartment. Bales can be unloaded by a 3-bale clamp truck, transported about 50 feet and placed in a row block for weighing and sampling, operation (1); weighed on a mobile beam scale attached to a lift truck, operation (2); sampled by a 3-man crew, operation (3); then picked up by a 4-bale clamp truck, operation (4), transported to the storage area inside the compartment, and placed in 3-high on-head stacks, operation (5). After storing the bales, the clamp truck returns to the row block outside the compartment for another load. The flow chart shows that each operation can be performed independently, in sequence, and that there will be no traffic problems if more than one clamp truck is used for transporting and stacking.

The shipping operation, figure 18(B), is more complex than the receiving operation because bales have to be broken out individually. Bales are broken out of storage, operation (1); transported to the main aisle and set down in temporary segregated blocks, operation (2). Bales are picked up from the segregated blocks by a 4-bale clamp truck, operation (3), and transported to a shipping block on the shipping platform, operation (4). After setting bales down on the platform, in a temporary block, the clamp truck returns to the main aisle for another load. A clamp truck picks up 2 bales from the shipping block, operation (5); transports them about 50 feet and loads them into a rail car, operation (6); or transports them about 125 feet and loads them onto road trucks, operation (7). After loading bales into the car or onto road trucks, the clamp truck returns to the shipping block for another load.

A detailed flow pattern and sequence of bale handling operations for breaking bales out of storage is shown in figure 19. A lift truck equipped with a breakout attachment moves to the stack containing the desired bale to be broken out. As bales are stored three high on head, one or two obstructing bales may have to be removed to reach the desired bale. Obstructing bales are removed from the storage stacks, operation (1); moved toward the warehouse wall, and set down in the cross aisle, operation (2). The desired bale is removed, operation (3); transported to the main aisle, and set down in a temporary block, operation (4). After setting the bale down in the main aisle the lift truck returns to the obstructing bales that were set down in the cross aisle, operation (5); picks them up one at a time, and returns them to the storage stack, operation (6). After returning the bales to the storage stack, the lift truck moves to the next bale to be broken out.

Usually bales are received and placed in storage, and the receiving crew has moved to another compartment before bales are broken out for shipment. Receiving and shipping operations are generally not occurring simultaneously in the same compartment. Bales are usually broken out and placed in the main aisle about 2 or 3 hours before being transported to a shipping block. However, in some instances the breakout operation and transporting to the shipping block will occur simultaneously.

Building Design

Roof.—The low pitched, gable roof is made of 29-gage high-strength, corrugated steel sheets supported by 2- by 10-inch purlins spaced 2 feet 9 inches on centers. This spacing of the purlins is adaptable to 12-foot roofing sheets with a 12-inch end lap. This type of construction is often classed as open joist construction by fire insurance agencies and a coverage of 90 square feet of roof area is allowed for each sprinkler head.

The roof slopes only 1½ inches in 12 inches. Most manufacturers of metal roofing of this type recommend a minimum slope of 3 or 4 inches in 12 inches. Field studies revealed, however, that in many cotton warehouses in the southwestern areas with low rainfall (below about 1.75 inches per hour) metal roofs have been used successfully with lower roof slopes (below 2″ in 12″) with only insignificant rain leakage (fig. 8).

In areas where a metal roof with the lower slope (1½″ in 12″) is adaptable, the roof design shown in figure 17 represents low cost but durable construction. The low pitch reduces column heights and reduces the area of the end walls, without going to the more expensive and heavy built-up roofing of asphalt and roofing felt. In areas of moderate rainfall (roughly from 1.75 to 2.5 inches per hour) the low pitched roof also may be used, but the roof joints should be sealed with extruded mastic beads or other equally effective sealers. In areas of higher rain-

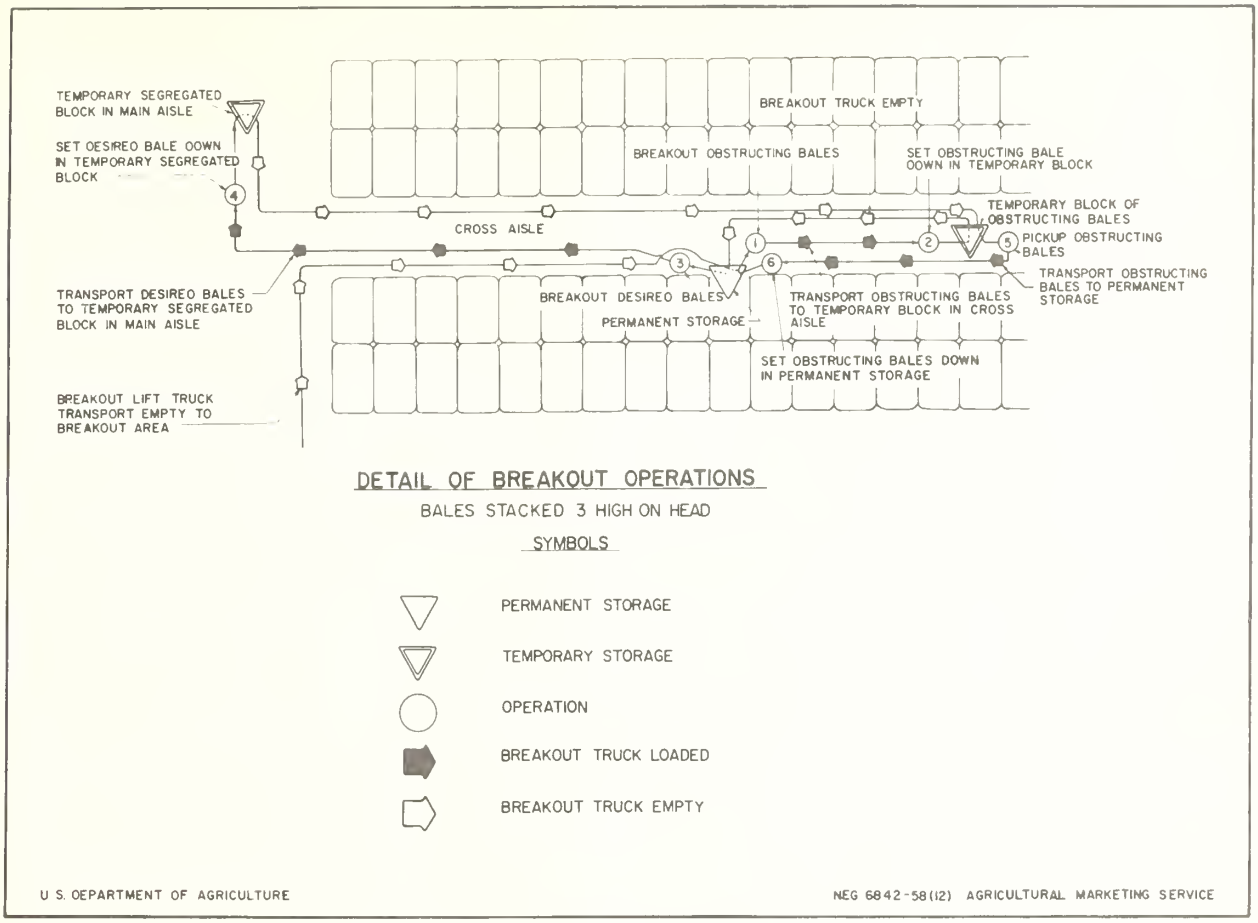

FIGURE 19

fall (over about 2.5 inches per hour) a metal roof with a minimum slope of 3 or 4 inches in 12 inches is advisable.

Walls.—The walls are designed to use 2- by 6-inch studding covered with corrugated steel sheets as used for roofing. Instead of using the common 24-inch stud spacing, a spacing of 2 feet 4 inches was used. This spacing is adaptable to 12-foot siding sheets with a 4-inch end lap (5 spaces of 2 feet 4 inches equals 11 feet 8 inches).

This construction represents a low cost but an acceptable design. However, the corrugated steel siding is easily damaged by clamp trucks, and wooden bumpers and guard posts are recommended to protect the building from such damage.

Structural framing.—The 2- by 10-inch roof purlins are supported by wooden girders (fig. 17). In turn these girders are supported by pressure-treated wooden poles serving as columns.

These pressure-treated wooden poles are the most notable feature of this design. They were chosen because they resist rot, decay, and termites; when deeply embedded in the earth, they need less elaborate and heavy knee bracing and should be less subject to clamp-truck damage than other types of wood columns. In addition, the bales of cotton can be easily "wrapped" about a round column (fig. 15).

It is important that the poles be thoroughly dry to prevent staining of the cotton bales by the preservative.

Floors.—The floors consist of a well-graded and well-compacted caliche or gravel base not less than 6 inches in thickness with a hot-mix bituminous concrete surface, 1½ inches thick. The main aisle, which is subject to considerable traffic, should have paving that is 3 inches thick instead of 1½ inches. The floor should have a slight grade toward the center aisle so that if the sprinkler system discharges, water will not puddle. This construction represents a low cost, durable floor which can be economically spread and finished with paving machinery used in highway work.

Plastic translucent panels.—Corrugated glass-fiber reinforced plastic translucent panels are provided in the roof to give natural daylighting. These panels match the corrugations in metal sheets and have been used extensively with corrugated metal construction. Translucent screening consisting of 14-mesh, galvanized wire impregnated with a plastic covering can be substituted for the plastic panels to provide natural daylighting. This screening is used in the sidewalls just below the eaves. This type of screening gives a low cost, watertight, fire resistant screen. However, it is not very durable and must be replaced about every 5 to 7 years.

Doors.—Overhead sectional wood doors, 12 feet wide and 12 feet high, are used at the ends of the main aisle. The door jambs should be adequately protected with guards to prevent clamp truck damage.

Sliding wood-frame doors covered with galvanized steel sheets are provided in the end walls for salvage operations in the event of fire.

Fire protection.—The compartment is protected by an automatic sprinkler system. Most insurance regulations covering cotton warehouses require a sprinkler coverage of 10 square feet less than recommended by the National Board of Fire Underwriters' Pamphlet No. 13, Section No. 14, for ordinary hazards (*4*, *5*, *8*). For this type of construction, a coverage of 90 square feet (100 sq. ft. for ordinary hazards) would then be allowed for cotton warehouses equipped with an approved type of sprinkler spray heads.

The compartment is also provided with an independent standpipe system with 4 or more hose racks with 50 feet of cotton, rubber-lined hose on each rack.

Lighting and electrical system.—Since bale tags can easily be read with little lighting, minimum artificial lighting is provided. Spotlights are used for lighting the aisles. Floodlights are installed outside the compartment above the doors at the end of the main aisle. All wiring, outlet boxes, lighting fixtures, etc., are installed in accordance with the National Electrical Code.

Construction Costs

The estimated total construction cost for this compartment is $72,000, or $1.74 per square foot. This estimate does not include costs for outside utilities, roadways, outside fire protection, rail sidings, etc., but it does include costs for the lighting, sprinkler systems, floors, excavations, and other work necessary for a complete storage compartment. It is assumed that the site is relatively level, that the soil is favorable, and that the work will be done under contract. The breakdown in the next column shows the estimated cost of the various construction items for design A.

The estimated costs are based on labor rates and material prices for the first quarter of 1958 for the Dallas, Tex., area. These rates and prices are based on information obtained from estimating handbooks, technical publications, manufacturers of building materials, contractors, and Government agencies.

The warehouseman may find considerable variation between his actual building cost and the estimated cost given here because of inherent difficulties in making a precise cost estimate and conditions existing when and where the compartment is built. The actual construction cost will be affected by site conditions, business conditions, and the geographical location. Caution should be used when considering the individual items in these cost estimates as some may be high while others may be low. Also, a percentage of the total overhead and profit should be added to the cost of each individual item. However, estimates given in the tabulation should provide an approximate construction cost as well as a basis for comparing the different designs presented in this report.

Item	*Cost*
Site preparation and excavation work	$800
Paving and floor construction	10,000
Concrete work	2,000
Carpentry	11,300
Metal siding and roofing	12,400
Doors and light panels	1,500
Lighting and electrical	1,200
Fire protection	18,200
Total	57,400
25 percent overhead and profit	14,350
Grand total	71,750

$$\text{Cost per sq. ft.} = \frac{\$72,000^{1}}{176.7 \text{ ft.} \times 233.7 \text{ ft.}^{2}} = \$1.74$$

$$\text{Cost per bale} = \frac{\$72,000^{1}}{7,476^{3}} = \$9.63$$

[1] Estimated construction cost rounded to nearest $500.
[2] Outside dimensions of compartment.
[3] Storage capacity in bales.

Annual Facility Costs

The estimated annual facility costs for design A, and the items considered in computing the costs are shown in table 3. These costs, based on the estimated construction cost of one compartment, are $72,000.

The assumed depreciation rates are based on the estimated useful life of the compartment. The estimated useful lives for the various compartments are based on observations of existing warehouses, consultation with other engineers, and reference to the following published material: "Income Tax Depreciation and Obsolescence, Estimated Useful Lives and Depreciation Rates," Bulletin "F" (*12*, pp. 16–19); "Boeckh's Manual of Appraisals" (*2*, pp. 721–724); and "Kidder-Parker Architects and Builders Handbook" (*7*, pp. 2052–2054).

A useful life of 25 years was assumed for design A, pole-frame construction (for light frame, industrial buildings of cheap construction Boeckh lists a useful life of from 20 to 25 years) (*2*).

As shown in table 3, depreciation is a large part of the total annual facility cost, and the useful life can greatly affect this total cost. The years of useful life depend not only upon the type and quality of construction but also upon shifting land values, changing agricultural practices, quality of building maintenance, and various economic factors. Depreciation, as used in this report, covers mainly the physical factors such as type and quality of construction. When making construction loans, most financial agencies usually assume shorter useful lives than the figures used in this report. The figures for this report, however, provide a reasonable basis for comparison of the four compartment designs.

TABLE 3.—*Estimated annual facility costs for the storage compartment of pole-frame construction (design A)*[1]

Item	Assumed rates	Annual costs
	Percent	*Dollars*
Depreciation [2]	4.0	2,880
Interest [3]	5.0	1,800
Maintenance and repairs	1.0	720
Taxes	1.0	720
Insurance:[4]		
California	0.23	(166)
Texas	0.38	(274)
Total annual facility cost:		
California		6,286
Texas		6,394

[1] Estimated initial construction cost, $72,000.

[2] Estimated useful life, 25 years (see page 22). As loan agencies usually will not make loans for this type of construction for a period of more than 15 to 20 years, the estimated annual facility costs shown probably would not yield sufficient revenue during the loan amortization period to pay off a 100-percent construction loan and meet maintenance, insurance, and related costs.

[3] Based on the average value of the building.

[4] Rate of $0.23 for California and $0.38 for Texas per $100 valuation.

Interest on the average investment was assumed to be 5 percent. Maintenance and repair costs were assumed to vary from 1.0 percent for the pole-frame construction to as low as 0.5 percent for the tilt-up concrete construction. The rates assumed for repairs and maintenance are based on observations in existing cotton warehouses, discussions with warehousemen on their maintenance problems, and information from government agencies dealing with building maintenance and from private consulting engineering services. Taxes were assumed to be 1 percent. Building insurance rates were obtained from the Pacific Rating Bureau and the Texas State Board of Insurance. The limitations and variations in the insurance rates on the stored cotton, discussed in the next section, also apply to insurance rates on the building.

Annual Insurance Cost on Stored Cotton

Insurance rates for Texas were obtained from the Texas State Board of Insurance; rates for Southern California were obtained from the Pacific Fire Rating Bureau.

For the pole-frame compartment the rate for both Texas and Southern California is $0.23 per year per $100 valuation of the cotton. Using this rate and assuming that 7,476 bales, valued at $150 per bale, are to be stored for 6 months, the annual insurance cost for the cotton stored in one compartment would be $1,290.

In actual practice the warehouseman will find considerable variation in this rate since the insurance rates depend upon the water supply, the type of watchman service, the local fire protection, and other factors.

Storage Compartment of Beam and Girder Construction

The beam and girder design shown in figure 20, design B, represents a somewhat higher quality of construction than the pole-frame design shown in figure 17, design A. Design B has a heavier gage roofing and siding, and heavier wooden structural members as well as other refinements not found in design A.

Layout

The storage compartment in design B is the same size as the one in design A. Columns, main and cross aisles, doors, storage sections, rail platforms, truck receiving areas, and truck loading courts are located as shown in design A.

Building Design

Roof.—The roof has three gable sections and is constructed of 21-gage, galvanized, corrugated steel roofing sheets supported by 4- by 10-inch wood purlins (fig. 20). This type of framing is often classed as semimill construction. A coverage of 100 square feet is allowed for each sprinkler head. The roof has a slope of 3 inches in 12 inches; this provides greater protection against rain than provided for in design A.

Walls.—The walls of the compartment are constructed of 2- by 6-inch studdings with 28-gage, galvanized, corrugated steel siding. On the side of the compartment subject to clamp truck damage, the lower 4 feet of the wall is constructed of reinforced concrete (fig. 21).

Structural framing.—The roof purlins are supported by heavy wooden girders. These, in

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FIGURE 21.—Concrete wall base, 4 feet high, prevents clamp-truck damage to wall.

turn, are supported by 8- by 8-inch wooden columns. The columns are fully anchored into the concrete foundations by steel angle irons on each corner of the column (fig. 20). This provides good structural anchorage as well as protection for the columns from clamp truck damage.

Floor.—The floor is paved with 1½-inch-thick bituminous paving on a gravel base. The main aisle has a 3-inch-thick paving. This is the same floor construction as provided for in design A.

Plastic translucent panels.—Translucent panels of corrugated plastic reinforced with glass fiber are provided in the roof to give natural daylighting. These panels match the corrugations in metal roofing sheets and have been extensively used with corrugated metal construction.

Doors.—Overhead sectional wood doors are shown in this design. Some cotton warehousemen prefer this type of door to the metal sliding doors. They feel that overhead doors are not as subject to clamp truck and wind damage.

Fire protection.—As in the other designs, the compartment is protected by an automatic sprinkler system and standpipes with hose racks. A coverage of 100 square feet per sprinkler head is allowed with this type of construction. When an actual sprinkler layout was made, however, it was found that nearly as many sprinkler heads were required for this design as for design A because of the column spacing used.

Lighting and electrical system.—Minimum artificial lighting is provided, similar to the lighting described under design A.

Construction Costs

The estimated construction costs for this compartment (design B) are $81,000, or $1.98 per square foot. These costs are based on labor rates and material prices for the first quarter of 1958 in the Dallas, Tex., area. The following breakdown shows the various construction items for design B:

Item	*Cost*
Site preparation and excavation	$1,000
Paving and floor construction	10,000
Concrete work	5,620
Carpentry	12,400
Metal siding and roofing	14,880
Doors and light panels	1,500
Lighting and electrical	1,200
Fire protection	18,400
Total	65,000
25 percent overhead and profit	16,225
Grand total	81,225

$$\text{Cost per square foot} = \frac{\$81{,}000\,^{1}}{175.8 \text{ ft.} \times 232.7 \text{ ft.}^{2}} = \$1.98$$

$$\text{Cost per bale} = \frac{\$81{,}000\,^{1}}{7{,}476\,^{3}} = \$10.83$$

[1] Estimated construction cost rounded to nearest $500.
[2] Outside dimensions of compartment.
[3] Storage capacity in bales.

