

AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

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Batch 89

DM00-0000-0000

1. SUBJECT CLASSIFICATION
A. PRIMARY Development and economics
B. SECONDARY Industries and industrialization

2. TITLE AND SUBTITLE

Plant requirements for manufacture of flush doors

3. AUTHOR(S)

(101) Andrews (George H.) Engineering Assoc., Inc., New York

4. DOCUMENT DATE
1957

5. NUMBER OF PAGES
35p. 370.

6. ARC NUMBER
ARC 694.61.A572

7. REFERENCE ORGANIZATION NAME AND ADDRESS

AID/TA/OST

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)

(Plant requirement no.50)

9. ABSTRACT

10. CONTROL NUMBER

PN-AAF-774

11. PRICE OF DOCUMENT

12. DESCRIPTORS

Doors
Industrial plants
Manufacturing

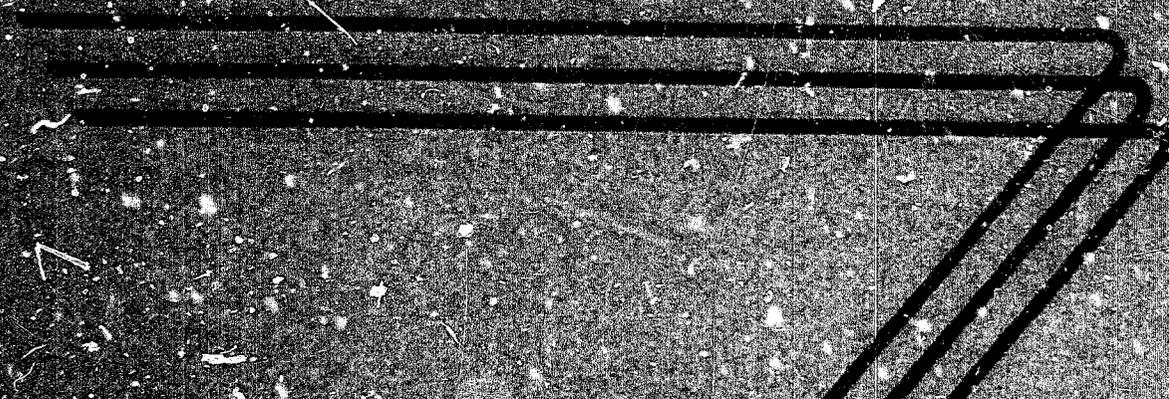
Requirements
Small scale industries

13. PROJECT NUMBER

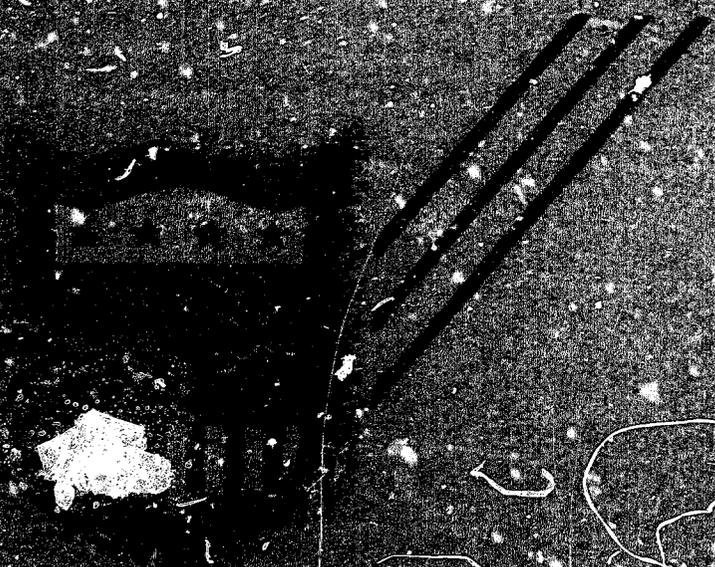
14. CONTRACT NUMBER
AID/TA/OST

15. TYPE OF DOCUMENT

REQUIREMENTS
FOR MANUFACTURE OF
ALUMINUM DOORS



TECHNICAL AID BRANCH
INTERNATIONAL COOPERATION
ADMINISTRATION
Washington, D. C.



FOREWORD

This brochure is one of a series of reports resulting from overseas technical inquiries on factory or commercial establishments, operation, management, and engineering. The report is designed to provide only a general picture of the factors that must be considered in establishing and operating a factory of this type. In most cases, plans for actual installations will require expert engineering and financial advice in order to meet specific local conditions.

Mention of the name of any firm, product, or process in this report is not to be considered a recommendation or an endorsement by the International Cooperation Administration, but merely a citation that is typical in its field.

Industrial reports prepared for ICA under special contract are customarily reviewed and edited before publication. This report, however, like other technical inquiry replies, has not been reviewed; it is the sole responsibility of the firm that prepared the report.

This brochure was prepared in September 1957 by the George H. Andrews Engineering Associates, Inc., Washington, D. C.

* * * * *

For further information and assistance, contact should be made with the local Productivity Center, Industrial Institute, Servicio, or United States Operations Mission.

Code Number

50

ACKNOWLEDGMENTS

The author gratefully acknowledges the cooperation of the following for providing technical information for use in this brochure:

Allegheny Plywood Company,
Elkins, West Virginia.

The Black Brothers Company, Inc.,
Mendota, Illinois,

Kvalheim Machinery Company,
Petaluma, California.

Thomas C. Mason,
Forest Products Division,
Business and Defense Service Administration,
U. S. Department of Commerce,
Washington, D. C.

Monsanto Chemical Company,
Plastics Division,
Springfield 2, Massachusetts.

Examination of this brochure was provided by:

Mr. E. Chat Shanks,
Wood Working Machinery Engineer,
Post Office Box 255,
Baltimore 3, Maryland.

His valuable suggestions are greatly appreciated and have been incorporated.

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FLUSH DOORS

INTRODUCTION

The equipment and operating procedures described in this brochure are intended for the production of flush doors as an addition to, or the expansion of, an existing woodworking plant, where there is sufficient demand for these products and where such a local operation would be practicable. The equipment and methods shown in this brochure are modern and capable of making all grades of flush doors, both interior and exterior, up to 3 feet wide and 7 feet long.

GENERAL ASSUMPTIONS

In order to make realistic estimates, certain assumptions must be made. These are:

1. All costs, such as those for equipment, materials and supplies, are based on prices in the United States.
2. The costs, including labor used, are taken from the actual experience on similar operations in the United States.
3. Adequate power and water are available at the existing plant site.
4. Adequate transportation facilities are available at the existing plant site.
5. All estimates are based on one 8 hour work shift per day, 5 days per week, or 40 hours per week.
6. Plywood door panels will be purchased sanded and ready for assembling.

7. Such woodworking equipment and machinery as a dry kiln, cutoff saw, planer, boring machine, trim saw, rip saw, are already available in an established woodworking plant.
8. Adequate floor space is available in the existing plant for the small amount of additional equipment needed to produce flush doors.
9. A market analysis has proved that annual sales of about 1,000 flush doors per month is possible.
10. The following items cannot be estimated realistically:
 - A. Freight in and out,
 - B. Distribution and sales cost,
 - C. Taxes, interest, insurance and other burdens.

While general estimates will be made of each of these items, for the purpose of completing cost estimates, adjustments should be made in accordance with actual local costs.

In fact, all costs contained in this brochure should be adjusted to conform to actual local conditions.

PRODUCTION CAPACITY

The production capacity of the flush door equipment shown in this brochure is 100,000 flush doors per year, using 15 men in the cabinet department for assembling the doors and using 20 men in the mill department to machine the door parts.

However, the cost figures and manufacturing operations shown in this brochure are based on a production of 1,000 doors per month, or 12,000 doors per year, using 2 men in the cabinet department to assemble the doors and 3 men in the mill department to machine the door parts.

No additional equipment would be required to assemble 100,000 flush doors per year.

PRODUCT SPECIFICATIONS

Both interior and exterior doors can be made with the equipment shown in this brochure. Standard sizes of flush doors are shown in the following table:

Note: ['] indicates feet; ["] indicates inches.

