AN ANALYSIS OF A PALLET MANUFACTURING PROCESS

Thesis for the Degree of M. S.

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James L. Bowyer

1965

THESIS

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ABSTRACT

AN ANALYSIS OF A PALLET
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by James L. Bowyer

In this study a small pallet mill was examined with respect to plant layout and materials flow, materials handling, waste disposal systems, and efficient use of machinery. Shortcomings of the system at the time of the study were quite typical of the problems associated with many small to medium-sized pallet mills; it was hoped that an objective analysis of the particular mill being examined would provide useful information to these other mills as well as showing the mill studied the way to make definite, cost-saving improvements.

Work sampling was the primary tool used to measure the present system. Each operation was broken into a number of classifications of time usage and observations falling in each classification were totaled and expressed in terms of percentage breakdowns of a work day. A brief headsaw study was then conducted and the data from it were used to compute the average log size used by the mill and the average amount of time required to cut up this log. Feed speed data for each machine, operation process charts for each product, and flow process charts for each product component were also used in the examination.

Difficulties were assessed on the basis of the work sampling data and improvements were suggested.

Feasibility of suggested improvements was measured by determining increased lumber output at the headsaw brought about by the change and then evaluating each machine in the sequence to determine whether or not the increased production could be handled by it. The final test of feasibility was accomplished through means of a cost evaluation.

Changes in the layout were suggested in the form of two proposals; the second proposed improvement was designed to follow the first at the end of a five-year period. The proposals were shown to have the potential of raising the rate of return on investment from three or four to over eighteen percent.

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by

James L. Bowyer

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter I. Introduction

The Wooden Pallet Industry

Commensurate with the development on the industrial fork lift truck during the years of World War II, a market for storage platforms materialized and then expanded. Wood, it seemed, was the most logical material from which to build these platforms. The product was simple in design, could be produced with a minimum investment in machinery, and could be quite acceptably constructed using inexpensive, otherwise hard to market, low-grade material. The opportunities in such an industry appeared promising to many, and thus wooden platform or pallet plants began to appear in increasing numbers near woodlands, cities, and industrial areas all over the nation. Perhaps most characteristic of these new establishments was their smallness. Many sawmills added the production of pallets to their operation, and some changed from lumber to pallet production entirely. Families got into the business, and farmers produced pallets in their spare time using wood from their own lots in many cases.

Since many people entering the pallet industry were entirely unfamiliar with the wood industry, or with any industry for that matter, problems were inevitable. Not the least of the problems was one of sound plant layout and efficiency, the lack of which caused many concerns to be plagued with low production rates, late shipments, excessive waste, and most importantly, marginal profit situations. Such problems still exist today in a great number of plants because of the

absence of inexpensive, available assistance, the lack of pertinent, easily understandable information, and quite often, because of the lack of realization that problems exist at all.

The importance of the wooden pallet industry at the present time is exemplified by the fact that about five percent of all lumber, or twenty-five percent of the hardwood lumber consumed in the U.S. last year (1964) went into pallet manufacture; production was estimated at 76.6 million pallets. In Michigan alone, the number of pallet plants increased from 78 in 1954, to 183 by 1961, and growth continues to occur. The outlook for Michigan and for the U.S. is for steady increases in numbers of firms, employees, and units produced.

The Subject of Study

The subject of this study was Peter's Crate Works, a pallet, box and building component mill located in the lower peninsula of Michigan near the town of Harrison. A fire swept through the mill in 1962 and following this time a barn was used to house the operation, with sawing of logs and nailing being done in this structure. In 1963, the construction of a new building was begun on a new site one-half mile north of the original location. Upon completion of the first part of the building, the assembly and nailing process was moved into it; log breakdown was done in the barn and material was transported over the one-half mile distance to be nailed and finally shipped. The profit and loss statement was "all red" for that year. In 1964 construction of the new building was finished, and most of the operation was moved to the site.