For a further discussion of the bases for these cost estimates, see the section on Construction Costs for the pole-frame compartment (page 22).

Annual Facility Costs

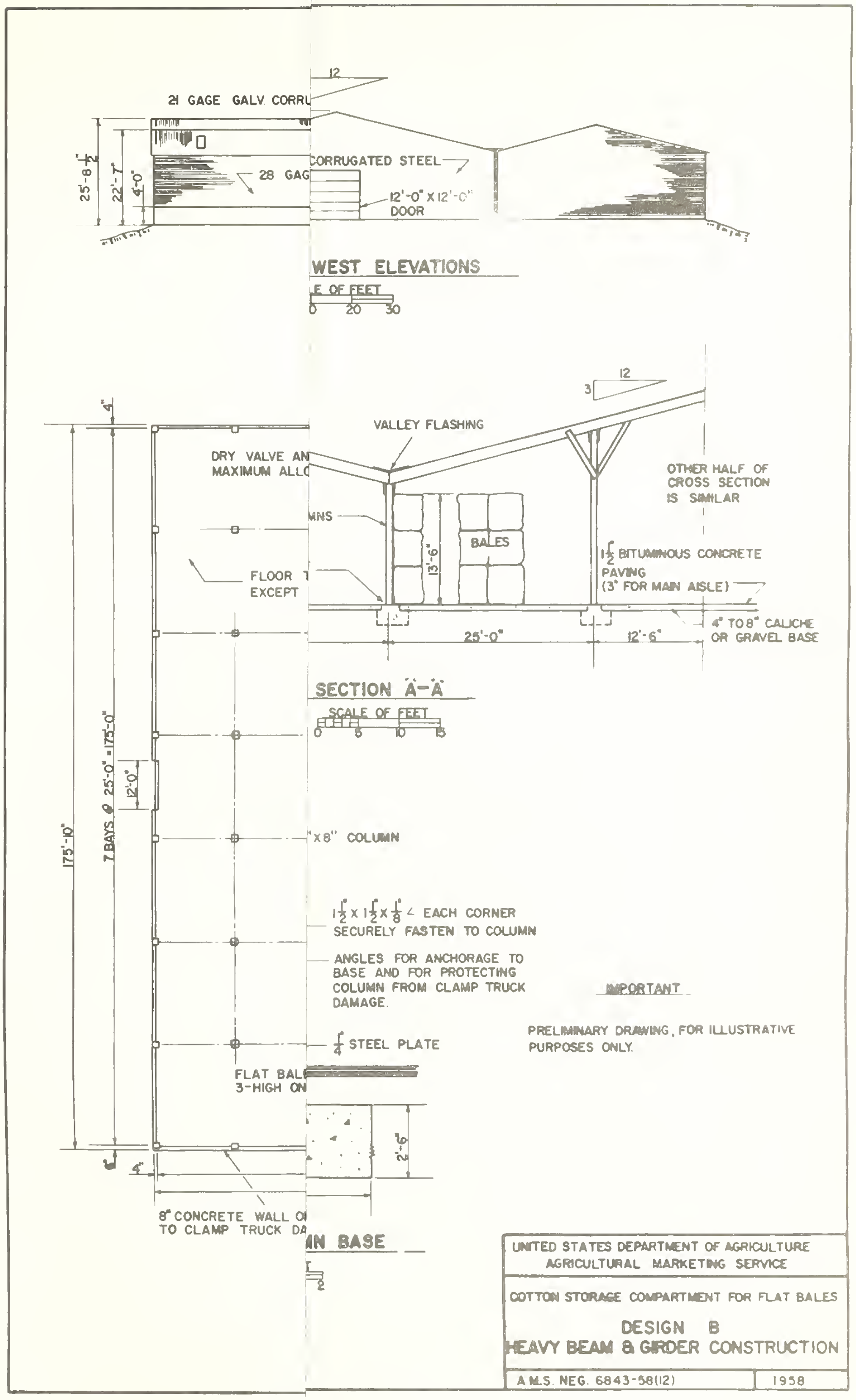
Table 4 shows the estimated annual facility costs for the compartment of beam and girder construction, design B. A useful life of 30 years was assumed for design B, the heavy wood beam and girder construction (for heavy frame, industrial buildings of cheap construction Boeckh lists a useful life of from 25 to 33 years) (*2*). For a further discussion on the bases for computing annual costs see the section on Annual Facility Costs for the pole-frame construction (page 22).

Annual Insurance Cost on Stored Cotton

The insurance rate used was $0.23 per year per $100 valuation, the same rate as used in design A. Therefore, the annual insurance costs would also be the same, which was $1,290.

Storage Compartment of Tilt-up Concrete Construction

The tilt-up concrete design shown in figure 22, design C, represents the most permanent type of construction of the four designs discussed in this report. The walls are constructed



512995 O - 59 (Face p. 24) No. 1

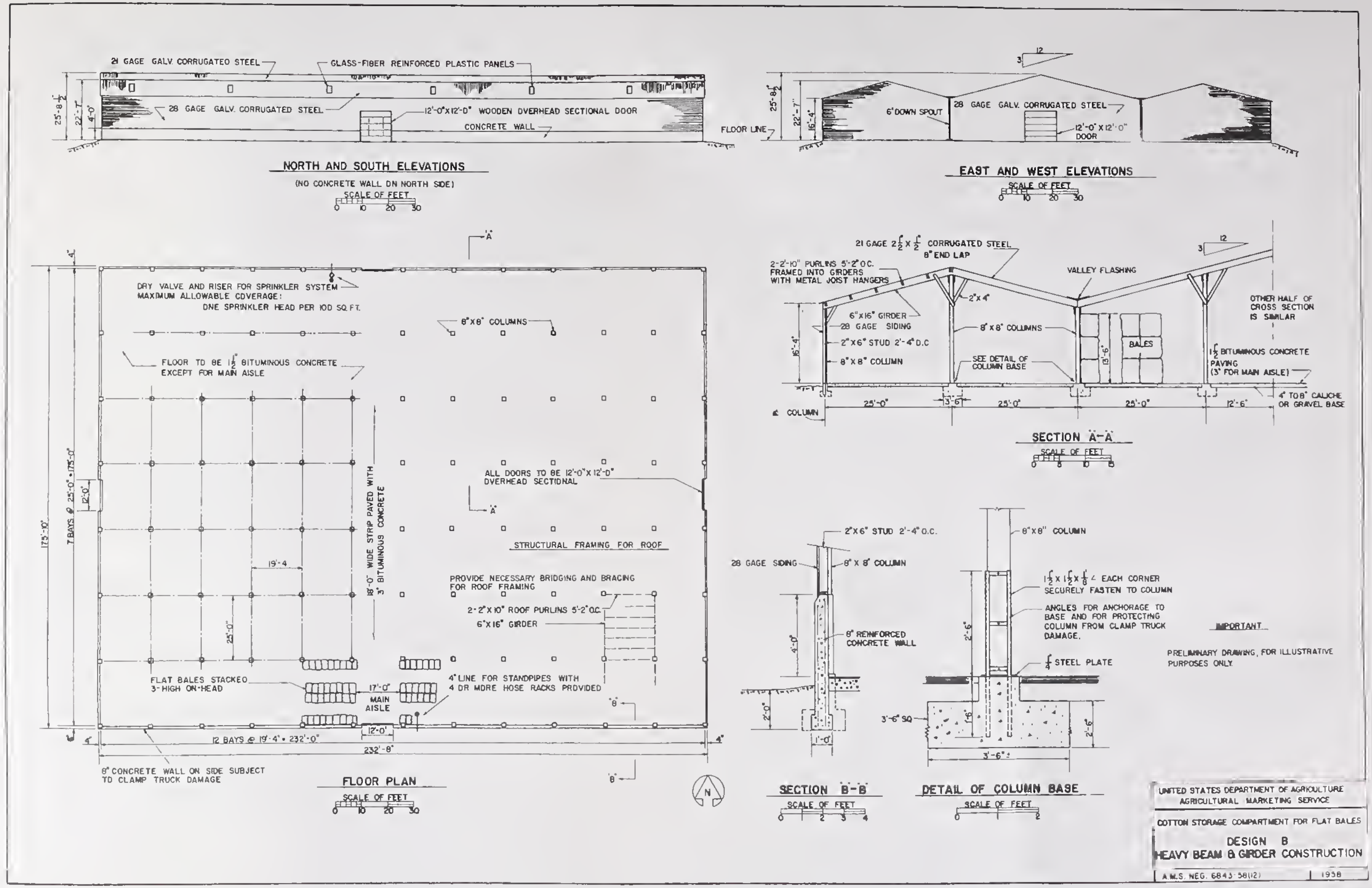
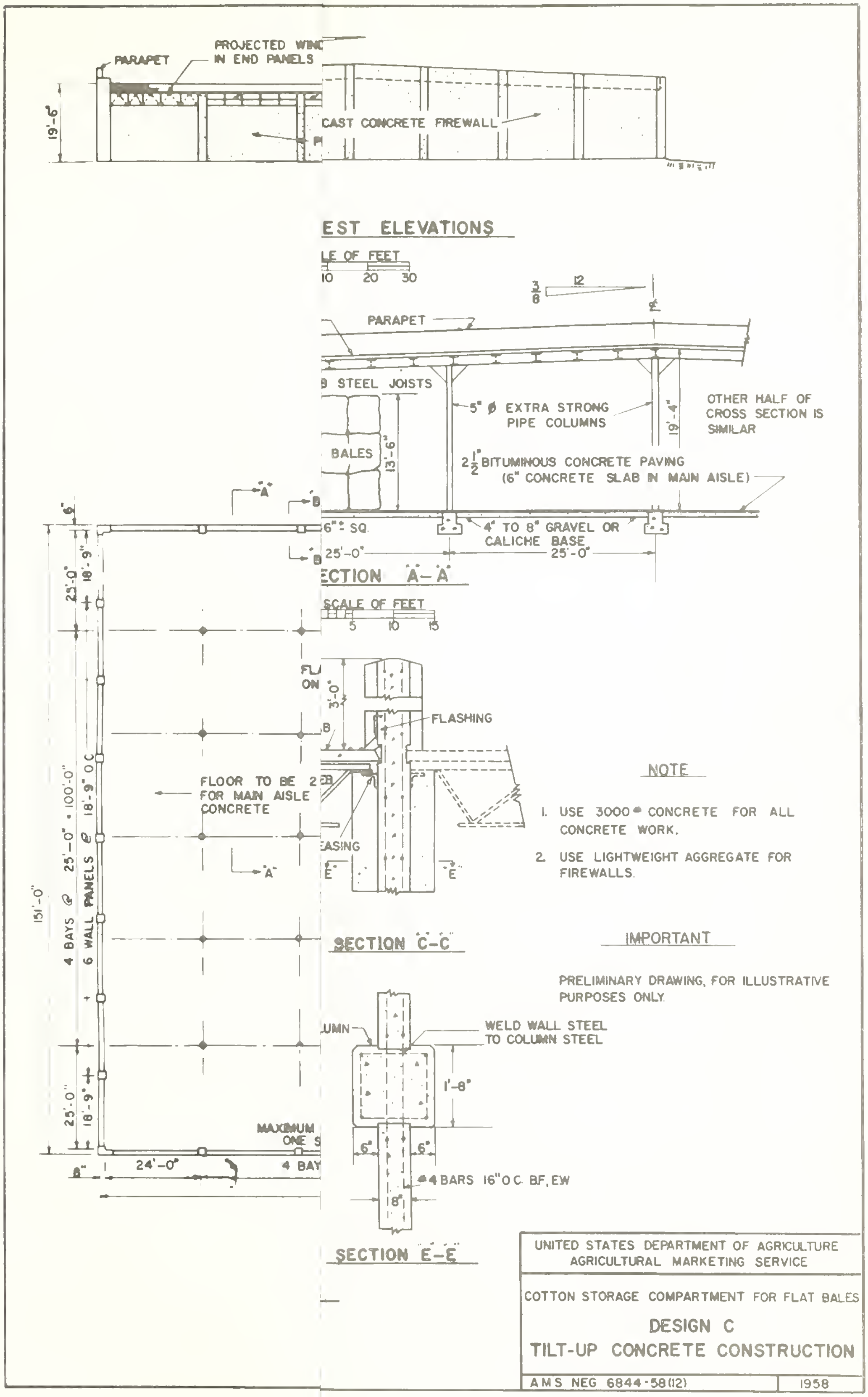


FIGURE 20

512995 O - 59 (Face p. 24) No. 1



512995 O - 59 (Face p. 24) No. 2

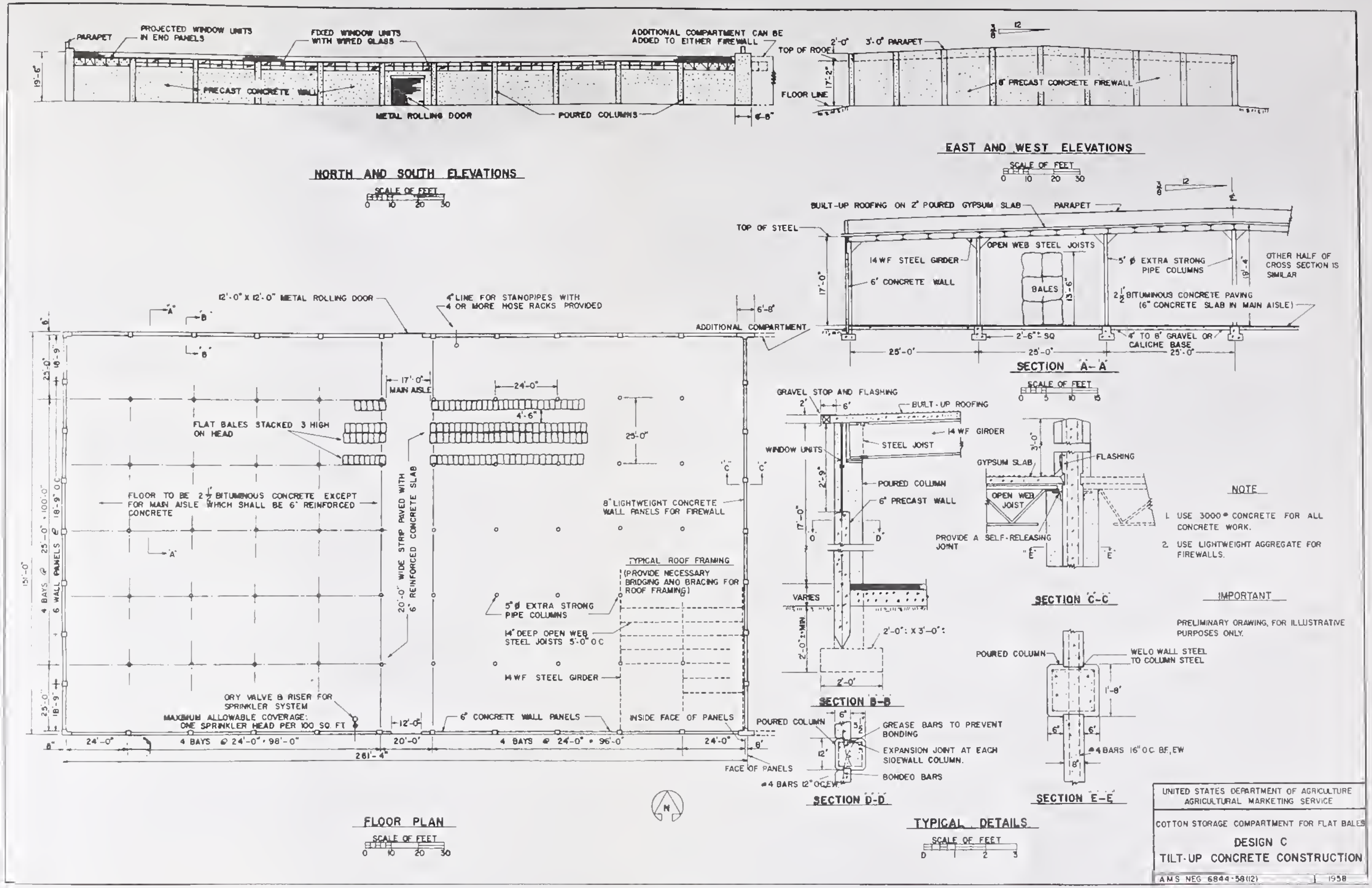

PARAPET
PROJECTED WINDOW UNITS IN END PANELS
FIXED WINDOW UNITS WITH WIRED GLASS
ADDITIONAL COMPARTMENT CAN BE ADDED TO EITHER FIREWALL
19'-6"
PRECAST CONCRETE WALL
METAL ROLLING DOOR
POURED COLUMNS
6'-8"
NORTH AND SOUTH ELEVATIONS
SCALE OF FEET
0 10 20 30
TOP OF ROOF
2'-0"
3'-0" PARAPET
17'-2"
FLOOR LINE
8" PRECAST CONCRETE FIREWALL
EAST AND WEST ELEVATIONS
SCALE OF FEET
0 10 20 30
BUILT-UP ROOFING ON 2" POURED GYPSUM SLAB
PARAPET
TOP OF STEEL
OPEN WEB STEEL JOISTS
14 WF STEEL GIRDER
5" Ø EXTRA STRONG PIPE COLUMNS
OTHER HALF OF CROSS SECTION IS SIMILAR
17'-0"
6" CONCRETE WALL
BALES
13'-6"
19'-4"
2 1/2" BITUMINOUS CONCRETE PAVING (6" CONCRETE SLAB IN MAIN AISLE)
2'-6" SQ
4" TO 8" GRAVEL OR CALICHE BASE
25'-0"
25'-0"
25'-0"
SECTION A-A
SCALE OF FEET
0 5 10 15
12'-0" X 12'-0" METAL ROLLING DOOR
4" LINE FOR STANDPIPES WITH 4 OR MORE HOSE RACKS PROVIDED
6'-8"
ADDITIONAL COMPARTMENT
17'-0" MAIN AISLE
24'-0"
4'-6"
25'-0"
FLAT BALES STACKED 3 HIGH ON HEAD
FLOOR TO BE 2 1/2" BITUMINOUS CONCRETE EXCEPT FOR MAIN AISLE WHICH SHALL BE 6" REINFORCED CONCRETE
20'-0" WIDE STRIP PAVED WITH 6" REINFORCED CONCRETE SLAB
8" LIGHTWEIGHT CONCRETE WALL PANELS FOR FIREWALL
TYPICAL ROOF FRAMING
(PROVIDE NECESSARY BRIDGING AND BRACING FOR ROOF FRAMING)
5" Ø EXTRA STRONG PIPE COLUMNS
14" DEEP OPEN WEB STEEL JOISTS 5'-0" O C
14 WF STEEL GIRDER
4 BAYS @ 25'-0" = 100'-0"
6 WALL PANELS @ 18'-9" O C
151'-0"
DRY VALVE & RISER FOR SPRINKLER SYSTEM
MAXIMUM ALLOWABLE COVERAGE: ONE SPRINKLER HEAD PER 100 SQ FT
6" CONCRETE WALL PANELS
INSIDE FACE OF PANELS
12'-0"
24'-0"
4 BAYS @ 24'-0" = 98'-0"
20'-0"
4 BAYS @ 24'-0" = 96'-0"
24'-0"
261'-4"
FACE OF PANELS
FLOOR PLAN
SCALE OF FEET
0 10 20 30
GRAVEL STOP AND FLASHING
BUILT-UP ROOFING
14 WF GIRDER
STEEL JOIST
WINDOW UNITS
POURED COLUMN
6" PRECAST WALL
VARIES
2'-0" MIN
2'-0" X 3'-0"
2'-0"
SECTION B-B
GYPSUM SLAB
FLASHING
OPEN WEB JOIST
PROVIDE A SELF-RELEASING JOINT
SECTION C-C
POURED COLUMN
GREASE BARS TO PREVENT BONDING
EXPANSION JOINT AT EACH SIDEWALL COLUMN.
BONDED BARS
#4 BARS 12" OC EW
SECTION D-D
POURED COLUMN
WELD WALL STEEL TO COLUMN STEEL
1'-8"
#4 BARS 16" OC BF, EW
SECTION E-E
TYPICAL DETAILS
SCALE OF FEET
0 1 2 3
NOTE
1. USE 3000# CONCRETE FOR ALL CONCRETE WORK.
2. USE LIGHTWEIGHT AGGREGATE FOR FIREWALLS.
IMPORTANT
PRELIMINARY DRAWING, FOR ILLUSTRATIVE PURPOSES ONLY.
UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL MARKETING SERVICE
COTTON STORAGE COMPARTMENT FOR FLAT BALES
DESIGN C
TILT-UP CONCRETE CONSTRUCTION
AMS NEG 6844-58(2)
1958

FIGURE 22

TABLE 4.—*Estimated annual facility costs for the storage compartment of beam and girder construction (design B)*[1]

Item	Assumed rates	Annual costs
	Percent	*Dollars*
Depreciation [2]	3.33	2,700
Interest [3]	5.0	2,025
Maintenance and repairs	1.0	810
Taxes	1.0	810
Insurance: [4]		
California	0.23	(186)
Texas	0.38	(308)
Total annual facility cost:		
California		6,531
Texas		6,653

[1] Estimated initial construction cost, $81,000.