TABLE I

INTERIOR DOORS

1 3/8 inch and 1 3/4 inch

1' 6" X 6' 6"	2' 0" X 6' 0"	2' 4" X 6' 8"	2' 8" X 7' 0"
X 6' 8"	X 6' 6"	X 6' 10"	2' 10" X 6' 0"
X 6' 10"	X 6' 8"	X 7' 0"	X 6' 6"
X 7' 0"	X 6' 10"	2' 6" X 6' 0"	X 6' 8"
1' 8" X 5' 6"	X 7' 0"	X 6' 6"	X 6' 10"
X 6' 8"	2' 2" X 6' 0"	X 6' 8"	X 7' 0"
X 6' 10"	X 6' 6"	X 6' 10"	3' 0" X 6' 0"
X 7' 0"	X 7' 6"	X 7' 0"	X 6' 6"
1 10" X 6' 6"	X 6' 10"	2' 8" X 6' 0"	X 6' 8"
X 6' 8"	X 7' 0"	X 6' 6"	X 6' 10"
X 6' 10"	2' 4" X 6' 0"	X 6' 8"	X 7' 0"
X 7' 0"	X 6' 6"	X 6' 10"	

EXTERIOR DOORS

1 3/4 inch

2' 8" X 6' 8"	2' 10" X 6' 8"	3' 0" X 6' 8"
X 6' 10"	X 6' 10"	X 6' 10"
X 7' 0"	X 7' 0"	X 7' 0"

Prefitting: When ordered "prefit", doors shall be supplied as follows:

- (a). All doors shall be prefit to 3/16 inch less in width and 1/8 inch less in height than the nominal door sizes, with a tolerance of 1/32 inch, plus or minus, allowed.
- (b). All prefit doors shall have vertical edges slightly eased.
- (c). All prefit doors shall have skid blocks, scuff strips, or other type of protection attached to the bottom of the door.

There are 3 grades, or qualities, of flush doors commonly called:

Premium Grade
 Good Grade
 Paint Grade

The following tables II to X, inclusive, show the grade, size and average factory selling price of flush doors in the United States:

TABLE II

Paint grade hardwood interior flush door, 1 3/8 inches thick, hollow core:

Width		Length		Factory Sales Price
Feet	Inches	Feet	Inches	
2	0	6	8	\$ 5.30
2	4	6	8	6.00
2	6	6	8	6.30
2	8	6	8	6.60

For doors 1 3/4 inches thick, add \$.50 each.

TABLE III

Paint grade hardwood exterior flush doors, 1 3/4 inches thick, hollow core:

Width		Length		Factory Sales Price
Feet	Inches	Feet	Inches	
2	6	6	8	\$ 7.80
2	8	6	8	8.10
3	0	6	8	8.60
3	0	7	0	9.60

TABLE IV

Good grade *Lauan mahogany interior flush door, 1 3/8 inches thick, hollow core:

Width		Length		Factory Sales Price
Feet	Inches	Feet	Inches	
2	0	6	8	\$ 4.80
2	4	6	8	5.15
2	6	6	8	5.50
2	8	6	8	5.65

For doors 1 3/4 inches thick, add \$.50 each.

TABLE V

Good grade *Lauan mahogany exterior flush door, 1 3/4 inches thick, hollow core:

Width		Length		Factory Sales Price
Feet	Inches	Feet	Inches	
2	6	6	8	\$ 7.30
2	8	6	8	7.50
3	0	6	8	8.00
3	0	6	8	9.00

* Good grade Lauan (Philippine Mahogany).

TABLE VI

Good Grade Natural Birch interior flush doors, 1 3/8 inches thick, hollow core:

Width		Length		Factory
Feet	Inches	Feet	Inches	Sales Price
2	0	6	8	\$ 6.60
2	4	6	8	7.60
2	6	6	8	7.90
2	8	6	8	8.20

For doors 1 3/4 inches thick, add \$.50 each.

TABLE VII

Good grade Natural Birch exterior flush doors, 1 3/4 inches thick, hollow core:

Width		Length		Factory
Feet	Inches	Feet	Inches	Sales Price
2	6	6	8	\$ 9.60
2	8	6	8	10.00
3	0	6	8	10.80
3	0	7	0	11.80

Note: Marine plywood must be used on all exterior doors.

TABLE VIII

Premium Grade African Mahogany interior flush doors, 1 3/8 inches thick, hollow core:

Width		Length		Factory Sales Price
Feet	Inches	Feet	Inches	
2	0	6	8	\$ 13.00
2	4	6	8	14.90
2	6	6	8	15.50
2	8	6	8	16.00
3	0	6	8	17.30
3	0	7	0	18.30

For doors 1 3/4 inches thick, add \$1.00 each.

For each additional 2 inches in height over 7 feet, add \$1.00 each.

For each additional 2 inches in width over 3 feet, add \$2.00 each.

TABLE IX

Premium Grade African Mahogany exterior flush doors, 1 3/4 inches thick, hollow core:

Width		Length		Factory Sales Price
Feet	Inches	Feet	Inches	
2	0	6	8	\$ 15.50
2	4	6	8	17.40
2	6	6	8	18.00
2	8	6	8	18.50
3	0	6	8	19.80
3	0	7	0	20.80

TABLE X

Premium Grade Exterior Flush Doors, 1 3/4 inches, solid cores:

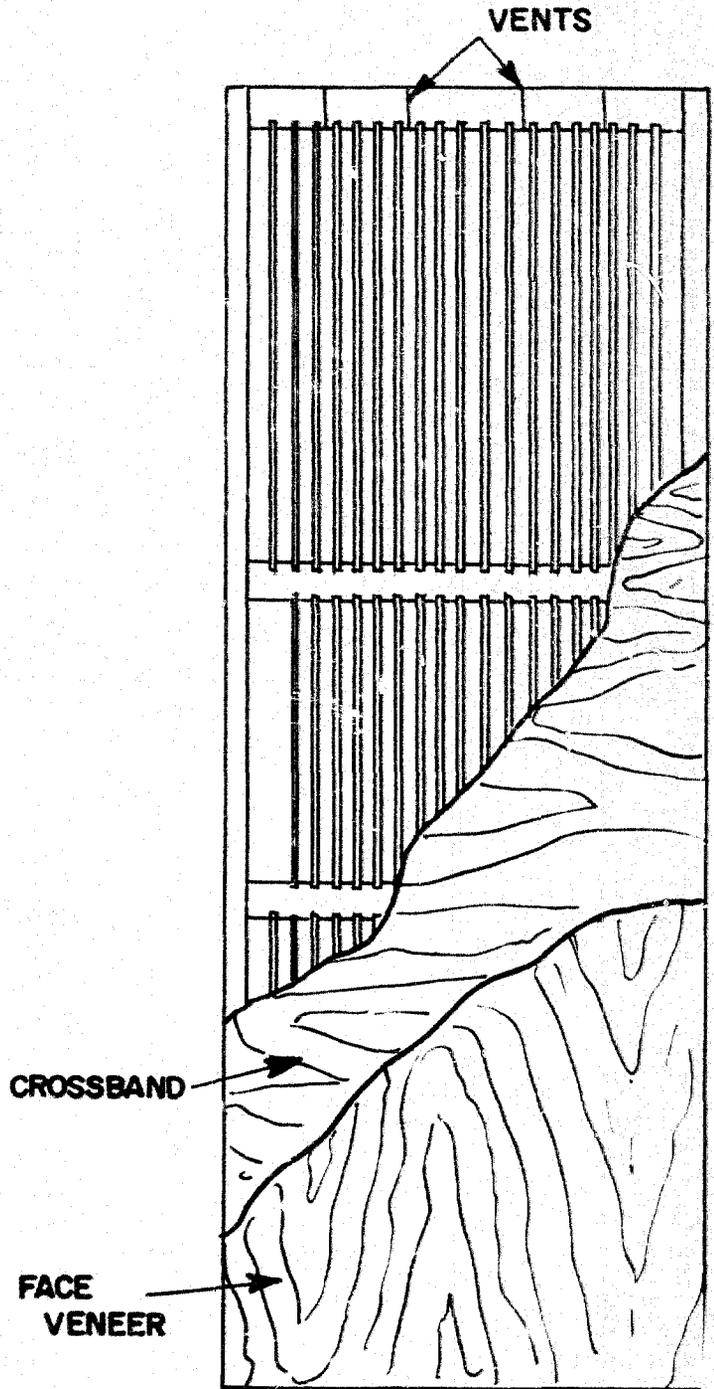
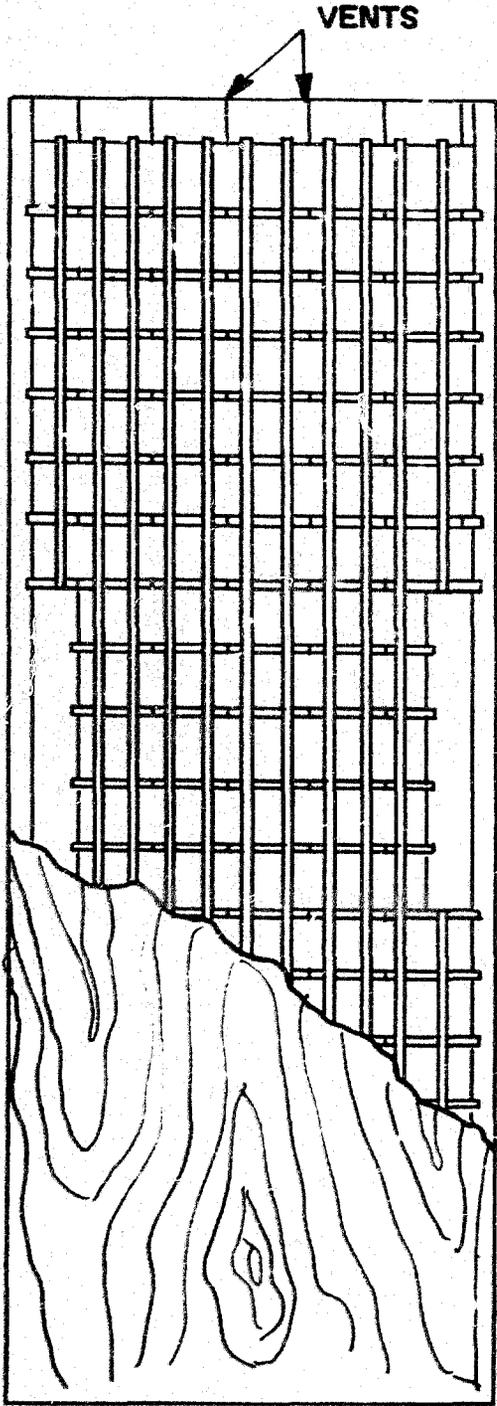
Width		Length		Factory Sales Price				
Feet	Inches	Feet	Inches	#1 Gum.	Birch	White or African Red Oak	Mahogany	Walnut
2	0	6	8	\$17.30	\$20.70	\$22.80	\$21.30	\$25.00
2	4	6	8	19.30	22.70	25.10	23.80	27.50
2	6	6	8	20.00	23.40	26.80	24.60	28.80
2	8	6	8	20.70	24.70	28.00	25.60	30.00
3	0	6	8	22.00	26.70	29.40	27.80	32.00
3	0	7	0	23.00	27.70	30.40	28.80	33.00

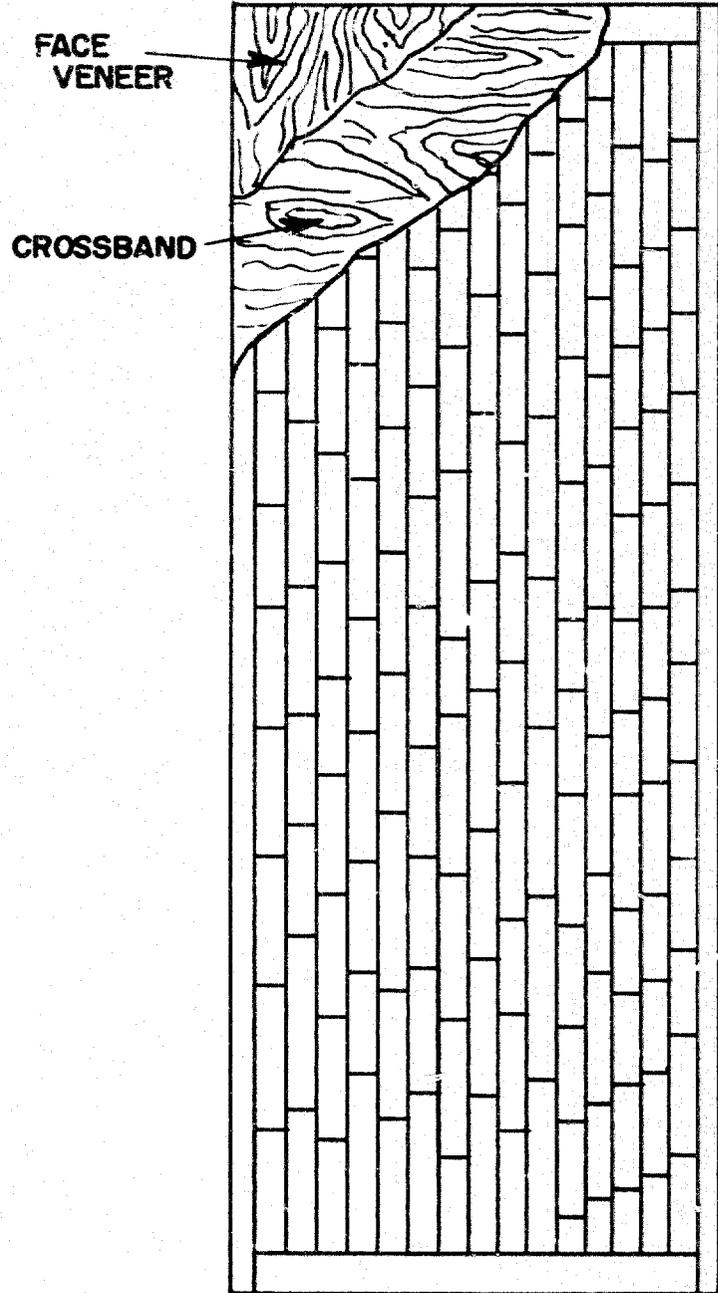
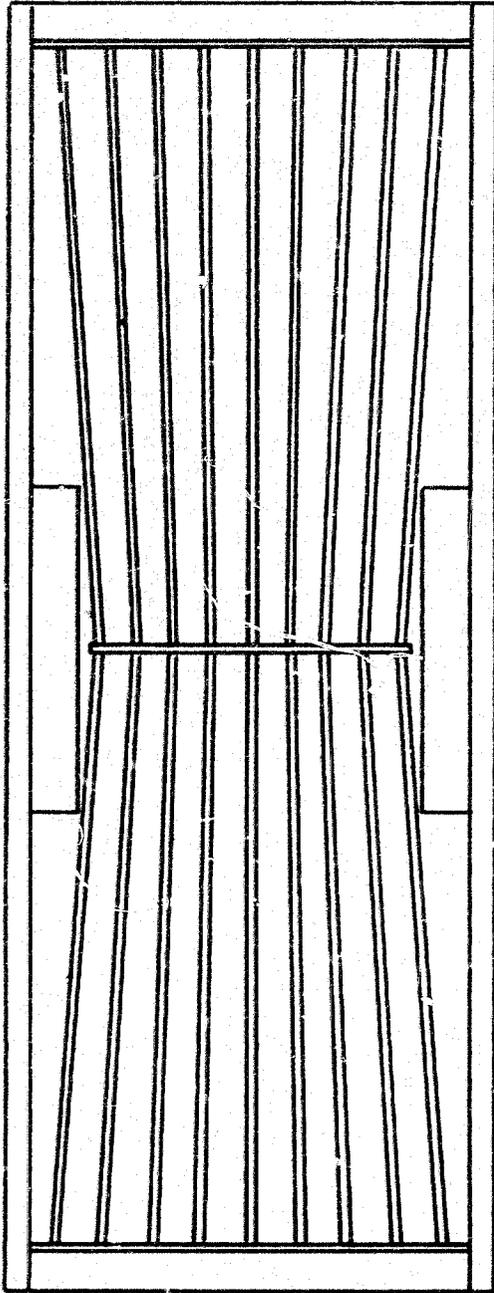
CORES