[2] Estimated useful life, 30 years (see page 24). As loan agencies usually will not make loans for this type of construction for a period of more than 15 to 20 years, the estimated annual facility costs shown probably would not yield sufficient revenue during the loan amortization period to pay off a 100-percent construction loan and to meet maintenance, insurance, and related costs.

[3] Based on the average value of the building.

[4] Rate of $0.23 for California and $0.38 for Texas per $100 valuation.

of precast concrete panels, the roof of poured gypsum roof decking covered with built-up roofing, and the structural framing consists of steel members. This is the only one of the four designs shown with connected compartments requiring firewalls.

Layout

The storage compartment is 150 by 260 feet (inside dimensions) providing 39,000 square feet of floor area. Walls are 17 feet high at the eaves, and the built-up roof is 19 feet 6 inches high at the ridge. One 12- by 12-foot metal rolling door is located in each of the 260-foot walls at the ends of the main aisle (fig. 22). The walls provide sufficient height for tiering flat bales 3 high on head throughout the compartment, plus the required clear space between the tops of the bales and the sprinkler heads.

Each storage section is 25 feet wide and 121½ feet long from the compartment end wall to the main aisle (fig. 22). Columns are spaced on 24- by 25-foot centers. The main aisle is 17 feet wide by 150 feet long, occupying 2,550 square feet, or about 6.5 percent of the total floor area. Segregating bales to be shipped, traffic movement, and sometimes weighing and sampling of bales, are the principal operations that can be performed in the main aisle.

There are two cross aisles in each storage section extending from the main aisle to the end wall. Each cross aisle is 4 feet 6 inches wide and, allowing for the 17-foot main aisle, 243 feet long; it occupies 1,093½ square feet of floor area. The total floor area occupied by the 12 cross aisles amounts to 13,122 square feet, or about 33.5 percent of the total floor area. Cross aisles are used as work aisles to perform the same operations as those described in design A, page 18.

Design C provides for a minimum storage capacity of 7,200 flat bales of cotton, using 23,328 square feet, or 60 percent of the total floor area. The overhead doors at either end of the main aisle provide ample space for loaded clamp trucks.

Receiving and shipping areas and storage stacks are located the same as those described in design A, page 18.

Building Design

Roof.—The roof consists of a poured gypsum-concrete slab 2 inches thick reinforced with welded wire mesh. This slab is supported by a ½-inch-thick rigid gypsum formboard and steel purlins. The roof deck is covered with built-up roofing made of three plies of felt and covered with tar and slag, or other lightweight aggregate. This type of roof construction was selected for its durability and fire resistance.

Walls.—The walls are precast concrete panels with the sidewalls 6 inches thick. The end walls are 8 inches thick and may serve as a fire division or firewall between compartments. Although most insurance agencies require a reinforced concrete wall 12 inches thick, the 8-inch-thick wall, using a lightweight aggregate such as slag, pumice, or shale, is suggested as an adequate substitute. The Public Buildings Service, U.S. General Services Administration, has built warehouses with 4-hour firewalls only 6 inches thick, using lightweight aggregate.

Structural framing.—The structural system supporting the roof is made up of open-web, steel joists on 14-inch, wide-flanged steel girders. The columns are 5-inch-diameter, extra-strong pipe sections. These columns should adequately resist damage from clamp trucks.

Floors.—The floors are constructed of a hot-mix bituminous concrete paving 2½ inches thick, except for the main aisle which is paved with a reinforced concrete slab 6 inches thick. The thicker bituminous paving and the reinforced concrete in the main traffic aisle provide a more durable and more maintenance-free floor than other designs shown in this report.

Window units.—The windows are fixed steel window units glazed with ¼-inch rolled wired glass. A few projected types of window units are shown to provide ventilation when necessary.

Doors.—The doors are chain-operated, metal rolling doors.

Fire protection.—The compartment is protected by automatic sprinkler systems and standpipes with hose racks as shown in the other designs. For this type of construction a sprinkler coverage of 100 square feet is usually allowed for cotton warehouses. An actual sprinkler layout, however, discloses that a sprinkler coverage of less than 80 square feet can be accomplished.

Lighting and electrical system.—For this design a minimum of lighting is provided, similar to the other designs.

Construction Costs

The estimated construction costs for this compartment (design C) are $112,500, or $2.85 per square foot. These costs are based on labor rates and material prices for the first quarter of 1958 in the Dallas, Tex., area. The following breakdown shows the various construction items for design C:

Item	*Cost*
Site preparation and excavation	$970
Paving and floor construction	12,340
Concrete work	14,000
Roof construction	20,500
Structural steel	18,000
Doors and windows	4,000
Lighting and electrical	1,700
Fire protection	18,400
Subtotal	89,910
25 percent overhead and profit	22,478
Grand total	112,388

$$\text{Cost per square foot} = \frac{\$112{,}500\,^{1}}{151.3\text{ ft.} \times 261.3\text{ ft}\,^{2}} = \$2.85$$

$$\text{Cost per bale} = \frac{\$112{,}500}{7{,}200\,^{3}} = \$15.62$$

[1] Estimated construction cost rounded to nearest $500.
[2] Outside dimensions of compartment.
[3] Storage capacity in bales.

As both firewalls are common to two compartments, the cost shown here includes the cost of only one firewall. For a further discussion of the bases for these cost estimates, see the section on Construction Costs for the pole-frame compartment (page 22).

Annual Facility Costs

Table 5 shows the estimated annual facility costs for the compartment of tilt-up concrete construction, design C. A useful life of 60 years was assumed for design C, tilt-up concrete construction (for reinforced concrete industrial buildings of good quality construction Boeckh (*2*) lists a useful life of from 56 to 90 years; Bulletin "F" (*12*) lists a maximum depreciation for warehouses as 75 years). For a further discussion on the bases for computing annual costs, see the section on Annual Facility Costs for the pole-frame compartment (page 22).

TABLE 5.—*Estimated annual facility costs for the storage compartment of tilt-up concrete construction (design C)*[1]

Item	Assumed rates	Annual costs
	Percent	*Dollars*
Depreciation [2]	1.66	1,875
Interest [3]	5.0	2,812
Maintenance and repairs	0.5	562
Taxes	1.5	1,125
Insurance: [4]		
California	0.09	(101)
Texas	0.36	(405)
Total annual facility cost:		
California		6,475
Texas		6,770

[1] Estimated initial construction cost, $112,500.
[2] Estimated useful life, 60 years (see page 26). As loan agencies usually will not make loans for this type of construction for a period of more than 15 to 20 years, the estimated annual facility costs shown probably would not yield sufficient revenue during the loan amortization period to pay off a 100-percent construction loan and meet maintenance, insurance, and related costs.
[3] Based on the average value of the building.
[4] Rate of $0.09 for California and $0.36 for Texas per $100 valuation.

Annual Insurance Cost on Stored Cotton

The insurance rate for this type of compartment is assumed to be $0.34 per year per $100 valuation for Texas and $0.18 per $100 valuation for California. Under the same assumption used in design A (page 23), the annual insurance cost for the cotton in one compartment would be $1,836 for Texas, and $972 for California.

Although this tilt-up concrete compartment is considered to be of fire-resistive construction, insurance rates on cotton stored in tilt-up concrete compartments are often higher than for compartments of wood-frame and sheet metal construction. Some of the reasons given by insurance agencies for these higher rates are: (1) New improved type of sprinkler heads reduces the importance of fire-resistive construction; (2) in case of fire, it may be difficult to break into concrete compartments to salvage bales or to vent the fire; and (3) statistical data from previous fires in facilities of tilt-up concrete construction is insufficient for establishing favorable insurance rates.

Storage Compartment of Long-Span Timber-Truss Construction

The timber truss design has the widest column spacing of the four designs, the columns being spaced 50 feet on centers both ways. The roof is supported by flat timber trusses, and the sides of the compartment are covered with aluminum sheets. This compartment, design D, is shown in figure 23.

Layout

This storage compartment is 150 by 250 feet (inside dimensions) and has 37,500 square feet of floor area available for storage of cotton bales. Walls are 21 feet high at the eaves, and the built-up roof is 22 feet 9 inches high at the ridge. Minimum clearance under the truss is 14 feet 7 inches. One 14- by 12-foot metal roll-up door is located in each of the 250-foot walls, at opposite ends of the main aisle (fig. 23). The walls provide sufficient height for tiering flat bales 3 high on head throughout the compartment plus the required clear space between the tops of the bales and the sprinkler heads.

Each storage section is 50 feet wide by 116 feet 6 inches long from the compartment end wall to the main aisle. The main aisle is 17 feet wide and 150 feet long and occupies 2,550 square feet, or about 7 percent of the total floor area. Segregating of bales to be shipped, traffic movement, and sometimes weighing and sampling of bales are the principal operations that can be performed in the main aisle.

Four cross aisles in each storage section extend from the main aisle to the compartment end walls. Each cross aisle is 4 feet 6 inches wide and, allowing for a 17-foot main aisle, is 233 feet long; it occupies 1,048 square feet of floor area. The total floor space occupied by cross aisles amounts to 12,582 square feet, or 33 percent of the total floor space. Cross aisles are used as work aisles to perform the same operations as those listed on page 18, for design A.

The layout in figure 23 provides for a minimum storage capacity of 6,984 bales of cotton, using 22,368 square feet or 60 percent of the total floor area. The two roll-up doors located at either end of the main aisle provide ample space for loaded clamp trucks. Wood columns are spaced 50- by 50-foot on centers; they are located between two rows of bales and are thus protected from damage by machines. They are spaced for efficient machine handling operations in stacking bales 3 high on head, breaking bales out of stacks for shipment, and transporting bales. There are no columns in the aisles.

Receiving and shipping areas and storage stacks are located as described on page 18, design A.

Building Design

Roof.—The structural framing of the roof is covered with ¾-inch-thick plywood to form the roof deck. This deck is covered with built-up roofing of three plies of felt covered with tar and lightweight aggregate. The roof is slightly pitched with a slope of ¼ inch in 12 inches. This construction represents a durable and relatively maintenance-free type of construction and is adaptable to areas with more rainfall than the area for which design A is suitable.

Wall.—The wall construction is of aluminum fluted or ribbed sheets supported on wooden girts. If these sheets are fastened properly to the wooden girts they should provide a durable, maintenance-free type of construction that presents a good appearance. As a rule, the aluminum sheets would be suitable for highly industrial areas and coastal regions having a highly corrosive atmosphere.

A reinforced concrete wall about 4 or 5 feet high should be built along the side of the compartment that is most subject to clamp truck damage; for example, along the loading platform.

Structural framing.—The roof deck is supported by 4- by 8-inch purlins framed upon timber roof trusses spaced about 16 feet 8 inches on centers. These roof trusses are, in turn, supported by carrying trusses which are connected to 12- by 12-inch wooden columns, spaced 50 feet on centers each way. This gives clear, column-free bays 50 feet by 50 feet. This type of framing in conjunction with the plywood roof decking can sustain severe lateral loads, such as wind and earthquakes.

Floor.—The floors are paved with hot-mix bituminous concrete similar to designs A and B.

Plastic translucent panels.—Corrugated plastic panels reinforced with glass-fiber, similar to those in design B, are used in the upper wall area to provide natural daylighting.

Doors.—The compartment is provided with chain-operated metal rolling doors.

Fire protection.—The compartment is protected by automatic sprinkler systems and standpipes with hose racks as in design A. For this type of construction a sprinkler coverage of 100 square feet is usually allowed for cotton warehouses. However, when an actual sprinkler layout was made, it was found that a sprinkler coverage of less than 80 square feet could be accomplished.

Lighting and electrical outlets.—For this design a minimum type of lighting similar to that in design A is provided.

Construction Costs

The estimated construction costs for this compartment, design D, are $101,000, or $2.66 per square foot. These costs are based on labor rates and material prices for the first quarter of 1958 in the Dallas, Tex., area. The breakdown on the next page shows the various construction items for design D.

For a further discussion of the bases for these cost estimates, see the section on Construction Costs for the pole-frame compartment (page 22).

Item	*Cost*
Site preparation and excavation	$760
Paving and floor construction	8,960
Concrete work	4,280
Carpentry	30,390
Metal siding	6,500
Roofing	5,700
Doors and light panels	4,500
Lighting and electrical	1,400
Fire protection	18,400
Total	80,890
25 percent overhead and profit	20,220
Grand total	101,110

$$\text{Cost per square foot} = \frac{\$101{,}000^{1}}{151.2 \text{ ft.} \times 251 \text{ ft.}^{2}} = \$2.66$$

$$\text{Cost per bale} = \frac{\$101{,}000}{6{,}984^{3}} = \$14.46$$

[1] Estimated construction cost rounded to nearest $500.
[2] Outside dimensions of building.
[3] Storage capacity in bales.

Annual Facility Costs

Table 6 shows the estimated annual facility costs for the compartment of long-span, timber-truss construction, design D. A useful life of 35 years was assumed for design D. (For heavy frame industrial buildings of average construction, Boeckh (*2*) recommends a useful life of from 33 to 40 years.) For a further discussion on the bases for computing annual costs, see the section on Annual Facility Costs for the pole-frame compartment, page 22.

TABLE 6.—*Estimated annual facility costs for the storage compartment of long-span, timber-truss construction (design D)*[1]

Item	Assumed rates	Annual costs
	Percent	*Dollars*
Depreciation [2]	2.86	2,889
Interest [3]	5.0	2,525
Maintenance and repairs	0.5	505
Taxes	1.0	1,010
Insurance: [4]		
California	0.22	(222)
Texas	0.38	(384)
Total annual facility cost:		
California		7,151
Texas		7,313

[1] Estimated initial construction cost, $101,000.
[2] Estimated useful life, 35 years (see page 28). As loan agencies usually will not make loans for this type of construction for more than 15 to 20 years, the estimated annual facility costs shown probably would not yield sufficient revenue during the loan amortization period to pay off a 100-percent construction loan and meet maintenance, insurance, and related costs.
[3] Based on the average value of the building.
[4] Rate of $0.22 for California and $0.38 for Texas per $100 valuation.

Annual Insurance Cost on Stored Cotton

The insurance rate for cotton stored in this type of structure is $0.23 per $100 valuation for Texas and $0.22 per $100 valuation for California. Therefore, the annual insurance costs for one compartment for 1 year would amount to $1,205 in Texas and to $1,152 in California.

Comparison of Space and Costs for Four Compartments

Comparison of the total available storage and aisle space for the four storage compartments is shown in table 7, page 29.

Table 8 shows a comparison of total annual facility costs for the four compartments.

Estimated insurance costs on bales of cotton in storage for 6 months for the four compartments are shown in table 9, page 30.

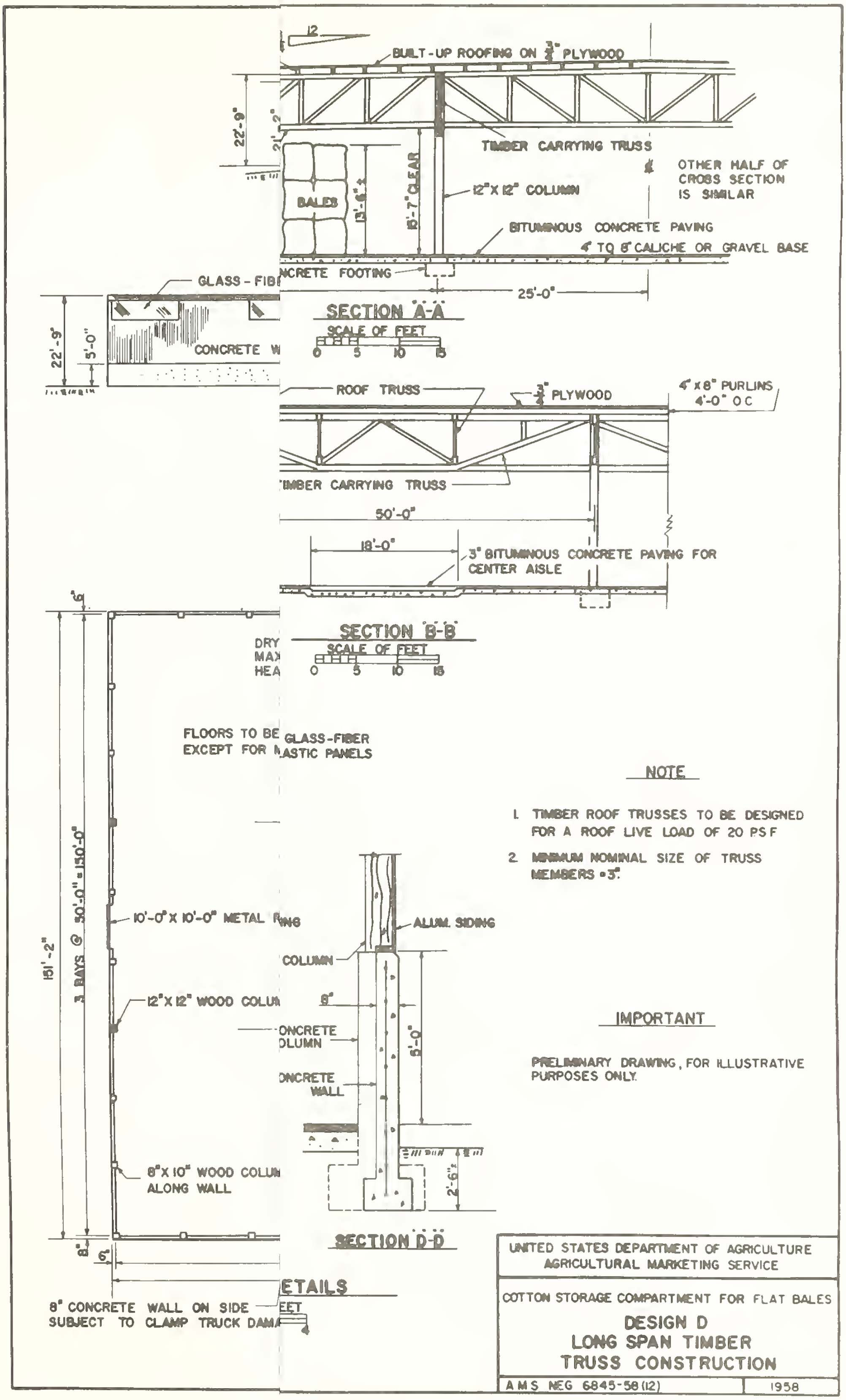
A 40,000- to 50,000-Bale Warehouse Using Compartments of Pole-Frame Construction

The type of layout selected for a warehouse determines the placing of storage compartments, roads, receiving and loading areas, fences, railroad siding, water tanks, offices, garage and machine shop, parking areas, and provisions for expansion.

When the pole-frame compartment was selected, consideration was given to the low construction costs as well as annual facility costs for this design. The pole-frame compartment was also the preference of most of the warehousemen who reviewed the various designs.

Although initial construction and annual costs are low for the compartments of pole-frame construction, other types of construction should be considered. Compartments of tilt-up concrete construction, as illustrated by compartment design C, have the advantage of permanence and good appearance. Some warehousemen may want to select a compartment similar to design D, longspan timber truss construction. The wide spacing of columns offers less difficulty in performing mechanized handling operations and provides more flexible use of storage space.

Site conditions that are normal for the



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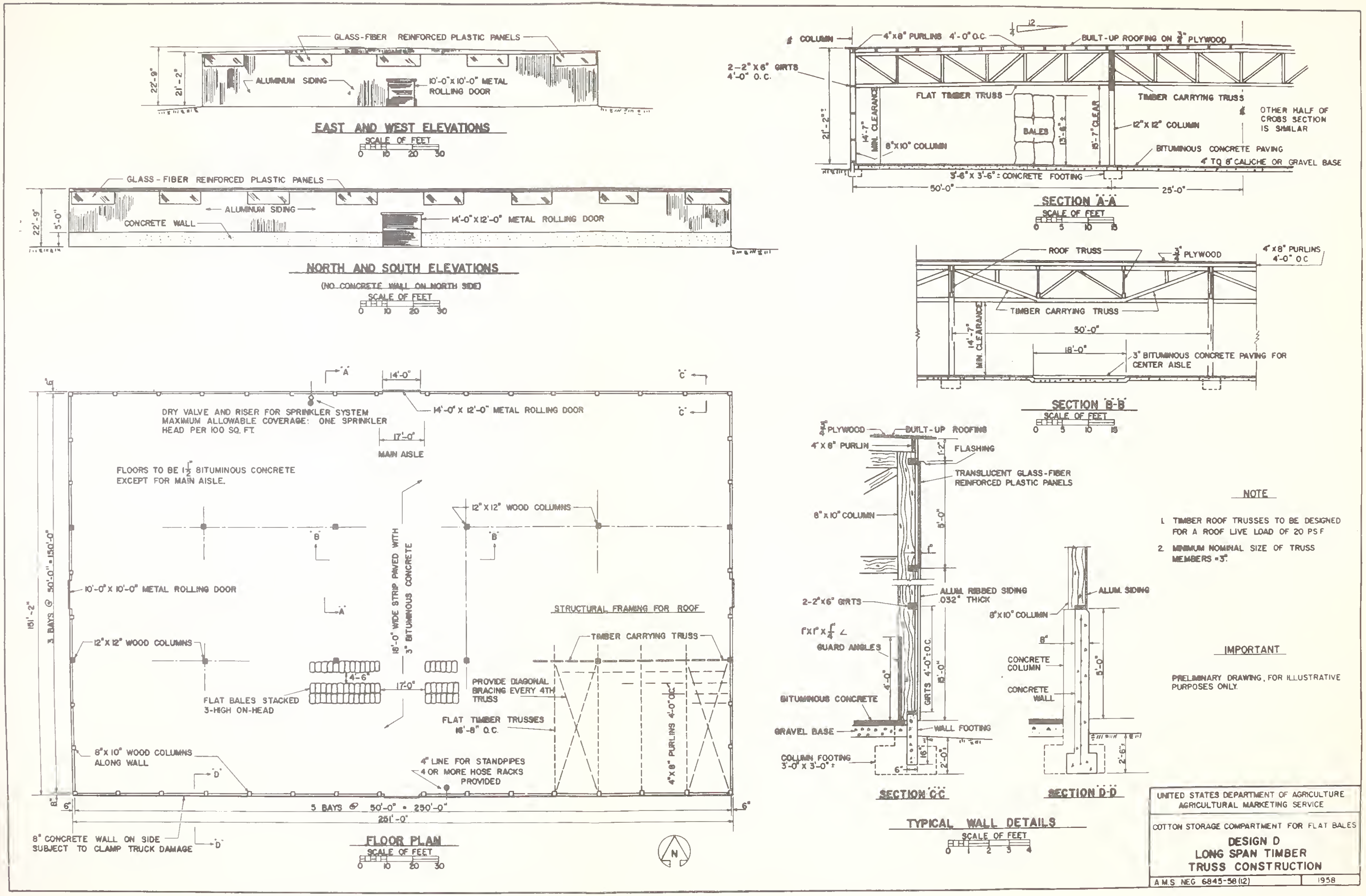


GLASS-FIBER REINFORCED PLASTIC PANELS
ALUMINUM SIDING
10'-0" X 10'-0" METAL ROLLING DOOR
22'-9"
21'-2"
EAST AND WEST ELEVATIONS
SCALE OF FEET
GLASS-FIBER REINFORCED PLASTIC PANELS
ALUMINUM SIDING
CONCRETE WALL
14'-0" X 12'-0" METAL ROLLING DOOR
NORTH AND SOUTH ELEVATIONS
(NO CONCRETE WALL ON NORTH SIDE)
SCALE OF FEET
COLUMN
4" X 8" PURLINS 4'-0" O.C.
BUILT-UP ROOFING ON 3/4" PLYWOOD
2-2" X 6" GIRTS 4'-0" O.C.
FLAT TIMBER TRUSS
TIMBER CARRYING TRUSS
OTHER HALF OF CROSS SECTION IS SIMILAR
BALES
14'-7" MIN. CLEARANCE
15'-7" CLEAR
12" X 12" COLUMN
8" X 10" COLUMN
BITUMINOUS CONCRETE PAVING
4" TO 6" CALICHE OR GRAVEL BASE
3'-6" X 3'-6" ± CONCRETE FOOTING
50'-0"
25'-0"
SECTION A-A
SCALE OF FEET
ROOF TRUSS
3/4" PLYWOOD
4" X 8" PURLINS 4'-0" OC
TIMBER CARRYING TRUSS
50'-0"
18'-0"
3" BITUMINOUS CONCRETE PAVING FOR CENTER AISLE
SECTION B-B
SCALE OF FEET
DRY VALVE AND RISER FOR SPRINKLER SYSTEM
MAXIMUM ALLOWABLE COVERAGE: ONE SPRINKLER HEAD PER 100 SQ. FT.
14'-0" X 12'-0" METAL ROLLING DOOR
17'-0" MAIN AISLE
FLOORS TO BE 1 1/2" BITUMINOUS CONCRETE EXCEPT FOR MAIN AISLE.
12" X 12" WOOD COLUMNS
18'-0" WIDE STRIP PAVED WITH 3" BITUMINOUS CONCRETE
10'-0" X 10'-0" METAL ROLLING DOOR
STRUCTURAL FRAMING FOR ROOF
TIMBER CARRYING TRUSS
12" X 12" WOOD COLUMNS
FLAT BALES STACKED 3-HIGH ON-HEAD
PROVIDE DIAGONAL BRACING EVERY 4TH TRUSS
FLAT TIMBER TRUSSES 16'-8" O.C.
4" X 8" PURLINS 4'-0" O.C.
8" X 10" WOOD COLUMNS ALONG WALL
4" LINE FOR STANDPIPES 4 OR MORE HOSE RACKS PROVIDED
3 BAYS @ 50'-0" = 150'-0"
151'-2"
5 BAYS @ 50'-0" = 250'-0"
251'-0"
8" CONCRETE WALL ON SIDE SUBJECT TO CLAMP TRUCK DAMAGE
FLOOR PLAN
SCALE OF FEET
N
PLYWOOD
BUILT-UP ROOFING
4" X 8" PURLIN
FLASHING
TRANSLUCENT GLASS-FIBER REINFORCED PLASTIC PANELS
8" X 10" COLUMN
ALUM. RIBBED SIDING .032" THICK
2-2" X 6" GIRTS
1" X 1" X 1/4" ∠ GUARD ANGLES
GIRTS 4'-0" ± O.C.
BITUMINOUS CONCRETE
GRAVEL BASE
WALL FOOTING
COLUMN FOOTING 3'-0" X 3'-0" ±
SECTION C-C
ALUM. SIDING
8" X 10" COLUMN
CONCRETE COLUMN
CONCRETE WALL
SECTION D-D
TYPICAL WALL DETAILS
SCALE OF FEET
NOTE
1. TIMBER ROOF TRUSSES TO BE DESIGNED FOR A ROOF LIVE LOAD OF 20 PSF
2. MINIMUM NOMINAL SIZE OF TRUSS MEMBERS = 3".
IMPORTANT
PRELIMINARY DRAWING, FOR ILLUSTRATIVE PURPOSES ONLY.
UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL MARKETING SERVICE
COTTON STORAGE COMPARTMENT FOR FLAT BALES
DESIGN D
LONG SPAN TIMBER TRUSS CONSTRUCTION
A.M.S. NEG. 6845-58 (12)
1958

FIGURE 23

TABLE 7.—*Comparison of the total available storage and aisle space for four cotton storage compartments*

Compartment type and size [1]	Total floor space	Bale-storage space			Aisle space								
					Main aisle			Cross aisles				All aisles	
		Capacity [2]	Floor space	Percentage of total floor space	Size	Floor space	Percentage of total floor space	Total	Size	Floor space	Percentage of total floor space	Floor space	Percentage of total floor space
	Square feet	*Bales*	*Square feet*	*Percent*	*Feet*	*Square feet*	*Percent*	*Number*	*Feet*	*Square feet*	*Percent*	*Square feet*	*Percent*
Design A: Pole frame, 175′ x 232′	40,600	7,476	24,080	59.4	17 x 175	2,975	7.3	14	4½ x 215	13,545	33.3	16,520	40.6
Design B: Wood frame beam and girder, 175′ x 232′	40,600	7,476	24,080	59.4	17 x 175	2,975	7.3	14	4½ x 215	13,545	33.3	16,520	40.6
Design C: Tilt-up concrete 150′ x 260′	39,000	7,200	23,328	59.9	17 x 150	2,550	6.5	12	4½ x 243	13,122	33.6	15,673	40.1
Design D: Wide span timber truss, 150′ x 250′	37,500	6,984	22,368	59.7	17 x 150	2,550	6.8	12	4½ x 233	12,582	33.5	15,132	40.3

[1] Dimensions are for the inside measurements of the compartment. [2] Bales stacked 3 high on head.

Southwestern States were assumed for this warehouse report. Operational costs were computed from data on materials-handling methods, equipment, and labor contained in the report on cotton handling (*3*). A perspective view, a diagram of the layout, and a flow chart of the warehouse, and the floor plan and design details of the compartment are shown in figures 24 through 29.

Layout

A layout for a cotton warehouse should provide the lowest building costs and retain flexi-

TABLE 8.—*Comparison of estimated annual facility costs for four cotton storage compartments*

Compartment type and size	Initial construction costs		Annual facility costs								
			Depreciation								
	Total	Per square foot [1]	Estimated life of compartment [2]	Cost per year	Interest on investment	Taxes	Insurance[3]	Maintenance	Total	Per square foot [4]	Per bale[5]
	Dollars	*Dollars*	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Design A: Pole frame, 175′ x 232′	72,000	1.74	25	2,880	1,800	720	220	720	6,340	0.156	0.848
Design B: Wood frame beam and girder, 175′ x 232′	81,000	1.98	30	2,700	2,025	810	247	810	6,592	.162	.882
Design C: Tilt-up concrete, 150′ x 260′	112,500	2.85	60	1,875	2,812	1,125	253	562	6,627	.170	.920
Design D: Widespan timber truss, 150′ x 250′	101,000	2.66	35	2,889	2,525	1,010	303	505	7,232	193	1.03

[1] Based on outside dimensions of the compartment.

[2] See pages 22, 24, 26, and 28 for basis of estimated useful life. As loan agencies usually will not make loans for these types of construction for more than 15 to 20 years, the estimated annual facility costs shown probably would not yield sufficient revenue during the loan amortization period to pay off a 100-percent construction loan and meet maintenance, insurance, and related costs.

[3] This is an average of California and Texas insurance costs.

[4] Based on total floor space of the compartment as shown in table 7.

[5] Based on the storage capacity of the compartment as shown in table 7.

TABLE 9.—*Comparison of estimated insurance costs on cotton for 6 months' storage for four compartments*

Compartment type and size	Storage capacity	Insurance cost for Texas	Insurance cost for California	Average insurance cost
	Bales	*Dollars*	*Dollars*	*Dollars*
Design A: Pole-frame, 175′ by 232′	7,476	1,290	1,290	1,290
Design B: Wood frame beam and girder, 175′ by 232′	7,476	1,290	1,290	1,290
Design C: Tilt-up concrete, 150′ by 260′	7,200	1,836	972	1,404
Design D: Wide-span timber truss, 150′ by 250′	6,984	1,205	1,152	1,178

bility and high utilization of labor, machines, and space. The layout selected for this cotton warehouse encompasses the above requirements and also includes space for expansion (fig. 25).

Warehouse Area

The site for this cotton warehouse is 1,495 feet long and 870 feet wide containing 1,300,000 square feet or 30 acres. Six storage compartments are used for storing 40,000 to 50,000 bales. These compartments and the receiving and shipping areas, roads, office, rail siding, parking area, and other warehouse facilities will occupy 56 percent of the available space. The remaining 44 percent is available for expansion and will provide sufficient area for 6 more storage compartments and the space required for handling operations. Thus, this layout provides sufficient expansion area for increasing the storage capacity of the warehouse by 100 percent (fig. 25).

Storage Compartments

In this layout a row of three storage compartments, spaced 100 feet apart, is located on each side of the main receiving area, which is 120 feet wide. One side of each compartment fronts on the main receiving area. One row of 3 compartments also has a rail siding along one side.

Working Areas

If handling operations can be performed outside the compartments, it is often possible to use machines capable of handling more than two bales at one time. Usually, more room is available outside for temporary working blocks, and larger quantities of bales can be handled during an operational period.

The receiving operations can be performed in two areas (fig. 25 and 26). The main receiving area is paved with asphalt and extends from the entrance gate to the access road at the end of the two rows of compartments. It is 100 feet wide and about 1,060 feet long. The other receiving area is located between one row of 3 compartments and the expansion area, and is 100 feet wide and about 1,000 feet long. This receiving area generally will be used only after the warehouse has been expanded to include additional compartments. The receiving areas are wide enough for unloading bales from road trucks with 2-, 3-, or 4-bale clamp trucks, for positioning the bales in temporary row blocks for weighing with a mobile beam scale on a lift truck, for sampling bales in the temporary row block, and for maneuvering clamp trucks while picking up and transporting bales into a storage compartment. Table 10 shows the space needed for efficient unloading and loading of road trucks when using clamp trucks.

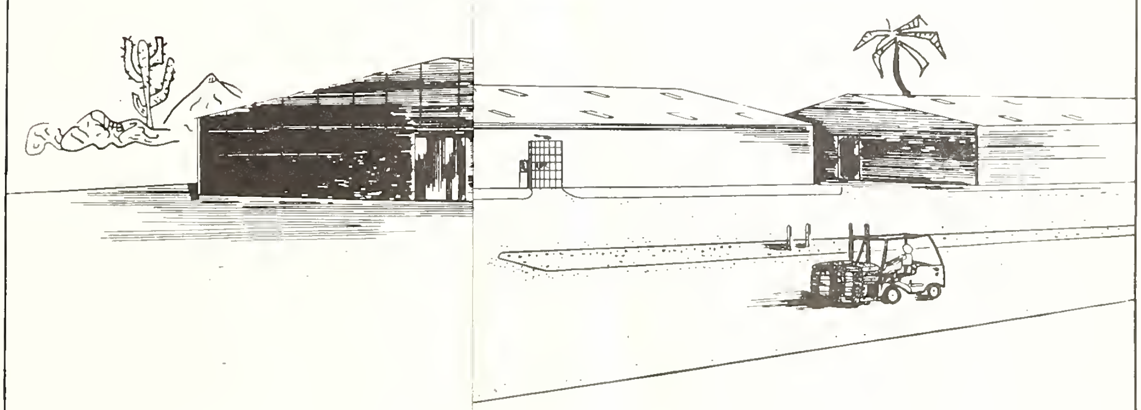
Warehouse Flow Chart

A flow chart, figure 26, for this warehouse shows the major activities and facilities, and recommended sequence of operations.

In the receiving operations road trucks enter the warehouse site and move to a receiving area outside any of the 6 storage compartments, operation (A). Unloading road trucks alongside the compartment where bales are to be stored saves the time and expense of transporting bales from a central receiving station to distant storage areas. All road trucks move in a one-way traffic pattern to avoid interfering with each other. There is sufficient room for clamp trucks to unload the road trucks without interfering with other operations (table 10). Bales can be weighed and sampled outside the compartment. Either 3- or 4-bale clamp trucks can be used to move the bales to the storage area inside the compartment, operation (B).