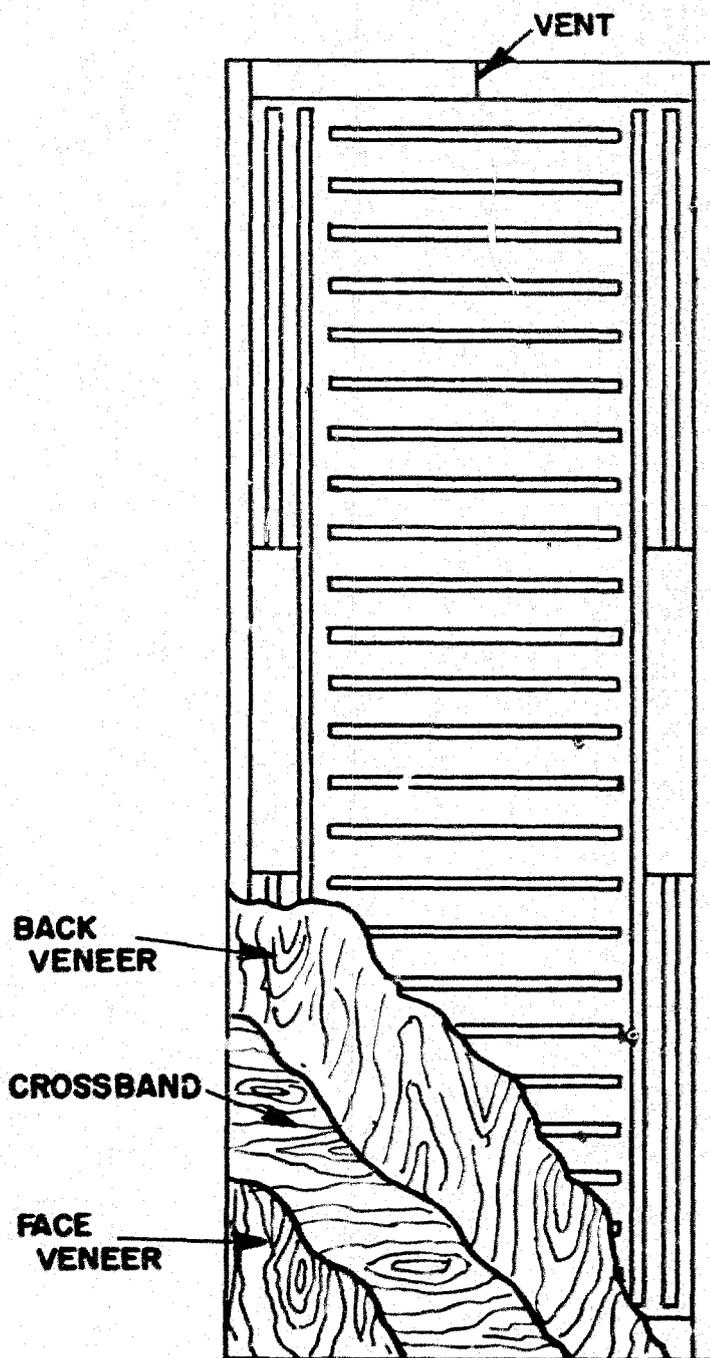
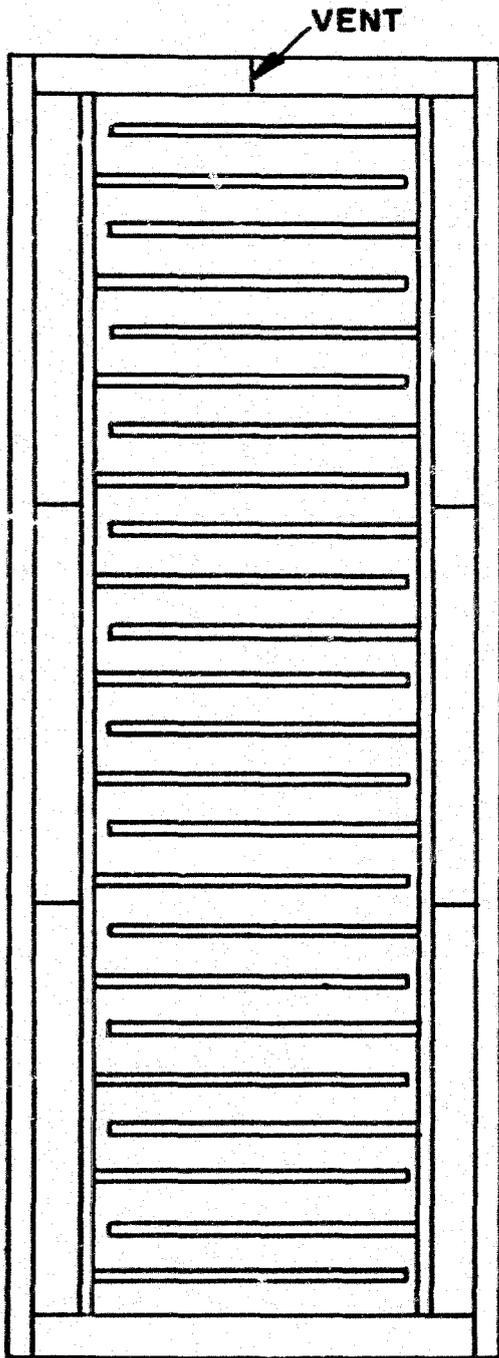
There are many types of cores used in the making of flush doors. Illustrations of some of the cores now being used in the United States are shown on Pages 8 to 11, inclusive.

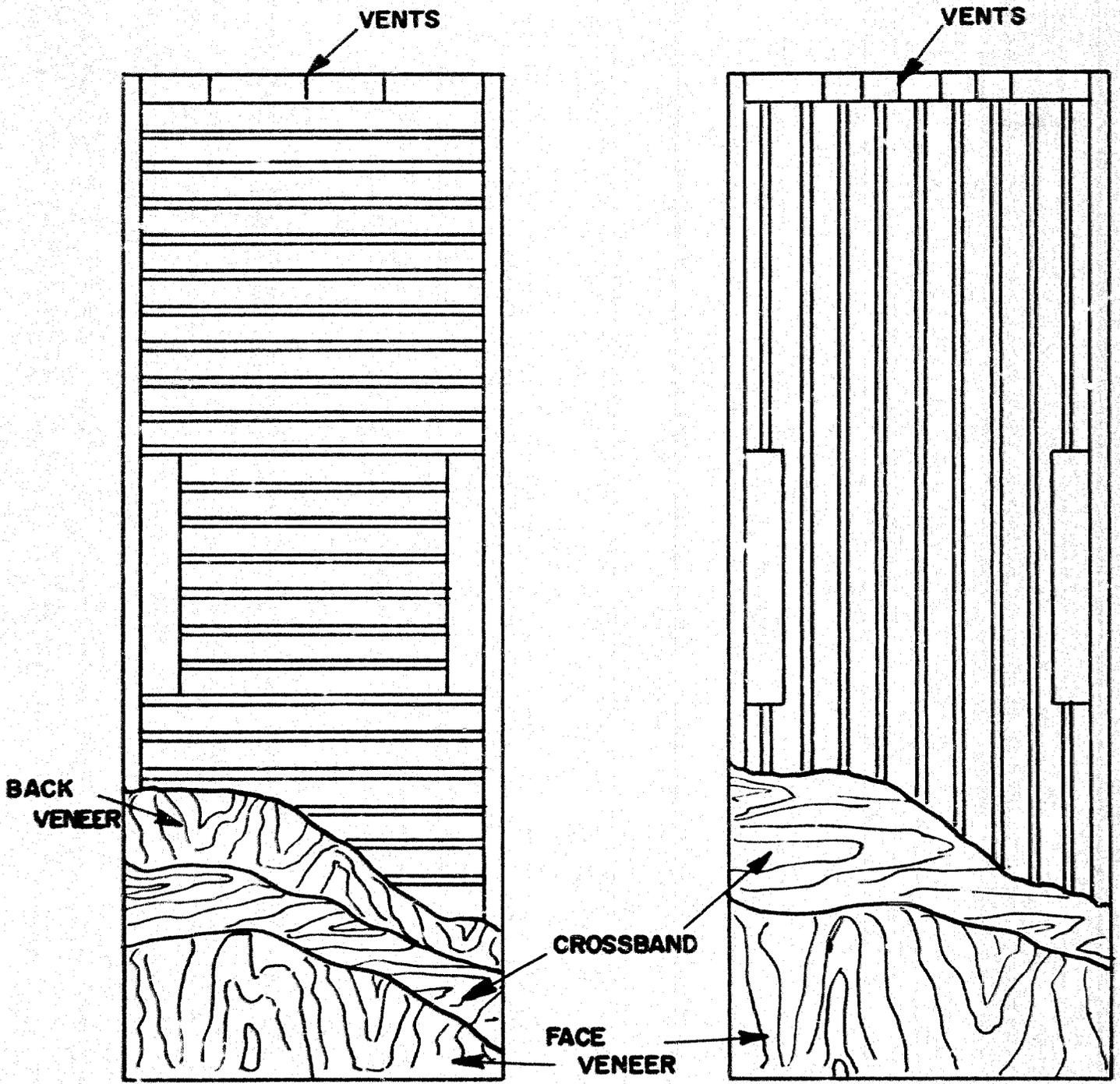
The kind of core used should be governed by such factors as:

1. The quality of the product.
2. The kind of scrap wood available from the woodworking operations of the plant
3. The kind of woodworking machines available to machine the core materials.
4. The size of the door.
5. The end use of the door. For example, a closet door is not used as much as most other doors.