TABLE 10.—*Estimated space required for clamp trucks operating at ground level to unload or load road trucks*

Equipment	Length of loaded clamp truck	Additional maneuvering space	Estimated total space
	Feet	*Feet*	*Feet*
2,000-pound clamp truck	10	2	12
3,000-pound clamp truck	10	3	13
4,000-pound clamp truck	11	4	15
6,000-pound clamp truck	15	5	20



UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL MARKETING SERVICE

COTTON WAREHOUSE FOR STORING
40,000 TO 50,000 FLAT BALES

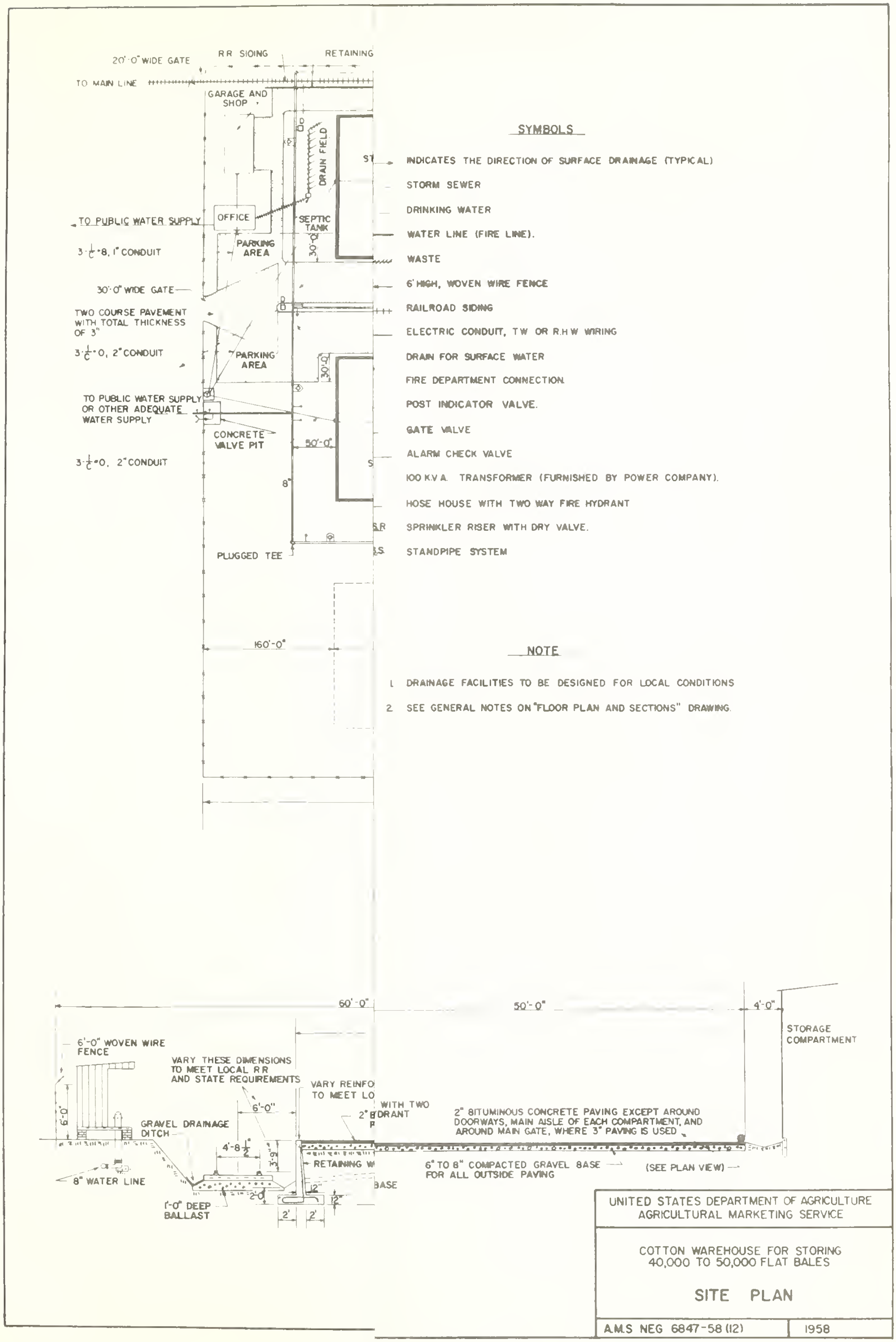
PERSPECTIVE

A.M.S. NEG 6846-58(12) | 1958

512995 O - 59 (Face p. 30) No. 1

Figure 24

512995 O - 59 (Face p. 30) No. 1



512995 O-59 (Face p. 30) No. 2

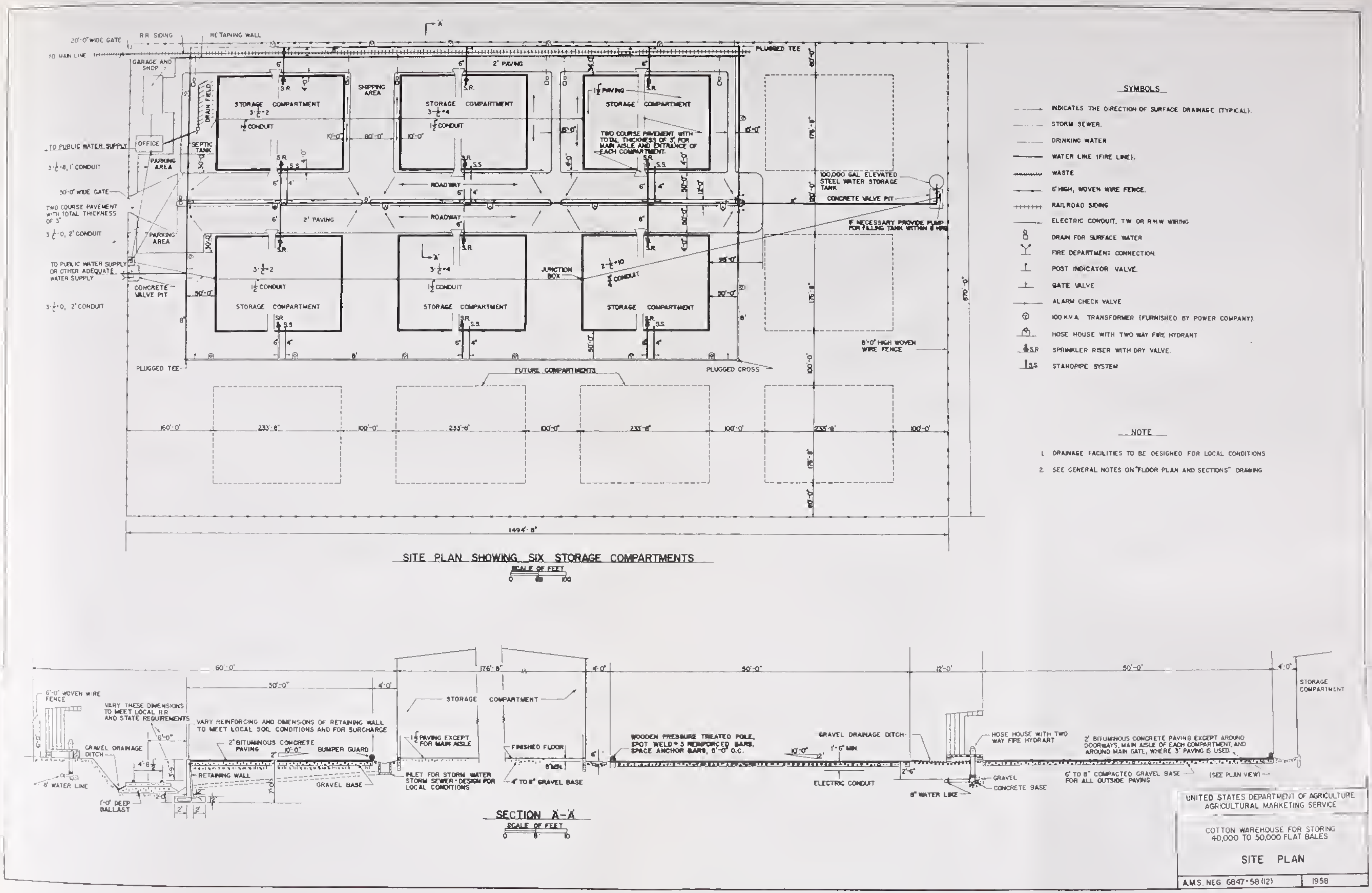
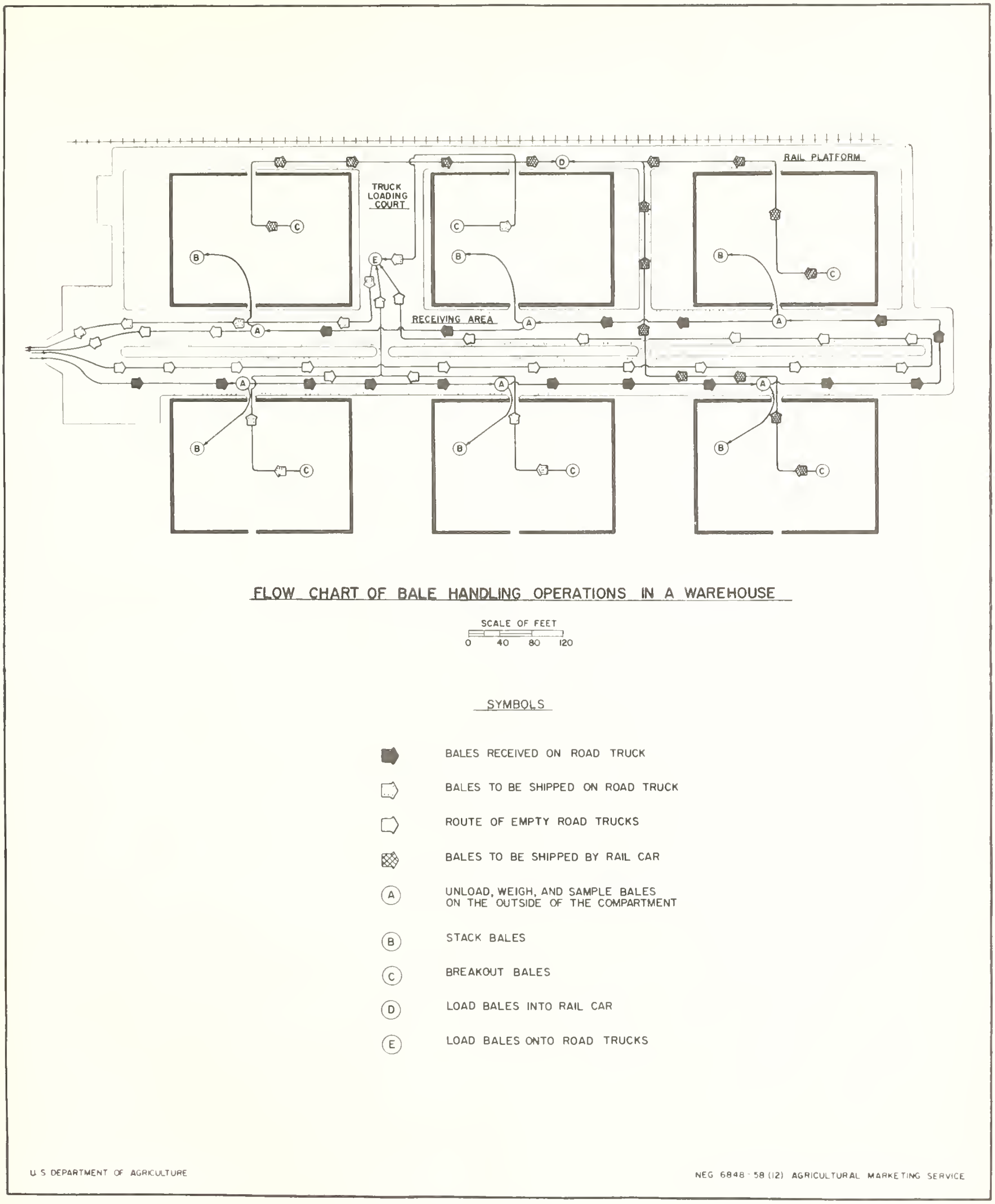


Figure 25

512995 O - 59 (Face p. 30) No. 2



512995 O-59-3

FIGURE 26

Truck loading and rail shipping areas are located apart from the receiving areas and do not interfere with transporting operations. A lift truck with a breakout attachment breaks out bales, operation (C), for rail or truck shipments. Bales can be transported by 4-bale clamp trucks from the storage compartments to the rail platform for loading into rail cars, operation (D), or to the truck loading court for loading onto road trucks, operation (E). In either case the flow of bales to shipping areas results in a minimum of interference with other operations.

Unloading road trucks outside the compartment door in the receiving areas permits a 30-foot minimum and a 250-foot maximum transporting distance to store bales in any compartment.

Areas for rail and truck shipments should be easily accessible to all storage compartments.

The rail platform is 30 feet wide and 1,030 feet long. Enough space is provided for loading 20 rail cars at one time. The 30-foot width permits stacking in temporary blocks enough bales to load 20 rail cars and also allows room for clamp-truck traffic. The platform is easily accessible from all of the storage compartments. Clamp trucks can transport bales from storage compartments to the shipping platform by moving over the 15-foot roadway located in the open space between the compartments (figs. 25 and 26).

Bales to be shipped can be placed in temporary blocks in the main aisle of the storage compartment. Later a 3- or 4-bale clamp truck picks up the bales in the main aisle and moves them to a shipping block on the rail platform. The maximum transportation distance from any compartment to the rail platform is 700 feet, the minimum 50 feet, and the average 350 feet.

Shipping by road truck is much the same as shipping by rail. However, the maximum distance a clamp truck has to transport bales to the truck loading court is 700 feet, the minimum 125 feet, and the average distance 350 feet.

Miscellaneous Areas

Rail siding.—Rail tracks are located adjacent to the rail platform and will not interfere with future storage compartments in the expansion areas.

Truck-loading court.—The truck-loading court is located between two compartments and next to the rail platform. It is easily accessible from all storage compartments and does not interfere with the receiving operation. The court extends 175 feet from the rail platform to the road leading out of the site. The paved court is 80 feet wide, which permits a shipping block of 50 bales to occupy a space 10 feet by 60 feet. With an aisle 2 feet wide between each shipping block, this court can accommodate 8 shipping blocks. It is possible to load 6 road trucks simultaneously and not interfere with other warehouse operations. The 450-foot distance from the site entrance to the court reduces to a minimum the chances of interference with road trucks moving to the receiving area.

Office and maintenance shop.—The office and the maintenance shop are located between the rail tracks and the site entrance, and between the end of the first storage compartment and the fence. Both are easily accessible to customers, visitors, and gasoline trucks, and for equipment storage and repair, etc. Also, by having the maintenance shop near the office the warehouseman has better control over the shop, parts, and gasoline usage.

Parking areas.—Parking for the warehouse employees is located near the entrance to the site. With this arrangement it is easier to control the movements of warehouse labor. Parking is provided in front of the office for customers, visitors, and office personnel.

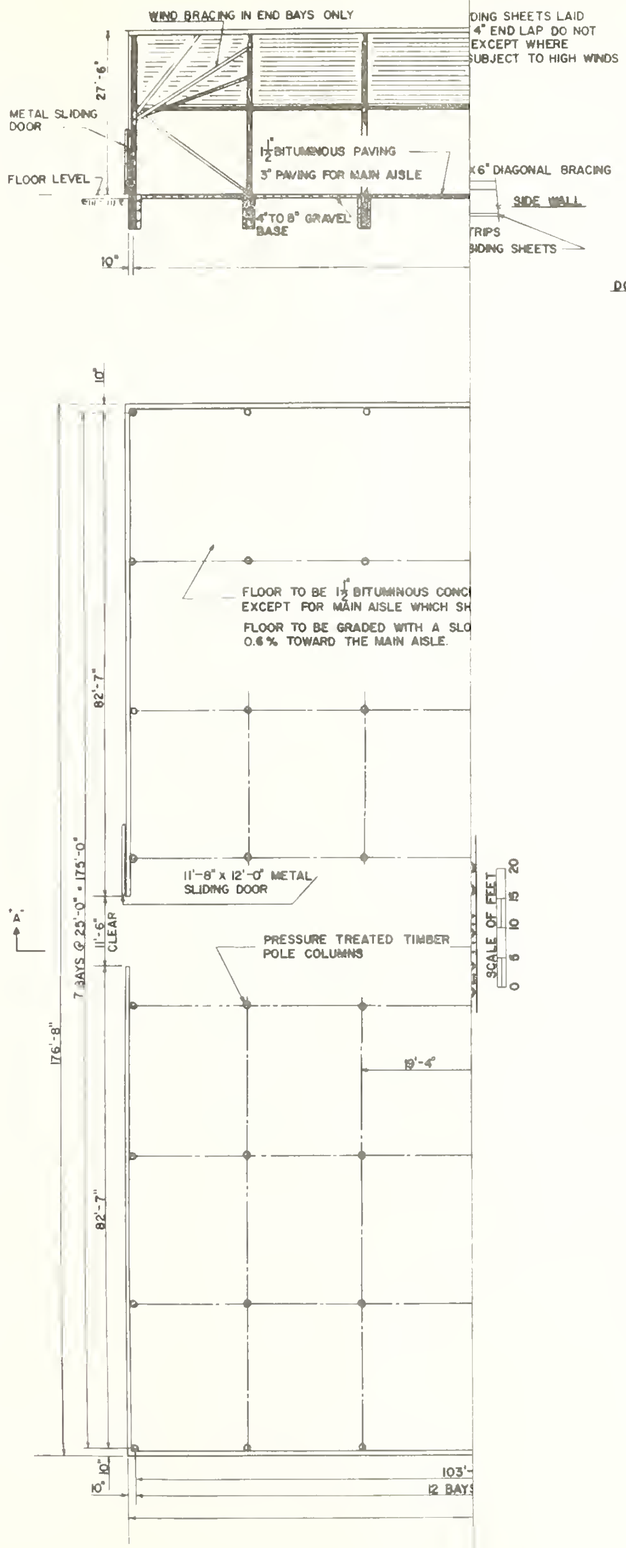
Other.—There are usually a few buildings needed for warehouse supplies, and building maintenance equipment and supplies. These buildings can be located in any space that is available to delivery and pickup trucks. Usually buildings used for these purposes are located near the maintenance shop.

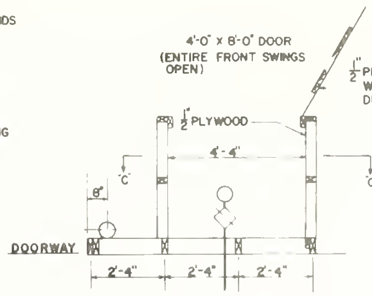
The water tank should be located far enough away from a compartment so that a fire will not damage the steel supports or exposed valves and supply pipes. In this layout the water tank can be located about 300 feet from the nearest compartment and on the opposite side of the site from the office. When expansion is necessary, a 100-foot clear space will separate the tank from the nearest storage compartment.

Building Design

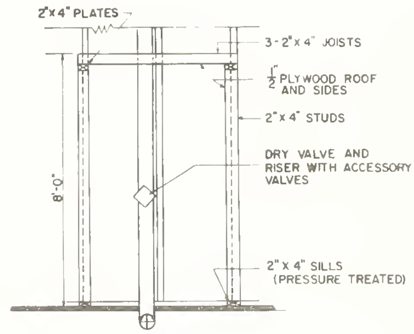
The warehouse consists of six compartments of pole-frame construction, design A. Figures 27 through 29 show the details of the design of the compartments. The specifications are included in the Appendix.

A system of cantilevered and suspended beams was selected for the main roof framing of the compartments. The system has the advantage of reducing the bending moment requirements by about 40 percent of that for simply supported beams; thus, the size of the structural members is reduced. This type of system has been used rather extensively with glued-laminated construction. The cantilever and suspended beam system, however, has the disadvantage of increasing the shear at certain supports. In the system shown plywood reinforcing pieces have been added to areas of high shearing stresses. This system also has the





PLAN OF VALVE ROOM



SECTION "C"-"C"

SCALE OF FEET
0 1 2 3 4

NOTE

1. DESIGN LOADS
   ROOF LIVE LOAD = 20 P.S.F
   WIND LOAD = 20 P.S.F
   SOIL BEARING CAPACITY = 3500 P.S.F
2. PURLINS, STUDS, ETC. TO BE OF A GRADE WITH A MINIMUM ALLOWABLE UNIT STRESS IN BENDING OF 1500 P.S.I.
3. GIRDERS TO BE OF A GRADE WITH A MINIMUM ALLOWABLE UNIT STRESS IN BENDING OF 1900 P.S.I.
4. POLE COLUMNS TO HAVE AN ULTIMATE STRENGTH IN BENDING OF 7,400 P.S.I.
5. WIND LOAD ALLOWABLE STRESSES MAY BE INCREASED 33⅓%. LIVE LOAD ALLOWABLE STRESSES MAY BE INCREASED 15%.
6. ROOF DESIGN IS FOR AREAS OF LOW RAINFALL INTENSITY ONLY
7. SEE SPECIFICATIONS IN APPENDIX OF THE TEXT

IMPORTANT

THESE DRAWINGS FOR THE COTTON WAREHOUSE ARE BASED ON THE ASSUMPTIONS LISTED ABOVE AND AS DISCUSSED IN THE TEXT. AN ARCHITECT OR ENGINEER SHOULD BE EMPLOYED TO ADAPT THESE DRAWINGS TO MEET LOCAL CONDITIONS AND TO SUPERVISE CONSTRUCTION

UNITED STATES DEPARTMENT OF AGRICULTURE AGRICULTURAL MARKETING SERVICE	
COTTON WAREHOUSE FOR STORING 40,000 TO 50,000 FLAT BALES FLOOR PLAN AND SECTIONS FOR COMPARTMENT	
A.M.S. NEG. 6849-58 (12)	1958

512995 O - 59 (Face p. 32)

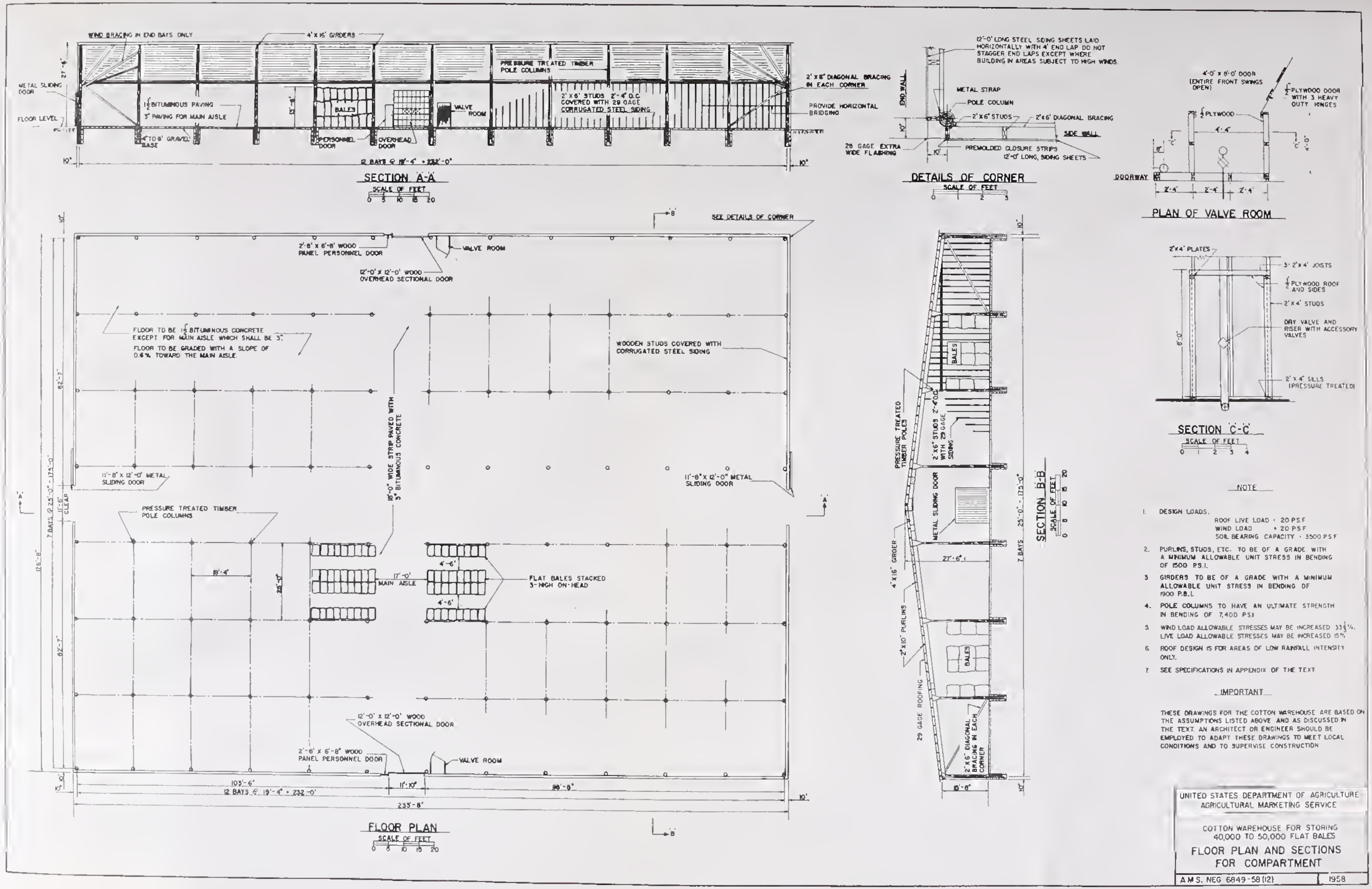


FIGURE 27

512995 O - 59 (Face p. 32)

disadvantage of poorly resisting unbalanced loading conditions. An alternate system using simple beam construction is also shown in figure 28. If large wood structural members are available at a comparable price, this latter system should be considered.

For the roof girders as well as other structural members it may be more economical in some areas to use larger but lower grade lumber than is shown in the drawings and designated in the specifications.

A bituminous paving similar to that shown for the compartment floors is used for the roadways interconnecting the compartments. An 8-inch water main, which forms a "loop" around the compartments, together with hydrants and hose houses, provides fire protection. A city water supply is considered as the primary source of water with a gravity water tank serving as the secondary source. Of course, the fire protection must be designed for local conditions and the water supply available.

The rail track is sunken so that the floors of rail cars are at platform height for loading and unloading. A reinforced concrete retaining wall supports the earth fill of the platform area.

The maintenance shop for the industrial trucks can be wood framing covered with metal siding. The office can be built to meet the owner's individual needs and taste. The entire warehouse area is enclosed by a woven wire fence 6-feet high.

Construction Methods

Besides the usually recognized good management practices which should be used in construction, the following recommendations are offered for reducing construction costs for this warehouse: (1) When available, use the handling equipment, such as clamp trucks, for handling and placing poles, wall framing, and other material; (2) where possible use a scaffold attached to the mast of a lift truck; (3) use the exact stud and purlin spacings and the length of roofing and siding sheets shown on the drawing; (4) prefabricate wall framing in large sections; (5) use large paving equipment to construct asphalt floors; and (6) drill holes for poles with powered equipment. (Openings can be left in floor for poles, or holes can be cut through the floor later.)

Construction Costs

Table 11 itemizes the construction costs for the warehouse. Construction cost for the entire facility is estimated to be $671,000. This figure is based on labor rates and material prices for the first quarter of 1958 for the Dallas, Tex., area. For further discussion of the bases for these costs, see the section on Construction Costs under design A, page 22. This figure does not include the cost of an office, maintenance shop, and miscellaneous utilities, such as sanitary sewers, domestic water lines, and intercommunication system. No cost is included for the land.

TABLE 11.—*Estimated construction cost of a warehouse for storing 40,000 to 50,000 flat bales of cotton*

Kind of work and materials used	Total units	Cost per unit	Total cost
FOR ONE COMPARTMENT		*Dollars*	*Dollars*
Site preparation and excavation work:			
Clearing	1 acre	150.00	150
Grading	5,000 sq. yds.	.10	500
Excavation	70 cu. yds.	1.50	105
Total			755
Paving and floor construction:			
6–inch gravel base	800 cu. yds.	5.00	4,000
3–inch bituminous paving	375 sq. yds.	2.40	900
1½–inch bituminous paving	4,250 sq. yds.	1.20	5,100
Total			10,000
Concrete work:			
Concrete curb	30 cu. yds.	40.00	1,200
Backfill for poles	26 cu. yds.	30.00	780
Total			1,980
Carpentry:			
Studding and plates	9.5 M.b.m. [1]	150.00	1,425
Purlins	25 M.b.m.	150.00	3,750
Girders	13 M.b.m.	205.00	2,665
Poles	2,800 Lin. ft.	1.05	2,940
Misc. nails, gussets, etc.			500
Total			11,280
Metal siding and roofing:			
Corrugated steel siding	170 squares	17.00	2,890
Corrugated steel roofing	500 squares	18.00	9,000
Misc. fasteners, flashing, etc			500
Total			12,390
Doors and light panels:			
Sliding metal door	2	150.00	300
Overhead wooden door	2	250.00	500
Plastic panels	600 sq. ft.	1.05	630
Personnel doors	2	35.00	70
Total			1,500
Lighting and electrical work			1,150
Fire protection:			
Sprinkler heads and piping	468 heads	28.00	13,104
Hose racks and piping	6	350.00	2,100

TABLE 11.—*Estimated construction cost of a warehouse for storing 40,000 to 50,000 flat bales of cotton—Continued*

Kind of work and materials used	Total units	Cost per unit	Total cost
		Dollars	*Dollars*
Misc. dry valves, alarms. etc.			3,000
Total			18,204
Total cost for one compartment (not including overhead and profit)			57,259
Less 4% for 4 or more compartments			−2,290
Cost for each compartment			54,969
FOR OUTSIDE UTILITIES AND YARDWORK			
Site preparation and excavation work:			
Clearing	25 acres	150.00	3,750
Grading	117,000 sq. yds.	.10	11,700
Excavation	6,000 cu. ft.	1.00	6,000
Total			21,450
Paving and road construction:			
7-inch gravel base	3,700 cu. yds.	4.00	14,800
2-inch bituminous paving	19,000 sq. yds.	1.30	24,700
Total			39,500
Concrete work:			
Retaining wall	380 cu. yds.	50.00	19,000
Misc. transformer pad, etc.			500
Total			19,500
Rail siding:			
Ballast, ties, and track	1,100 ft.	15.00	16,500
Total			16,500
Outside fire protection:			
Underground loop, hydrants, equipment, and valves			60,000
Gravity water tank	1	30,000	30,000
Total			90,000
Outside electrical work			4,900
Woven wire fencing and gates	4,700 lin. ft.	3.30	15,510
Total cost for outside utilities and yard work			207,360
FOR WAREHOUSE			
6 compartments at $54,969 [2]			329,814
Outside utilities and yard work			207,360
Total			537,174
Plus 25% overhead profit			134,294
Grand total for warehouse			[3]671,468
Cost per bale			14.91

[1] M.b.m. = Thousand (feet) board measure.
[2] Storage capacity, 45,000 bales.
[3] Rounded to $671,000.

Estimated Annual Facility Costs

Table 12 itemizes the estimated annual costs for the entire warehouse facilities, including storage compartments, roadways, and fire protection systems. For a further discussion on the bases for annual costs see the section on Annual Facility Costs for design A (p. 22).

TABLE 12.—*Estimated annual facility costs for a warehouse with a storage capacity of 45,000 bales*[1]

Item	Assumed rates	Annual costs
	Percent	*Dollars*
Depreciation	[2] 4	26,840
Interest	[3] 5	16,775
Maintenance and repairs	1	6,710
Taxes	1	6,710
Insurance	[4] .30	2,013
Total cost		59,048

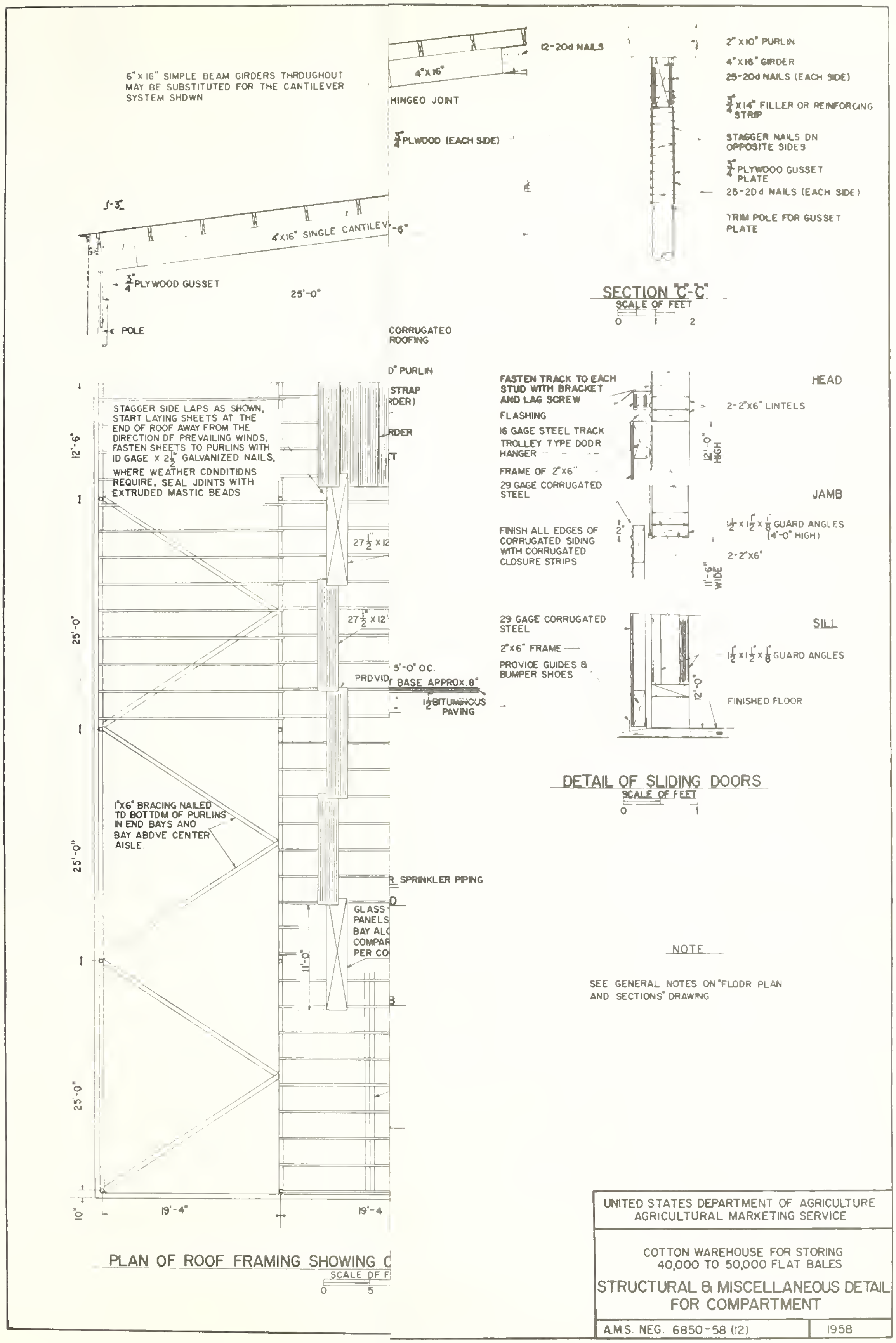
[1] Estimated initial construction cost $671,000.
[2] Estimated useful life, 25 years (see page 22). As loan agencies usually will not make loans for this type of construction for a period of more than 15 to 20 years, the estimated annual facility costs shown probably would not yield sufficient revenue during the loan amortization period to pay off a 100-percent construction loan and meet maintenance, insurance, and related costs.
[3] 5 percent of the average value of the facility.
[4] An average of the rates for Texas and California.

Annual Insurance Costs on Stored Cotton

The assumed insurance rate for the stored cotton is $0.23 per year per $100 valuation, the same rate as used for design A. At this rate the total annual insurance cost for the stored cotton in the 6-compartment warehouse would be $7,740, using the same assumptions as used in design A, page 23.