MANUFACTURING OPERATIONS

The door frame parts include:

- 2 stiles
- 1 top rail
- 1 bottom rail
- 2 lock blocks
- core material

The exact method used in machining the above parts will depend upon the machines available in the plant. The following sequence of operations is recommended:

MILL OPERATIONS

1. Kiln dry the lumber to from 8 to 10 percent moisture content.
2. Plane 2 sides to size.
3. Rip to size.
4. Cut to length, eliminating defects.
5. Re-rip defective material into 3/8 inch core strips.
6. If enough core strips cannot be secured from mill scrap or defective lumber, then good lumber will have to be planed two sides to size and ripped into 3/8 inch core strips.
7. Trim to length on double cutoff saw or trim saw.
8. Notch all parts for core and ventilation.
9. Bore dowel holes.

Note: For cheaper doors, staples or corrugated nails may be used instead of dowels.

CABINET OPERATIONS

1. Glue dowels into stiles.
2. Glue lock blocks to stiles.
3. Assemble and glue up frame complete with core in form or jig.
4. Pass frame through the glue spreader, gluing 2 sides with one pass.
5. Place bottom caul on glue up table.
6. Place 1 veneer panel on caul, face side down.
7. Place assembled door frame on veneer panel.
8. Place 2 veneer panels on door frame, face sides together.
9. Place another assembled door frame on veneer.
10. Place 2 more veneer panels on door frame and continue until enough doors are glued up for a press load.
11. Place caul on top of glued up doors.
12. Load glued up doors into press and apply pressure. The pressing time to secure a good bond will depend on the type of glue used and may be as low as 30 minutes.
13. Remove doors from press.
14. Trim sides and ends for size and squareness.
15. Inspect.
16. Repair and sand any defects.
17. Package and ship.

CAULS

Cauls are plywood boards slightly larger than the door and about 2 inches thick. The cauls are used on top and bottom of each stack of doors which are placed in the press. This helps to keep the pressure even on the doors and to keep the press clean. While it is entirely possible to press the doors without using them, it is recommended that cauls be used.

GLUE

INTERIOR DOORS

For interior doors, a water resistant bond is required. The bond must retain practically all of its strength when occasionally subjected to a thorough wetting and drying. Polyvinyl, urea and extended phenolic resins are suitable adhesives.

EXTERIOR DOORS

For exterior doors, the bond must be fully water-proof. The bond must withstand full weather exposure. It must not be affected by micro-organisms. The use of phenolic resins, melamine and resorcinol adhesives are suitable.

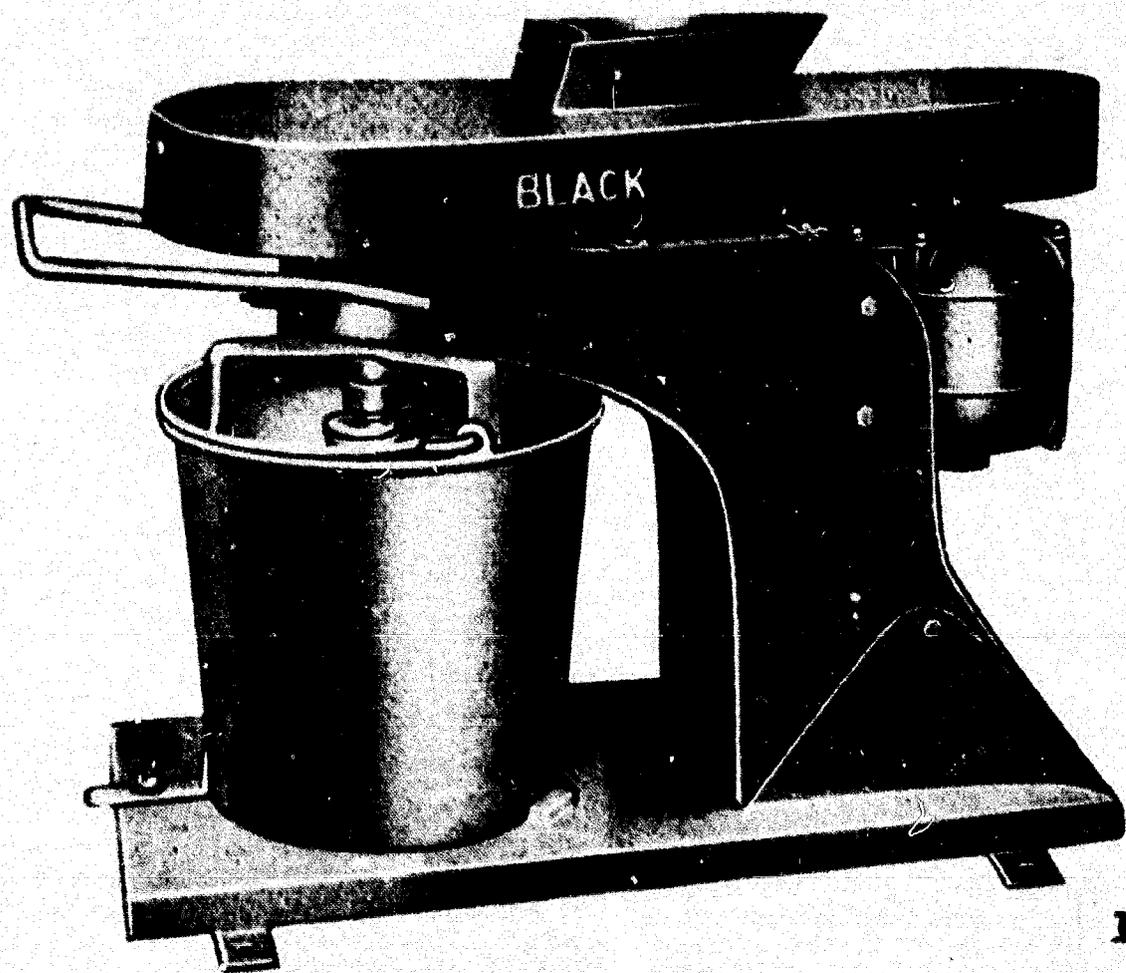
Although the cost of such glue is fairly high, it is considered economical for use where a good bond is required. The cost of glue of this quality for interior doors will amount to about \$.10 per door, or an annual cost of approximately \$1,200.

Using the above glues in a cold press, the bonding time required in the press will vary according to local conditions.

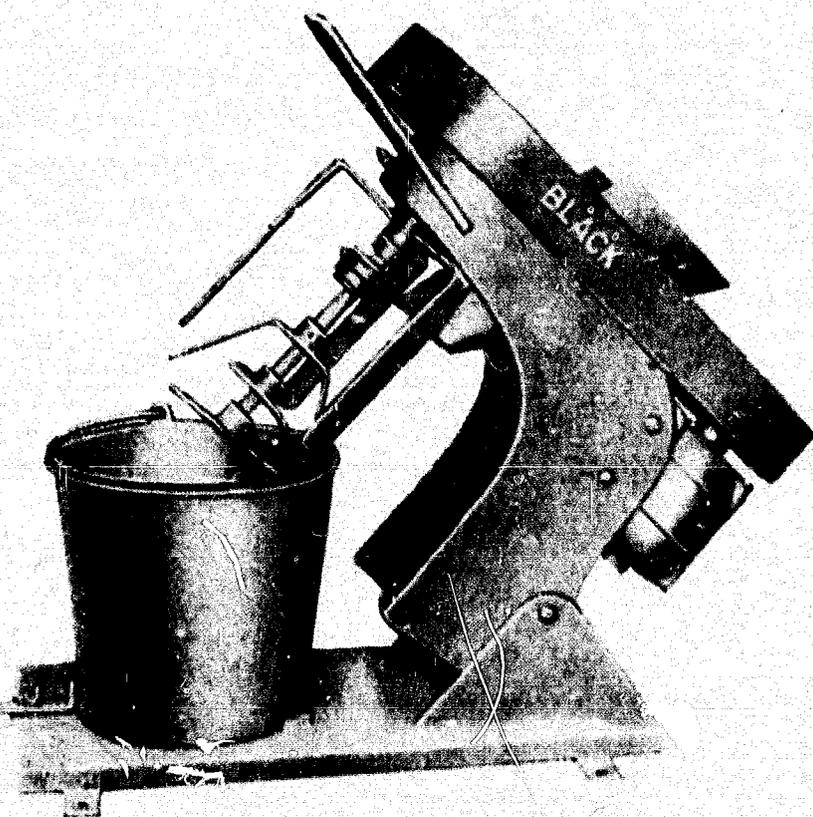
The company furnishing the glue will provide full information and instructions for its use. These instructions will include, how to mix the glue, how to apply it, how long to leave it in the press, under what conditions and in what quantities extenders, such as low grade flour, chalk and other additives may be used, and other pertinent information.