Handling Operations, Labor, and Equipment

Many warehousemen believe that the bale which is least handled is best handled. This



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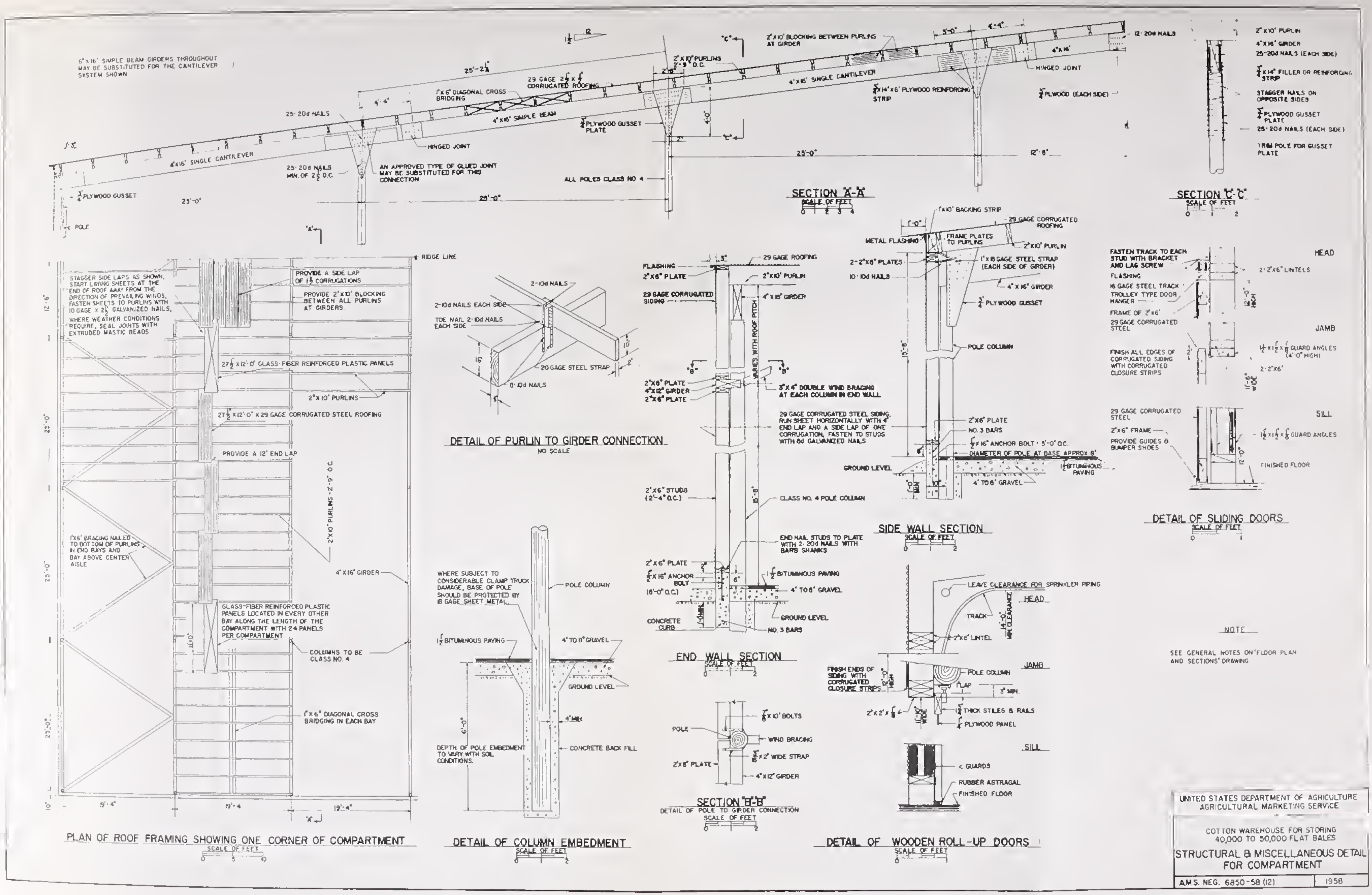
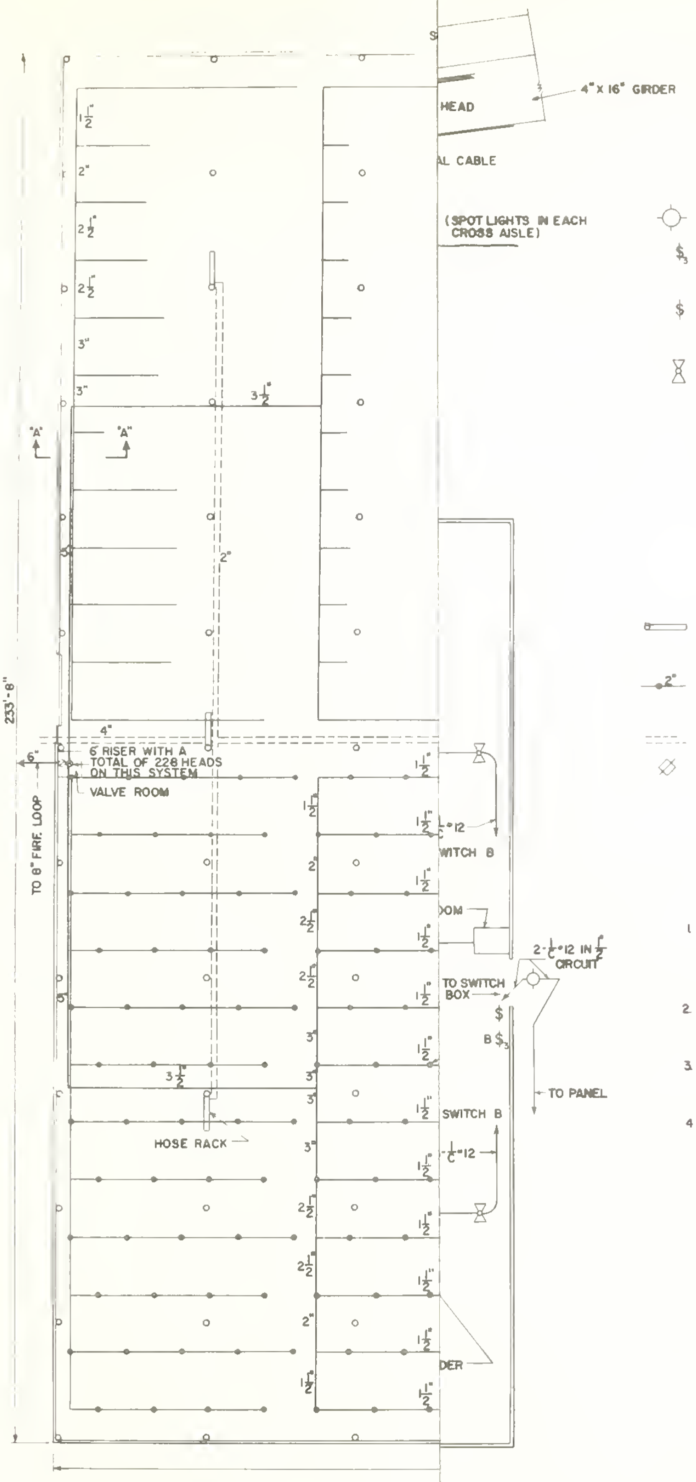


Figure 28



ELECTRICAL SYMBOLS

150 WATT FLOODLIGHT.

4 GANG SWITCH BOX AND COVER WITH FOUR 3-WAY TOGGLE SWITCHES-30 AMP. T RATING

SWITCH BOX WITH SINGLE POLE TOGGLE SWITCH-15 AMP.

4"x4"x1/2" OCTAGONAL BOX WITH TWO 150 WATT PAR SPOTLIGHTS PER BOX, IN ADJUSTABLE FIXTURE BOX MOUNT ON BOTTOM OF WOODEN GIRDERS. WHERE MOUNTING HEIGHT IS LESS THAN 17 FEET WIDE ANGLE SPOTLIGHTS OR FLOODLIGHTS SHOULD BE USED.

SPRINKLER SYSTEM SYMBOLS

HOSE RACK WITH 50 FEET OF COTTON LINED HOSE.

2" SPRINKLER LINE, SHOWING PIPE SIZE, WITH SPRAY TYPE SPRINKLER HEAD.

BURIED WATER LINE FOR HOSE RACK

DRY VALVE WITH QUICK OPENING DEVICES, ALONG WITH ACCESSORY VALVES, FITTINGS, AND ALARM

NOTE

1. ELECTRICAL WIRING TO RUN ACROSS CEILING, WHERE POSSIBLE ANY WIRING ON WALLS TO BE IN CONDUITS.
2. CEILING WIRING TO BE IN BX CABLE UNLESS TYPE NMC INSULATION IS USED.
3. ALL ELECTRICAL WORK TO MEET LOCAL APPLICABLE CODES
4. SEE GENERAL NOTES ON "FLOOR PLAN AND SECTIONS" DRAWING

UNITED STATES DEPARTMENT OF AGRICULTURE AGRICULTURAL MARKETING SERVICE	
COTTON WAREHOUSE FOR STORING 40,000 TO 50,000 FLAT BALES SPRINKLER AND ELECTRICAL PLANS FOR COMPARTMENT	
A.M.S. NEG 6851-58(12)	1958

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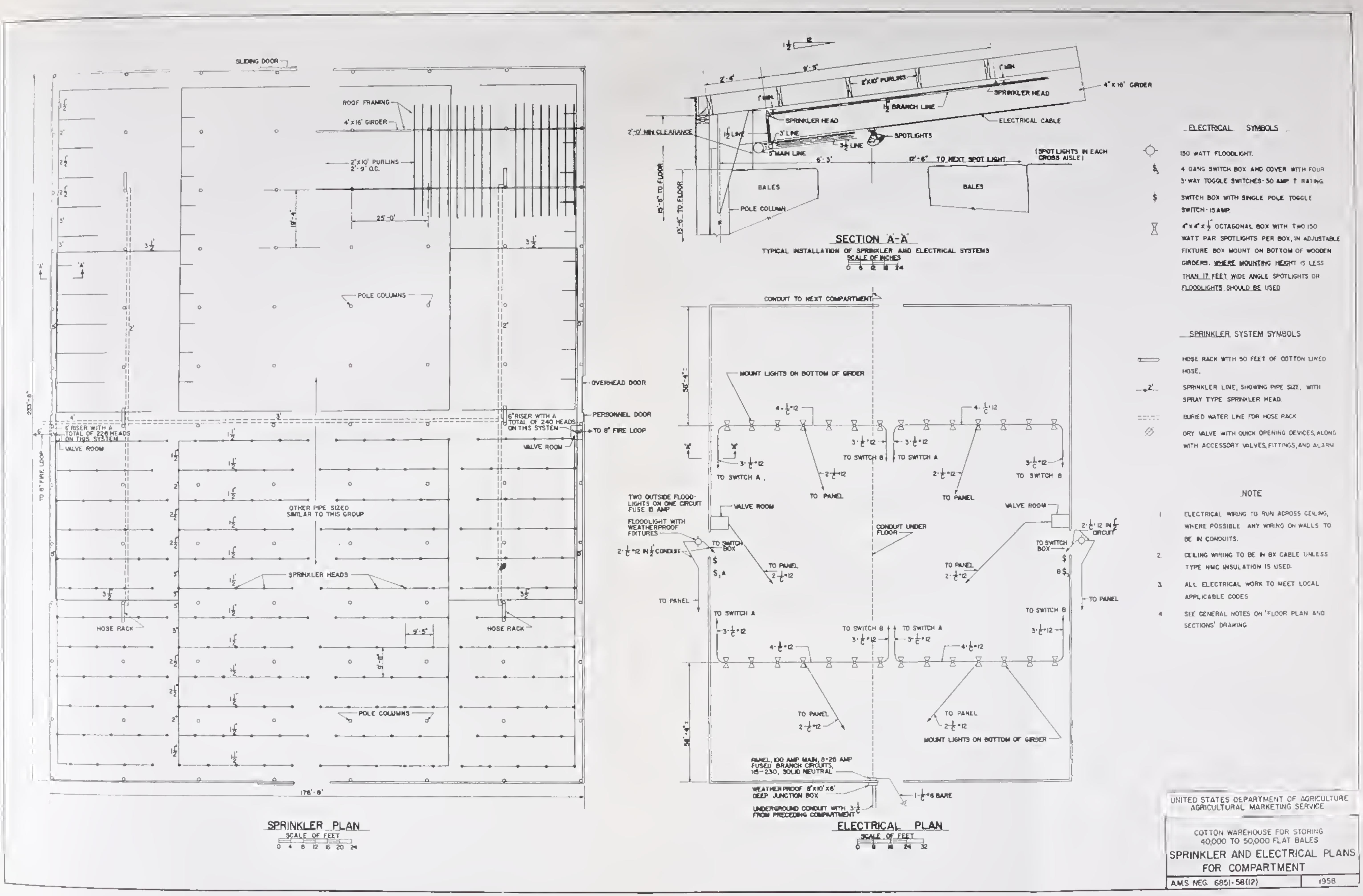

FIGURE 29

is a misleading concept, and movement of bales is not a necessary evil to be eliminated whenever possible. Additional moves frequently make for better utilization of men and equipment. Movement of bales allows operations to be broken down or split. This permits all the advantages of division of labor, greater supervision over quantity of bales handled, equipment used, and performance of operations.

In developing the layout for a warehouse having a storage capacity of 40,000 to 50,000 flat bales it was assumed that: (1) Bales would be received from August through March; (2) the largest number of bales would be received during September, October, and November; (3) all bales would be received by road truck; 75 percent would be shipped by rail car and 25 percent by road truck; and (4) a total of 65,000 bales would be received and shipped per season. These assumptions were used for computing the size of crews, the handling operations, and the equipment needed. Data from the report on cotton handling were used in estimating labor and equipment costs (*3*).

Bale Handling Operations

The operations to be performed in this warehouse are described as follows:

Unloading bales.—Bales transported by road truck from the cotton gin to the warehouse can be taken directly to the front of the compartment in which they are to be stored. Bales can be unloaded from road trucks by one or two 3-bale clamp trucks, moved about 50 feet, and set down in temporary row blocks.

Weighing bales.—Bales can be weighed while they are in the temporary row block. Warehouse tags may be attached to bales by one man before the actual weighing operation. A beam-type, or an electronic scale mounted on a lift truck can be used to weigh the bales while they are in the temporary row block. One man will operate the lift truck; one man will ride on a platform attached to the lift truck mast, attach and release bale hooks, weigh bales, and call out the previous bale tag number; and one man will attach and release hooks on the opposite side of the bale and record weights and other necessary information.

Sampling bales.—Bales can be sampled while in the row block after the weighing operation is completed. A 3-man crew can do the sampling; 2 men, working on opposite sides of the row block, cut and pull the sample and place the cut sample on top of the bale; one man trims the sample cut in bale and wraps the sample.

Combined transporting and stacking operations.—Bales in the temporary row block can be picked up by 3- or 4-bale clamp trucks and transported 150 feet to the storage area.[7] The same clamp truck that transports bales from the row block stacks them three high on head.

Breakout operation.—A lift truck with a breakout attachment can remove bales to be shipped from 3-high stacks. The bales are transported an average of 40 feet in the cross aisle to the main aisle and placed in temporary segregated shipping blocks (*14*).

Transporting bales to the shipping area.—Bales in shipping blocks can be picked up by 4-bale clamp trucks, transported an average of 350 feet to the rail platform or the truck-loading court, and again set down in shipping blocks ready for loading.

Shipping operation.—Rail cars can be loaded by 3-bale clamp trucks carrying 2 bales per trip from the shipping blocks on the rail platform. Bales can be picked up, moved 50 feet through the car door, and loaded into the car (*15*).

Road trucks can be loaded from ground level by 3- or 4-bale clamp trucks. Bales are transported an average of 50 feet and loaded on head onto the truck (*15*).

Labor

Bale handling operations in a warehouse require men to operate trucks, weigh bales, and cut, pull, and wrap samples. A permanent crew of two men can be used to handle bales in this warehouse, and extra labor can be employed during the peak receiving and shipping seasons. The receiving season usually lasts 4 to 10 weeks.

A warehouseman can use a minimum of 6 workers to perform all handling operations during the peak season. The following is a list of the number of men required at the peak of the season and the operations they can perform:

- 1 man to weigh bales
- 3 men to sample bales and, when not sampling, to assist in other operations
- 2 clamp-truck operators to break out bales from storage, transport bales, store bales in stacks, unload bales from road trucks, load bales into rail cars and onto road trucks, and assist in weighing the bales

The following is a suggested guide for the warehouseman to use in estimating the number of bales that crews of different sizes can efficiently handle per week in this warehouse:

Men	*Bales*
2	1,700
3	3,000
4	4,200
5	5,500
6	7,000

A 2-man crew unloads, weighs, transports, breaks out, and loads bales using 3-bale clamp

[7] Bales may be transported a maximum of 250 feet, a minimum of 50 feet, and an average of 150 feet each way.

trucks. Weighing and breakout attachments can be used on the 3-bale trucks. Sampling is done manually. Each operation is performed in sequence but as an independent operation by the two workers.

When a 3-man crew is employed, the work can be divided into several independent operations that occur at the same time. Two men receive the cotton, using 3-bale clamp trucks and the weighing attachment. One man breaks bales out of storage with a 3-bale clamp truck and a breakout attachment and hauls the bales to the loading platform or court. He can use a 4-bale clamp truck to transport bales to the shipping area and to load bales onto a road truck, but he needs a 3-bale clamp truck for loading bales into rail cars. This man can also assist the other men in weighing and sampling the cotton being received.

When a 4-man crew is employed, three men receive the cotton, and the fourth performs the shipping operation.

When a 5-man crew is employed, four men receive the cotton. One of them uses a 3-bale truck to unload bales and a 4-bale clamp truck to move bales into the compartment and place them in storage stacks. The other three men weigh and sample the cotton independently of the unloading and storing operations. The fifth man performs the shipping operations with 3- and 4-bale clamp trucks.

When a 6-man crew is employed, 2 men perform the shipping operations instead of 1 man. These 2 men should have time also to assist with the weighing or sampling.

It is estimated that the two permanent employees would work 4,256 man-hours during the year in performing warehouse operations, and that four part-time employees would work a total of 2,492 man-hours. The six employees would work a total of 6,648 man-hours per year in performing warehouse operations.

Equipment

This warehouse layout was developed for the use of standard size machine equipment and bale-handling attachments. Two clamp trucks carrying 4 bales each can be used for transporting, unloading, loading road trucks, and stacking operations. Three 3-bale clamp trucks can be used for unloading, weighing, breaking out, and loading. For weighing, the 3-bale clamps can be removed and a boom attachment equipped with a beam scale attached to the mast of the lift truck. A lift truck equipped with a breakout attachment can break bales out of storage stacks. Assuming that the peak receiving season lasts for 10 weeks and that 95 percent of the bales are shipped during the year, the following list shows the size and number of machines and attachments that can be used in the handling operations:

Machines:
2—4-bale clamp trucks
3—3-bale clamp trucks
Attachments:
1—Beam scale mounted on a boom attachment
2—Breakout devices
2—4-bale clamps
3—3-bale clamps

Annual Costs

Data from the cotton handling report (*15*) were used in determining the receiving and shipping operations to be performed and the crew sizes and in computing man-hours required to handle 65,000 bales per year in a 40,000- to 50,000-bale warehouse (*3*). Unloading, weighing, sampling, transporting to storage, and storing the cotton will require 3,746 man-hours per year. Breaking bales out of storage, transporting and loading them into rail cars and onto road trucks will require 2,902 man-hours per year. A total of 6,648 man-hours will be required to handle 65,000 bales of cotton.

Direct labor and equipment costs[8] were developed for each receiving and shipping operation according to volume of bales handled and crew size. The estimated annual labor costs for the receiving and shipping operations are as follows:

Labor cost for receiving (unloading, weighing, transporting, and storing)	$4,621.80
Labor cost for shipping (breakout, transport, loading into rail cars and onto road trucks)	3,634.20
Total direct labor cost per year	8,256.00

The estimated annual equipment costs for the receiving and shipping operations are as follows:

Equipment costs for receiving (two 3- and one 4-bale clamp trucks, beam scale on a boom attachment)	$1,669.00
Equipment costs for shipping (one 3- and one 4-bale clamp truck, and 2 breakout devices)	3,208.00
Total equipment cost per year	4,877.00

The following figures show the estimated annual costs for direct labor, equipment, facility, and insurance on stored cotton for a 40,000- to 50,000-bale warehouse handling 65,000 bales a year:

Labor	$ 8,256
Equipment	4,877
Facility [1]	59,048
Insurance on stored cotton [2]	7,740
Total	79,921
Cost per bale	$1.23

[1] See table 12.
[2] See page 23.

These costs do not include overhead, management, office help, utilities, supplies, etc. However, the costs can be used by warehouse owners as a guide for direct labor and equipment, annual building, and cotton insurance costs.

[8] See Appendix C, Hourly Costs.

Literature Cited

(1) AMERICAN STANDARDS ASSOCIATION.
1955. AMERICAN STANDARD BUILDING CODE REQUIREMENTS FOR MINIMUM DESIGN LOADS IN BUILDINGS AND OTHER STRUCTURES. New York, N.Y.

(2) BOECKH, E. H.
1956. BOECKH'S MANUAL OF APPRAISALS. Ed. 5. E. H. Boeckh and Associates, Washington, D.C.

(3) BOLT, CHARLES D., and WILMETH, JO BRICE.
1958. STATISTICAL SUPPLEMENT TO HANDLING BALES OF COTTON IN PUBLIC WAREHOUSES. METHODS AND EQUIPMENT. U.S. Dept. Agr. Mktg. Res. Rpt. 250, 67 pp.

(4) COTTON WAREHOUSE INSPECTION SERVICE.
1955. AMENDMENTS TO STANDARDS APPLICABLE TO MARINE CLASSIFICATIONS. New York, N.Y.