It is recommended that these instructions be followed completely. No attempt should be made to change the mix, shorten the press time, or in any way to deviate from the instructions of the company furnishing the glue.

An annual volume of 12,000 doors requires a production of only 48 doors per day, based on 5 working days per week, 50 weeks per year. Therefore, the doors may be left in the press for long periods of time, if necessary.

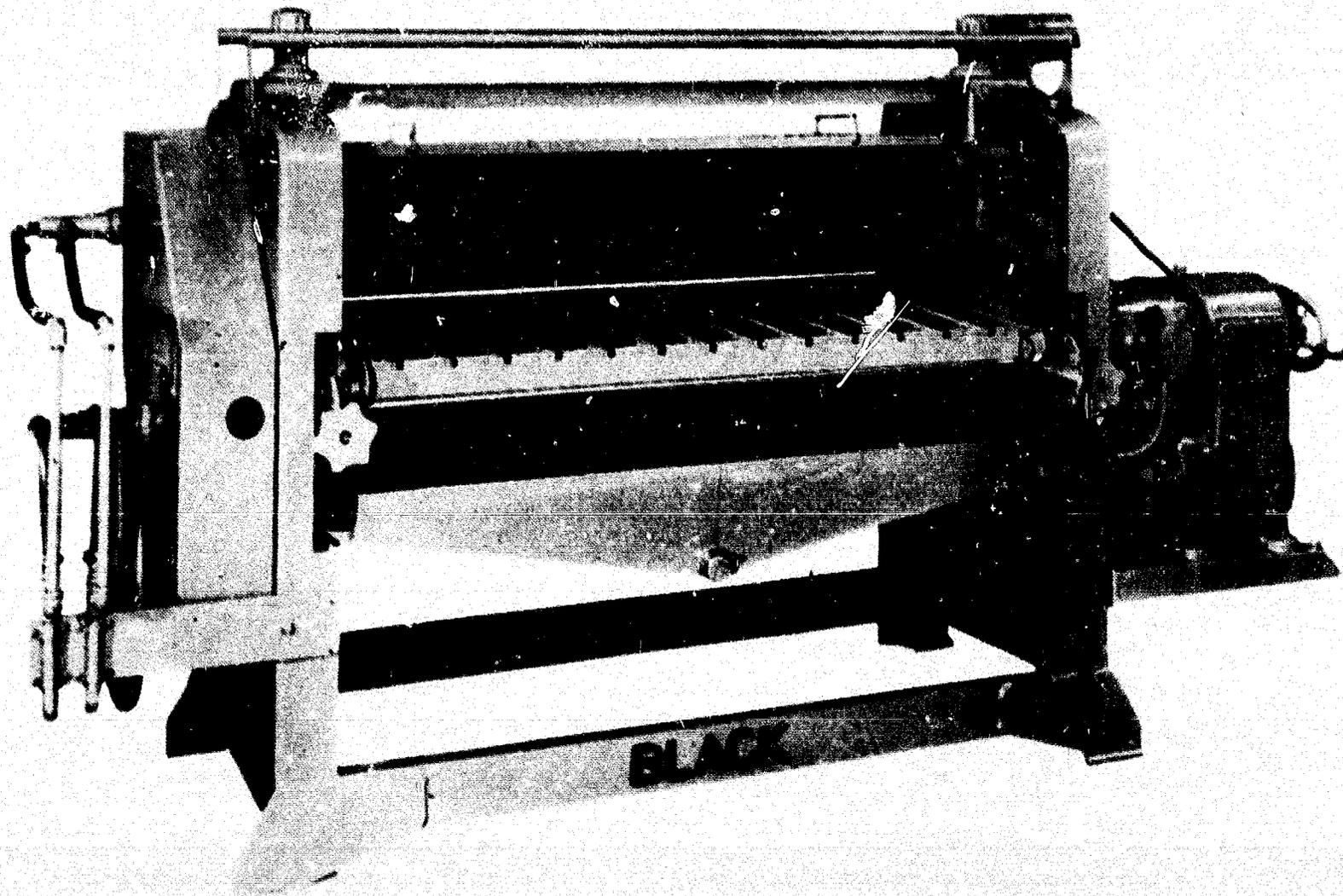


MIXING POSITION



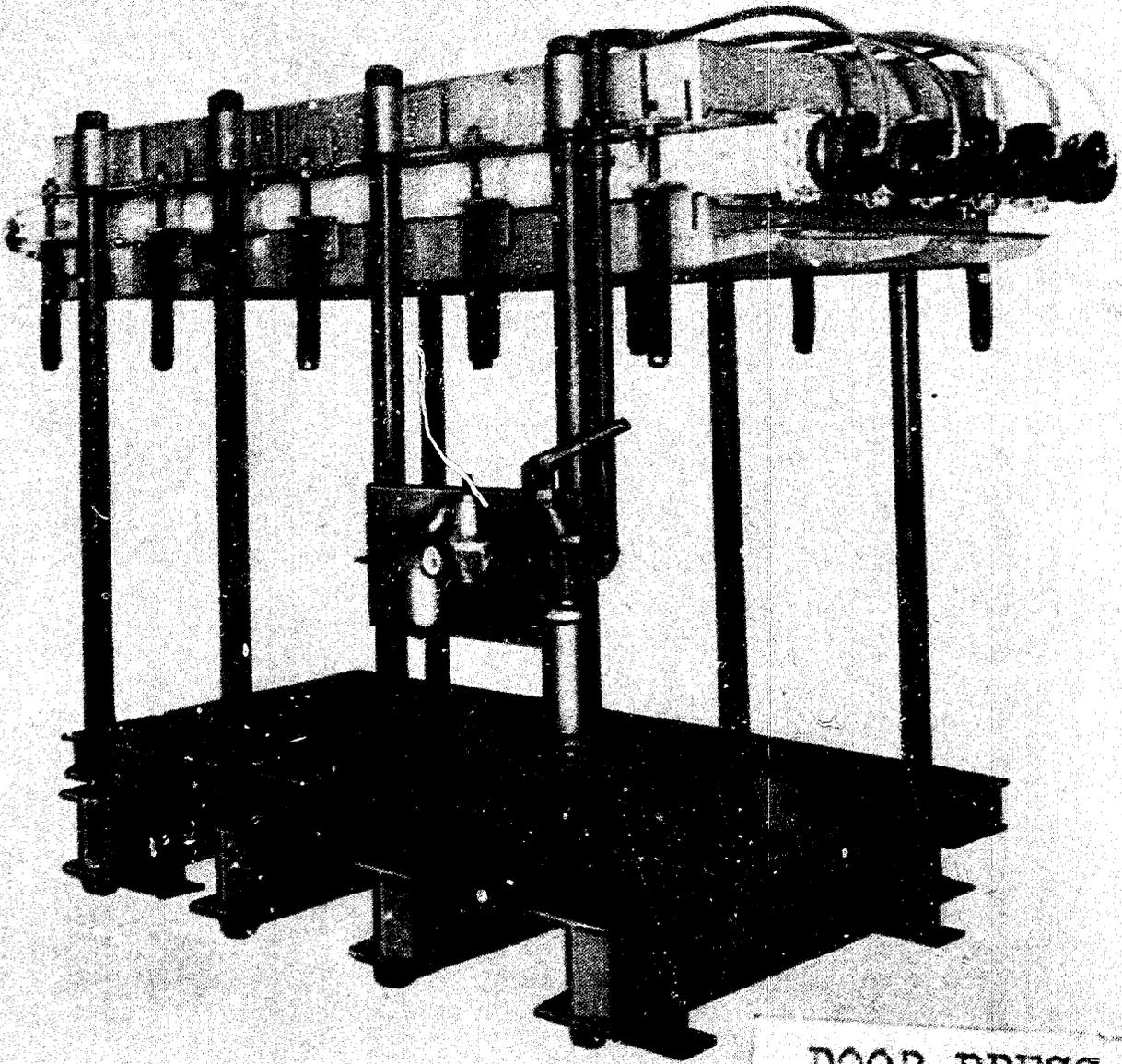
OPEN TO REMOVE PAIL

GLUE MIXER



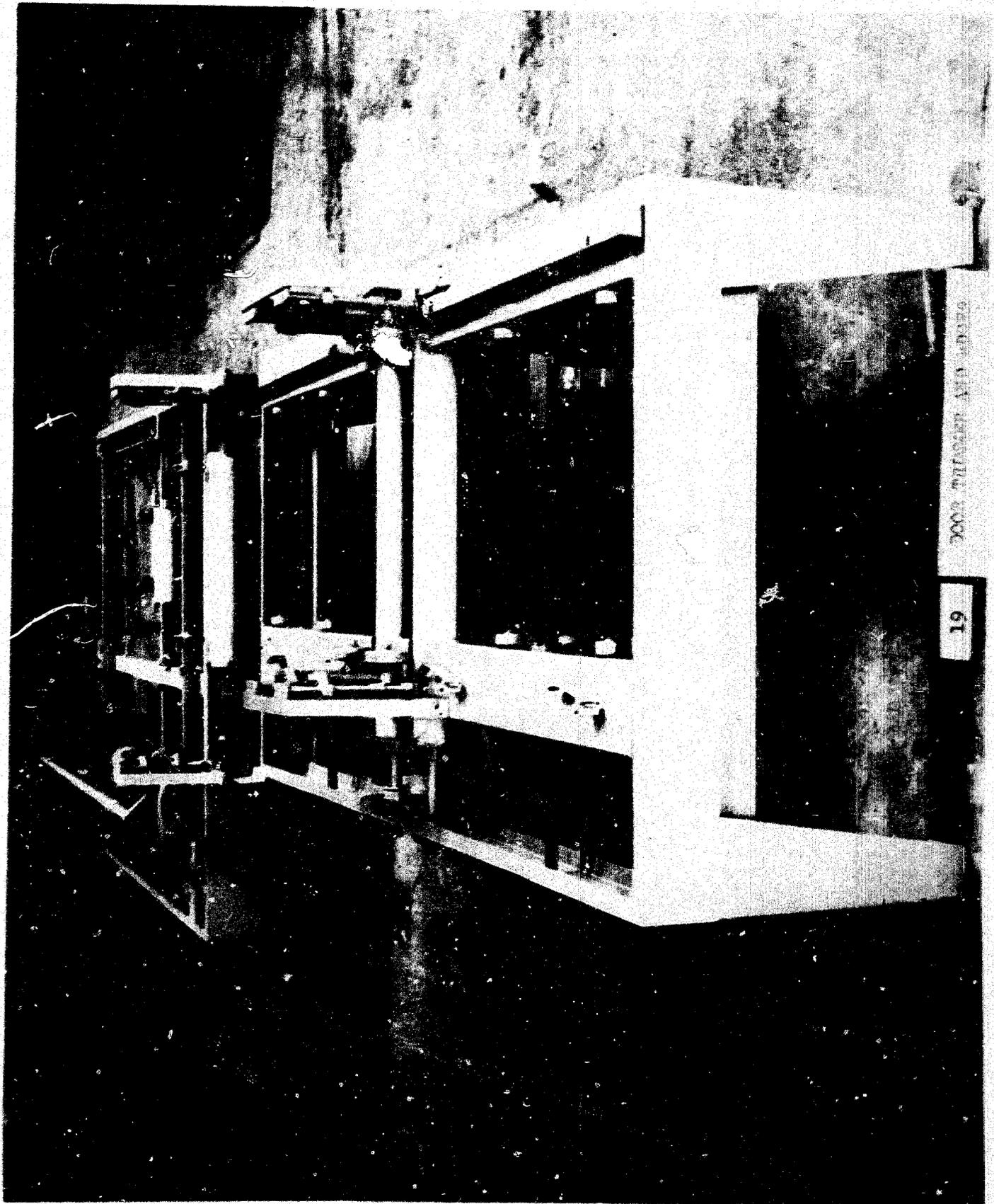
17

GLUE SPREADER



18

DOOR PRESS



GENERAL ELECTRIC INSTRUMENT CO. INC.

19

MATERIAL COST

2 Plywood Door Panels at \$.12 per square foot	\$ 51,200
2 Stiles = 6 1/4 feet of lumber, including waste at \$60 per thousand board feet	4,500