(5) ———
1959. STANDARDS FOR CONSTRUCTION, PROTECTION, AND MAINTENANCE OF COTTON COMPRESSES AND SIMILAR PROPERTIES. New York, N.Y.

(6) INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS.
1958. UNIFORM BUILDING CODE. Los Angeles, Calif.

(7) KIDDER, FRANK E., and PARKER, HARRY.
1955. KIDDER-PARKER ARCHITECTS AND BUILDERS HANDBOOK. Ed. 18. New York, N.Y.

(8) NATIONAL BOARD OF FIRE UNDERWRITERS.
1953. STANDARDS OF THE NATIONAL BOARD OF FIRE UNDERWRITERS FOR THE INSTALLATION OF SPRINKLER SYSTEMS AS RECOMMENDED BY THE NATIONAL FIRE PROTECTION ASSOCIATION. NBFU Pamphlet 13, 131 pp., illus.

(9) ———
1955. NATIONAL BUILDING CODE. New York, N.Y.

(10) ———
1959. NATIONAL ELECTRICAL CODE. New York, N.Y.

(11) SOUTHERN BUILDING CODE CONGRESS.
1953. SOUTHERN STANDARD BUILDING CODE. Birmingham, Ala.

(12) UNITED STATES BUREAU OF INTERNAL REVENUE.
1942. BULLETIN "F." INCOME TAX DEPRECIATION AND OBSOLESCENCE ESTIMATED USEFUL LIVES AND DEPRECIATION RATES. U.S. Treasury Dept.

(13) WILMETH, JO BRICE, and BOLT, CHARLES D.
1952. SOME IMPROVED METHODS FOR RECEIVING BALES OF COTTON IN COMPRESSES AND WAREHOUSES. U.S. Dept. Agr. Agr. Inform. Bul. 80, 54 pp., illus.

(14) ——— and BOLT, CHARLES D.
1954. BREAKING OUT BALES OF COTTON STORED ON HEAD. U.S. Dept. Agr. Mktg. Res. Rpt. 61, 23 pp., illus.

(15) ——— and BOLT, CHARLES D.
1958. HANDLING BALES OF COTTON IN PUBLIC WAREHOUSES. METHODS AND EQUIPMENT. U.S. Dept. Agr. Mktg. Res. Rpt. 250, 74 pp., illus.

(16) ——— STEINBERG, ALAN W., and BOLT, CHARLES D.
1953. COTTON HANDLING GUIDE FOR WAREHOUSE MANAGERS AND FOREMEN. U.S. Dept. Agr. Mktg. Res. Rpt. 50, 78 pp., illus.

Appendix A—Layout Guides

The layout should provide an economical arrangement of facilities and personnel that will streamline handling methods and use space efficiently. More specifically, the layout should make it possible to—

Increase production by providing opportunities to examine methods and equipment and eliminate bottlenecks.

Reduce operating expenses by providing a floor plan for a facility which is economical both to operate and to maintain.

Improve working conditions by eliminating excessive noise; providing for convenient parking areas; painting equipment, doors, posts, fire equipment, and lining of storage areas in different colors.

Use improved equipment on the number of bales to be handled, and the number of bales that can be moved as a unit for each operation. A layout should provide for a minimum transportation distance and for efficient materials-handling operations and the possible multi-purpose use of equipment.

Eliminate confusion by providing for a smooth flow through the warehouse compartments with the possibilities of traffic moving in only one direction.

Utilize space efficiently by arranging working and storage area in facilities to save space and by locating office, service, and maintenance facilities, truck unloading and loading courts, rail sidings, and bale reconditioning facilities in order to serve the warehouse to the best advantage.

Plan for future expansion by allowing sufficient space so that operations will not be disrupted and space will be provided for increasing the receiving and shipping facilities.

Appendix B—Platform Width

The width of platforms is determined by the operations to be performed on them, the methods to be used, and the kind and size of equipment selected for performing the various operations. Each operation must be considered in relation to those preceding and succeeding it. Space must be adequate for operators to work in without being crowded, but not big enough to increase unnecessarily the distances they must travel in performing the operations. Space must also be provided for traffic moving to and fro.

Appendix C—Hourly Costs[9]

Equipment[10]

2-wheel hand truck	$0.01
2-bale capacity clamp truck	1.20
Breakout device on lift truck	1.15
Lift truck with beam scale	1.10
3-bale capacity clamp truck	1.35
3-bale capacity clamp truck with rotating clamps	1.45
Boom truck	1.40
4-bale capacity clamp truck	1.80
6-bale capacity clamp truck	2.25
Industrial tractor	.45
Industrial trailers (cost of 4 trailers)	.30
Beam scale (stationary)	.05
Beam scale (mobile, manually propelled)	.07
Beam scale (mobile, pneumatic hoist)	.10
Platform dial scale (installed)	.20
Platform dial scale (portable)	.40
Automatic dinky press feeder (installed)	.90
Portable yard ramp (magnesium)	.30

Wage Rates[11]

Unskilled labor (hand truckers, samplers, hookmen, stackers, etc.)	$1.00
Skilled labor: Clamp truck and tractor operators	1.25
Recording clerks	1.50
Weigher	2.00

Appendix D—Specifications for a Cotton Warehouse for Storing 40,000 to 50,000 Flat Bales[12]

Site Preparation and Excavations

a. The site shall be thoroughly cleared and grubbed. All grass, brush, shrubs, large stones, and other debris shall be removed from the site. All stumps and roots shall be removed to a minimum depth of 2 feet below the subgrade.

b. All soil and other unclassified material shall be excavated to provide for foundation,

[9] Data for Hourly Costs was obtained from "Handling Bales of Cotton in Public Warehouses. Methods and Equipment" (*15*).

[10] Clamp trucks, lift trucks, and tractors are gasoline propelled.

[11] Estimated.

[12] These specifications are intended to illustrate the type and quality of materials shown in figures 23 to 28 and considered in the cost estimate. Warehousemen can substitute other materials as required and desired.

footings, retaining walls, pipe trenches, etc. Where excessive cuts are made, the area shall be filled with thoroughly compacted soil or other material as specified in item c.

c. Where fills are required under floors and roadways to bring the existing grade up to the finished grade, earth, sand, or gravel shall be uniformly spread in layers not more than 6 inches thick and thoroughly compacted to a maximum density. The holes for the wood poles shall be backfilled with 2,000-pound concrete.

Concrete Work

a. Cement shall be type I portland cement (A.S.T.M. Designation: C 150).

b. Concrete aggregate shall conform to A.S.T.M. Designation: C 33. The maximum size of aggregate shall not be larger than one fifth of the narrowest dimensions between forms.

c. Water shall be clean and free of organic material.

d. All reinforcing bars shall be deformed to the requirements of A.S.T.M. A–15 (Billet-Steel), A.S.T.M. A–16 (Rail Steel), or A.S.T.M. A–160 (Axle Steel).

e. The cement, aggregate, and water shall be proportioned to give a strong, workable mix. All concrete shall have a minimum 28-day compressive strength of 2,500 p.s.i. except for the concrete backfill for the poles which may be 2,000-pound concrete.

f. The concrete shall be mixed, deposited, and cured in an approved manner and shall conform to the requirements of the American Concrete Institute's ACI–614.

Carpentry

a. All framing members shall be of the nominal size shown on the drawings, and the American Lumber Standard dressed sizes shall be considered as the net size. All carpentry work shall be done in a workmanlike manner in accordance with the best practices of the trade.

b. All purlins, studs, plates, and bridging shall be of a grade listed in the National Design Specification recommended by the National Lumber Manufacturers Association and having the following minimum allowable unit stresses:

Unit stress—	*P.s.i.*
in extreme fiber in bending	1,500
in horizontal shear	120
in compression parallel to the grain	1,200
in compression perpendicular to the grain	390
Modulus of elasticity	1,760,000

c. All girders (members 4″ or more thick) shall be of a grade listed in the National Design Specification having the following minimum unit stresses:

Unit stress—	*P.s.i.*
in extreme fiber in bending	1,900
in horizontal shear	120
in compression parallel to the grain	1,500
in compression perpendicular to the grain	415
Modulus of elasticity	1,760,000

d. Pole columns shall be class 4 as indicated on the drawings and shall conform to specification No. 05–1–1948 of the American Standards Association. The poles shall have an ultimate fiber stress in bending of 7,400 p.s.i. All poles shall be pressure treated with pentachlorophenol with a net retention of 0.4 pound (dry chemical) per cubic foot of wood. Other approved type of preservative in accordance with Federal specification TT–W–571 may be used. The poles shall be well dried after treatment and be suitable for use in a cotton warehouse.

e. All structural members shall be fastened securely with nails and metal straps as shown in the drawings or by other approved methods to withstand the maximum design loads imposed upon them.

f. Plywood shall be made B–D (interior) and shall conform to U. S. Commercial Standards USCS 45 or equal.

g. An approved type of hinged connection shall be provided for the roof girders as indicated on the drawings. The connection shall be constructed to transfer design loads, be tight enough to prevent excessive movement of the connecting members, and be constructed to eliminate the transfer of bending moment between the members.

Metal Siding and Roofing

a. The sides and roofs of the compartments shall be covered with steel sheets with standard 2½- by ½-inch corrugations. The sheets shall be formed of steel of 29-gage high tensile strength with a minimum-yield strength of 80,000 p.s.i. If high tensile strength steel is not used, the sheets shall be of 28-gage thickness. The siding sheets shall be 26 inches wide; the roofing sheets shall be 27½ inches wide.

The sheets shall be of the lengths shown on the drawings and shall be galvanized in accordance with A.S.T.M. Specifications A–361 with a minimum coating of 1.25 ounces of zinc per square foot.

b. Roofing sheets shall be installed with a minimum end lap of 12 inches; siding sheets shall have an end lap of 4 inches. The roofing sheets shall have a side lap of 1½ corrugations, and the siding sheets shall have a side lap of one corrugation.

c. The roofing and siding sheets shall be securely fastened to purlins or studs with spirally grooved or ringed shanked galvanized nails, 10 gage by 2½ inches, backed with neoprene or lead washers. The sheets shall be fastened together at the side and end laps with ¼- by ¾-inch galvanized self-tapping screws backed with neoprene washers. Each 12-foot roofing sheet shall be fastened to the purlins with a minimum of 10 nails, with 2 nails per purlin. Roof end laps shall be fastened together with the self-tapping screws or nails 5½ inches on centers. Side laps shall be fastened together every 6 to 12 inches on centers. Each 12-foot long siding sheet shall be fastened to the studs with a minimum of 8 nails and a minimum of one nail per stud; the side laps shall be fastened together approximately every 14 inches on centers. End laps shall be fastened together every 7½ inches on centers. All fastenings shall be made in the crowns of the corrugation.

d. The metal siding and roofing shall be grounded with the necessary conductor cable and ground pipes for lightning protection.

e. The joints of roofing sheets shall be sealed with extruded mastic beads. The beads shall be not less than 3/16 inch in diameter, shall have a noncuring polysulfide rubber base, and conform to military specifications MIL–S–11030 B, type 1, Class 1. Other approved types of mastic or caulking compounds may be substituted. The mastic or caulking shall be applied in a way to insure weathertight joints.

Paving and Floor Construction

a. A mechanically stabilized base such as gravel or caliche shall be provided for all floors and other pavements. The base for compartment floors shall be 4 to 8 inches thick, depending on soil conditions; the base for roadways, courts, and other outside paving shall be 6 to 8 inches thick. The base shall be well graded and well compacted in accordance with applicable sections of U.S. Public Roads Standard Specification–FD–57.

b. All floors and pavements shall consist of a hot-mix, hot laid, bituminous paving consisting of a combination of coarse aggregate, fine aggregate, and mineral filler uniformly mixed with bituminous material. All materials should meet the requirements of Federal Specification SS–A–706 b.

c. The coarse aggregate, all material retained on a No. 10 mesh sieve, shall consist of clean, hard, durable stone or gravel. The aggregate shall have a percent of wear of not more than 50 when subjected to the Los Angeles Abrasion Test.

d. The fine aggregate, all material passing through the No. 10 sieve and retained on the No. 200 sieve, shall consist of sand or stone screenings free from clay, loam, and other foreign matter.

e. The mineral filler, all material passing through the No. 200 sieve, shall consist of thoroughly dry stone dust, slate dust, or portland cement which is free from foreign and other injurious matter.

f. A bituminous cement shall be used which is uniform in character and free from water with 60 to 70 penetration. The exact grade shall be designated after design tests have been made using the mineral aggregates which will be used for the project.

g. The paving mixtures shall consist of a uniform mixture of the aggregates and bituminous material. The mixture shall be well graded and proportioned to produce a highly stable, dense, nonscaling surface. The wearing surface shall be mix No. IV–a, in accordance with Specification Series No. 1 of the Asphalt Institute, with the following grading of the aggregate:

Sieve size	*Total passing by weight (percent)*
½ inch	100
⅜ inch	80–100
No. 4	55– 75
No. 8	35– 50
No. 30	18– 29
No. 50	13– 23
No. 100	8– 16
No. 200	4– 10

Asphalt cement shall be added to the above at the rate of 3.5 to 8.5 pounds per 100 pounds of aggregate.

Where 2-course pavement is shown in the drawings the binder course shall be mix IV-c, in accordance with Specification Series No. 1 of the Asphalt Institute, with the following grading of the aggregate:

Sieve size	*Total passing by weight (percent)*
1 inch	100
¾ inch	80–100
⅜ inch	60– 80
No. 4	48– 65
No. 8	35– 50
No. 30	19– 30
No. 50	13– 23
No. 100	7– 15
No. 200	0– 8

The asphalt cement content for the binder course shall be within the same limits specified for the surface course. Other comparable mixes specified by local highway departments may be substituted for the above mixes.

h. The paving mixture shall be mixed, transported, and placed in an approved manner in accordance with Specification Series No. 1 of the Asphalt Institute. The mixture shall be thoroughly and uniformly compressed with a powerdriven roller weighing not less than 10 tons. The finished surface shall be smooth and true to the established crown and grade and shall at no point vary more than ¼ inch from the specified thickness.

Doors

a. The doors at the end of main aisles shall be wooden sectional overhead doors, six sections high and eight panels wide. Stiles and rails shall be of nominal 1¾-in-thick Douglas fir with 3-ply, ¼-inch-thick plywood panels. Two or more panels shall be glazed with ¼-inch wired glass. The doors shall be provided with high lift steel tracks to provide a minimum clearance from the floor of 14 feet. The doors shall be accurately counterbalanced with torsion springs, the doors shall be provided with all necessary approved types of hardware including galvanized steel fittings, ball-bearing rollers, and cylinder lock set.

b. The doors on the ends of the building shall be sliding doors consisting of a wood frame covered with the same type of metal siding used on the building walls. The doors shall be installed on a 16-gage steel track mounted to the building with steel brackets approximately 2 feet on centers. The doors shall be provided with an approved type of roller bearing sliding door hangers.

c. A wood panel door for personnel shall be provided as shown in figure 27. The stiles and rails shall be of 1½-inch lumber. The door shall have one glazed panel of ⅛-inch wired glass and shall be equipped with approved types of hardware including butt hinges, knob latch set, and cylinder lock set.

Translucent Structural Panels

Translucent structural panels shall be installed in the roof to provide natural daylighting. These panels shall be molded of polyester resin plastic, reinforced with a minimum of 2 ounces of glass fiber per square foot. The panels shall be of the same size and type of corrugation as the metal roofing panels. They shall have a minimum light transmission of 80 percent. Before installation, the sheets shall be covered with a light acrylic coating. The sheets shall be fastened in place by the same method used for the metal roofing sheets. The dimensions and quality of the panels shall conform to the standards of Commercial Standard CS214–57 of the U.S. Department of Commerce.

Fire Protection

a. The compartments shall be protected by automatic sprinkler systems and standpipes. The warehouse as a whole shall be protected by an outside fire loop with hydrants and hose houses. The fire protection systems for the warehouse shall be supplied by two sources of water. Each warehouse installation must meet the regulations of insurance agencies having jurisdiction in the area and must be designed around the available water supply.

b. Automatic sprinkler systems shall be provided for each compartment. Where allowable a wet system should be used (a dry-pipe system is assumed for this design). The system shall utilize approved types of spray sprinkler heads in accordance with NBFU's pamphlet, No. 13, Section 14(*8*). Sprinkler head shall be located to cover 90 square feet of ceiling area (10 square feet less than the area for ordinary hazard occupancies). Two systems shall be provided for each compartment. Pipe used shall be designed to withstand working pressures of not less than 175 pounds in accordance with American Standard B36.10–1950, wrought steel and wrought iron pipe. The system shall include necessary dry pipe valves, air pressure source, and alarms. All material and equipment, and the installation and maintenance of the sprinkler system shall be in accordance with the current standards of the National Board of Fire Underwriters.

c. Standpipes with hose racks shall be provided for each compartment. The racks shall be a swing type with 50 feet of 1½-inch cotton rubber-lined hose.

d. Cast iron pipe, class 150, 8 inches in diameter, with mechanical joints shall be provided for the fire loop (where insurance regulations permit, asbestos-cement pipe may be used). Necessary post indicator valves, fire hydrants, hose houses, gate valves, fire line siamese, and miscellaneous fitting shall be types approved by NBFU and Factory Mutual (NBFU Pamphlet 24).

e. A galvanized steel gravity water tank shall be provided and installed in accordance with the standards of NBFU Pamphlet No. 22. Necessary pumps shall be provided for filling the tank in 8 hours or less.

Lighting and Electrical Systems

a. Complete lighting and power systems shall be provided starting at the termination of power company's line. All materials and workmanship shall conform to applicable sections of the National Electrical Code (*10*), and in accordance with the local power company's regulation and any other local code having jurisdiction.

b. The compartments shall be lighted with 150-watt spotlights with built-in mirror reflector and a 2,000-hour rating. Yard lights shall have 14-inch steel reflectors with porcelain enameled finish and cast aluminum brackets for attaching the light to the supporting structure.

c. All wiring, conduit boxes, panels, and switches shall be of the size and type shown on the drawings.

Fencing

a. A woven wire fence shall be provided around the warehouse site and around the electrical transformer. The fence shall be 6 feet in height plus 3 strands of barbed wire on 45° extension arms.

b. The fence shall be 9-gage wire woven in a 2-inch mesh. Top and bottom selvage shall have twist and barb finish. The wire shall be hot-dip galvanized after weaving.

c. Line posts shall be H-section with minimum dimensions of 1⅞-inch by 1⅝-inch (2.75 pounds per foot). Terminal posts shall be square 2-inch tubing weighing 3.85 pounds per foot. The line posts may be secured in the ground by steel angle-shaped drive anchors and shall be spaced 7 feet or less on centers. All posts shall be hot-dip galvanized. The top rail may be omitted.

d. The double swinging gates shall be constructed of welded 2-inch O. D. pipe or equivalent and shall be provided with bracing, hinges, latch, and miscellaneous fittings of approved types.

Painting

a. Wooden overhead doors, swinging doors, and exposed door framings shall receive one prime coat and one finish coat of exterior oil paint.

b. All bumper guards, door jambs, etc., which are highly subject to clamp truck damage shall be painted with a conspicuous pattern such as yellow and black stripes.

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