2 Rails, 1 top and 1 bottom, = 2 feet of lumber, including waste at \$60 per thousand board feet	1,440
2 Lock Blocks = 2 feet of lumber, including waste at \$60 per thousand board feet	1,440
11 Long Mesh Strips = 4 feet of lumber, including waste at \$60 per thousand board feet	2,880
18 Cross Mesh Strips = 3 feet of lumber, including waste at \$60 per thousand board feet	2,160
Dowels, sandpaper and other	380
Glue	<u>1,200</u>
 TOTAL ANNUAL COST OF MATERIALS	 \$65,200

EQUIPMENT REQUIREMENTS

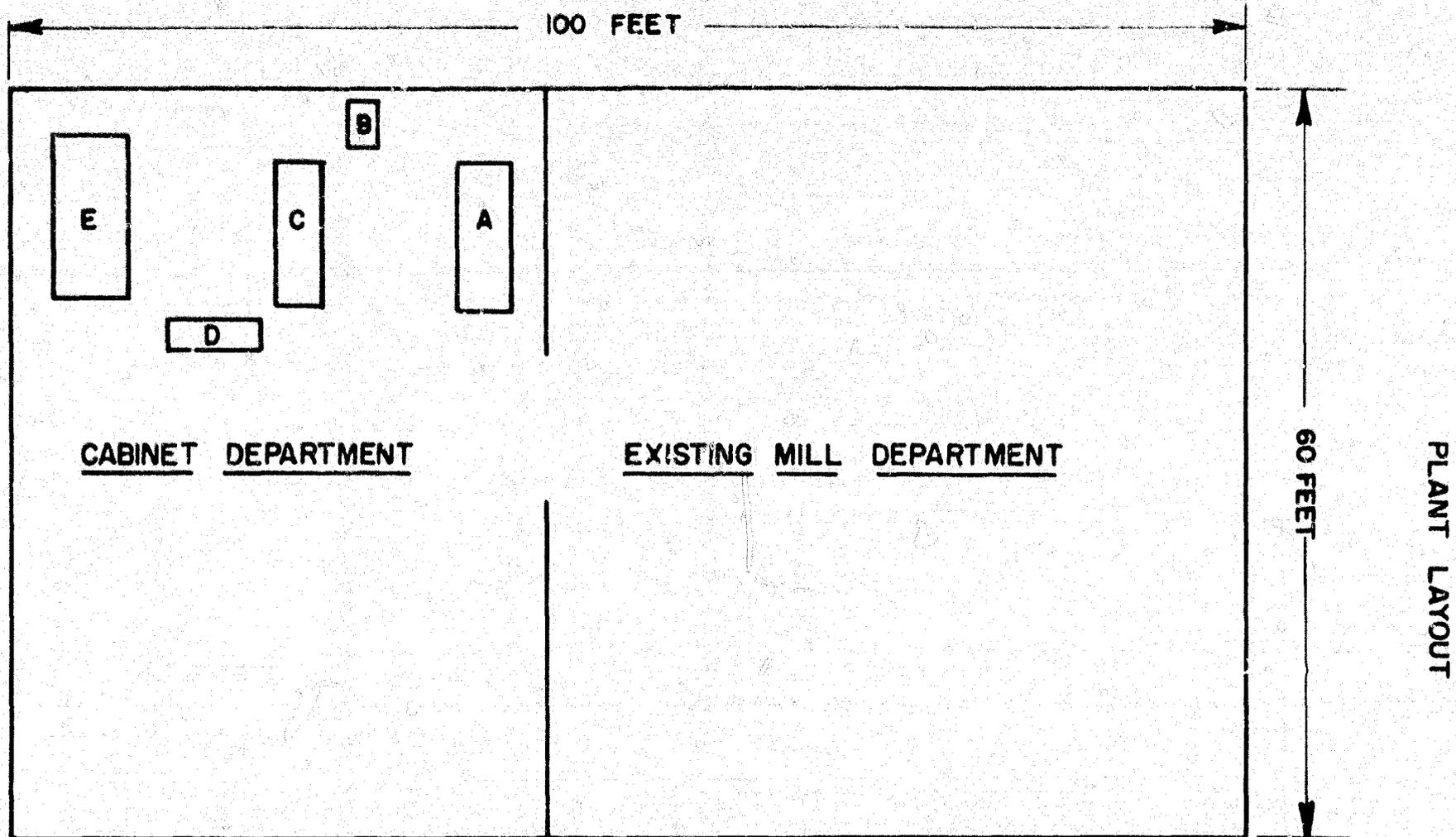
The following equipment is required to assemble and press flush doors. When operated 8 hours per day with a crew of 15 workers, this equipment has a capacity of 100,000 doors per year. However, the production operations, costs, and the estimates shown in this brochure are based on 12,000 doors per year.

Door frame forms should be made at plant	\$ 200
Wood cauls, about 2 inches thick, should also be made at plant	100
Glue mixer	400
Glue spreader, water cooled doctor rolls	2,700
Cold press, air operated	<u>2,100</u>
TOTAL COST OF EQUIPMENT	\$ 5,500

Note: It is recommended that, for a much larger production, a combination automatic door edger and trimmer be used. A picture of this equipment is included here. The cost of this equipment is about \$7,000.

DEPRECIATION

The annual depreciation of equipment, based on a life of 15 years, will amount to \$367.



- A. Form for frame and core assembly.
- B. Glue Mixer.
- C. Glue Spreader.
- D. Stacking Table.
- E. Cold Press for Flush Doors.

The flow of production is straight line A to E with no back-tracking.

PERSONNEL REQUIREMENTS

Since the flush door operations are to be conducted in a woodworking plant already established, management, supervision and clerical personnel will be available without additional cost. The only additional direct mill cost will be the machining of the door parts. This will require 3 additional men at \$1.50 per hour, or an estimated annual cost of

\$ 9,000

Two men at \$1.50 per hour will be required for assembling and packaging 40 doors per day. The annual cost of these assemblies will be

6,000

TOTAL ANNUAL LABOR COSTS \$ 15,000

SAFETY

If first aid facilities are not already established in the plant, it is recommended that a first aid room be maintained with the usual first aid kits available and that one member of the office staff be appointed to administer first aid when required. It should also be his responsibility to have everything necessary for first aid treatment in stock at all times.

The glue spreader should always be opened wide for cleaning to avoid accidents. A brush should be used, since a cloth could pull a person into the machine. The spreader should be cleaned immediately after it is used. There are safety attachments on the glue spreader.

SALES

The descriptions of manufacturing operations and the cost estimates included in this brochure are based on producing 12,000 good grade 7 ply flush doors, 2 feet 8 inches wide by 6 feet 8 inches long by 1 3/4 inches thick, using an egg-crate, or mesh core, and natural birch panels, as shown in Table VI, Page 6.

The factory selling price of this door is \$8.70. On this basis, the annual sales would amount to \$104,400.

Since the doors are to be produced in an existing wood-working factory, it is assumed that a sales organization is already established. However, \$3,000 is provided for the possible need of an additional clerk in the sales department.

RECAPITULATION OF COST, SALES AND PROFIT

ANNUAL COST OF MATERIALS	\$ 65,200
ANNUAL COST OF LABOR	<u>15,000</u>
ESTIMATED ANNUAL OPERATING COST	\$ 80,200
DEPRECIATION OF EQUIPMENT	\$ 367
INSURANCE	200
UNFORSEEN EXPENSE	2,633
SALES COST	3,000
PROFIT BEFORE TAX	<u>18,000</u>
ESTIMATED ANNUAL BURDEN COST	\$ 24,200
ANNUAL SALES	\$ 104,400

SUMMARY

The addition of equipment to an existing woodworking plant to produce flush doors, in accordance with the assumptions made in this brochure, would be a profitable undertaking.

There are some things, however, that should be determined before a decision is reached to add flush door equipment to a woodworking plant. Among the necessary determinations to be made are those with respect to the following items:

SALES

Will the potential annual sales amount to 12,000 flush doors?

COSTS

After revising the estimate of costs and earnings shown in this brochure so they conform to actual local costs, where it is proposed to produce flush doors, will a profitable operation be indicated?

COMPETITION

Is there potential competition which will reduce the revenue below a profitable level either by lowering the price, or by reducing the volume of sales?

PLYWOOD

Will a dependable supply of plywood door panels of suitable quality be assured at a stable price?

FLOOR SPACE

Does the existing woodworking plant have sufficient floor space available to accommodate the addition of the flush door equipment and production operations?

Flush door equipment, such as described in this brochure, when installed and operating in an existing woodworking plant, will serve as a good nucleus for a much larger operation.

When a greater production is justified, the equipment shown in this brochure is capable of producing 400 flush doors in one 8 hour day.

NOMENCLATURE AND DEFINITIONS

The definitions below give the meaning of the various terms used in this brochure:

CORE. -- The innermost layer of veneered door construction, enclosed by the faces, stiles, and rails.

HOLLOW CORE. -- A core assembly of strips or other units of wood, of a wood derivative, or of insulation board, which supports the outer plywood faces, with intervening hollow cells or spaces.

EGG-CRATE or MESH CORE. -- A hollow core composed of strips of wood, of a wood derivative, or of insulation board, so joined and/or interlocked as to form a mesh, lattice, or grid throughout the core area, with air cells or spaces between the strips.

LADDER CORE. -- A hollow core composed of strips of wood, of a wood derivative, or of insulation board, running either horizontally or vertically throughout the core area, with air cells and/or spaces between the strips.

IMPLANTED BLANKS CORE. -- A hollow core composed of a series of blanks, forms, and shapes of wood, or a wood derivative, or of insulation board, which may or may not be joined together, implanted between and supporting the outer faces of the door, with air cells or spaces between the blanks.

CROSSBANDING. -- The veneer used in the construction of flush doors which is placed beneath the face veneers, with the direction of the grain at right angles to that of the face veneer.

FLUSH DOORS:

FIVE-PLY FLUSH DOOR has two plies of veneer on each side of the core.

SEVEN-PLY FLUSH DOOR has three plies of veneer on each side of the core.

KILN-DRIED. -- Dried in a closed chamber in which the removal of moisture is controlled by artificial heat and usually by controlled relative humidity.

RAILS. -- The cross, or horizontal pieces, of a door.

BOTTOM RAIL. -- The bottom cross or horizontal pieces of a door.

TOP RAIL. -- The top cross or horizontal piece of a door.

STILES. -- The upright or vertical outside pieces of a door.

PLYWOOD FACE. -- The side of the plywood used for the face of the door.

LOCK BLOCK. -- A solid block of wood the thickness of the door stile, attached to the inside edge of the stile, into which the lock is fitted.

ENGINEERS

The services of professional engineers are desirable in the design of a flush door plant, even though the proposed plant is small. A correct design is one which provides the greatest economy in the investment of funds and establishes the basis of operation that will be most profitable in the beginning and will also be capable of expansion without expensive alteration.

The addresses of professional engineers who specialize in industrial design, some of whom may be willing to undertake such work on low cost projects overseas, can be secured by reference to the published cards in various engineering magazines. They may also be reached through their national organizations, one of which is the

National Society of Professional Engineers,
2029 K Street, Northwest,
Washington D. C.

Manufacturers of industrial equipment usually employ engineers familiar with the design and installation of their specialized products. These manufacturers are usually willing to give prospective customers the benefit of technical advice by those engineers in determining the suitability of their equipment in any proposed industrial project. The equipment manufacturers also know and can recommend professional engineers in private practice, who are willing and able to provide appropriate consulting services.

BIBLIOGRAPHY

Federal Specifications LLL - D - 581, Doors, Exterior and Interior, Wood, Flush Type, Veneered, Price 10 cents.

General Services Administration,
Seventh and D Streets, Southwest,
Washington 25, D. C.

Veneer, Plywood, and Laminated Wood,

Forest Products Laboratory,
Madison 5, Wisconsin.

A Treasury of Hardwood Plywood,

Hardwood Plywood Institute,
600 South Michigan Avenue,
Chicago 5, Illinois.

Commercial Standards CS 200 - 55, Hardwood, Veneered, Hollow-Core, Flush Doors, Price 10 cents.

A recorded voluntary standard of the trade.
Superintendent of Documents,
U. S. Government Printing Office,
Washington 25, D. C.

PERIODICALS

Progressive Architecture,

Monthly; Reinhold Publishing Corporation,
430 Park Avenue,
New York 22, New York.

New York Lumber Trade Journal,

Monthly; New York Lumber Trade Association,
5624 Grand Central Terminal,
70 East 45th Street,
New York 17, New York.

Southern Lumberman,

Semi-monthly; J. H. Baird Publishing Company,
2916 Sidco Drive,
Nashville 4, Tennessee.