Little advanced planning as to machine locations, materials flow, and disposal of waste was carried out prior to construction of the mill and the result was a layout in need of major changes from the very day production began in the new structure. To this date (August, 1965) several changes have been made in the layout but even more need to be effected. The changes that have been made have improved efficiency somewhat, as reflected in increasing profits, and it is thought that additional well-planned changes will insure a continuation of this trend.

Objective of Study

The purpose of this study is to locate several of the more important problems involved in production at Peter's Crate Works and to make positive suggestions for improvement after a complete investigation and analysis of these problem areas. Such an analysis is designed to aid Peter's mill to become more efficient and also is designed to help gain an understanding of problems involved in pallet production in general.

The Area of Study

After visiting the mill site several times to observe the mill process and to gather certain basic information, it was decided that the most critical areas for improvement associated with the process were those of plant layout and materials flow, materials handling, waste disposal systems, and efficient use of machinery. Problems in marketing of finished goods, product mix, and so forth were considered as secondary in importance, and subject to investigation at a later date.

Review of Literature

Plant layout and materials flow has been the subject of a great deal of attention among industrial concerns since before the turn of the century. From about 1880 to 1930 a tremendous growth of industry occurred in the United States. This was a period when demand for goods far exceeded the production potential; in many cases, the limit of how much a company could sell was determined only by how much that company could produce. Consequently, a substantial amount of work was done on improvement of manufacturing techniques with great contributions being made by such men as Gilbreth, Taylor, and Emerson; these men laid the groundwork for development of systematic operations analysis procedures (17, 22).

Since that time, much has been accomplished and the basic theories have been used by a number of people in various ways to evaluate specific types of operations.

The U.S. Forest Service has done a large amount of work on sawmill efficiency studies. Some early work was done on plant layout and utilization of waste (4, 6, 23) while later studies by C. J. Telford, have focused on waste and materials handling devices (24, 25, 26, 27). In one of the most recent studies, Heebink and Forbes described a typical pallet operation and developed an "ideal" plant layout (10).

Another significant piece of work pertaining to pallet plant layout was written by Peter Koch, in which the plan for an integrated plant design was revealed (11). This study, as well as the work done by Heebink and Forbes involved the establishment of a new mill, rather than improvement of an existing one.

Methods of analyzing and improving current operations have been developed by Compton (8), Nelson (16), Pauley and Batdorf (18), Waldo (28), and many others (2, 3).

While much work has been done, little effort has been expended in developing a simplified analysis technique applicable specifically to pallet production; an attempt is made, in the following text, to demonstrate such techniques.

Limitations and Assumptions

The actual process of producing pallets, boxes, lumber, or any other good in a manufacturing plant is only a part of the entire sequence of events involved in transforming a standing tree to units of finished product in the hands of the consumer. Also involved in the process is the timber owner, loggers, truckers, and others. Further, after delivery of logs to the mill site, they may remain in inventory for some period of time before being used in production. After final processing, units of finished goods may again remain in inventory for some period of time before being moved, loaded, and then shipped to the point of use.

Because the actual manufacturing process is only part of the total production picture (and thus accounts for only a part of the total costs involved) a complete analysis should necessarily involve a look at all other factors in the sequence as well. For example, purchase of specified length, rather than random length, logs might enable the firm to realize substantial savings through waste reduction; purchase of wood in the form of boards or cants might also prove to be more efficient than purchasing in log form. Inventory studies of both raw material and finished goods could possibly reveal several opportunities for cost reduction. Some way might be found to cut shipping costs by using more efficient loading methods, by scheduling, or by systematic analysis of routing. This study, then, only represents a good beginning toward a systematic analysis; those aspects mentioned above and many more should be closely scrutinized if full cost saving and the greatest level of efficiency is to be attained.

Little attention was given to possible product improvement as it was assumed that product designs adequately satisfied the end use requirements and also allowed efficient use of materials. It should be noted that the great majority of pallet and box products are manufactured according to specifications set forth by the purchaser, and the manufacturer can only make suggestions in this respect.

For purposes of this study it was assumed that any increases in the output of pallets, boxes, or building (cabin) materials brought about by increased efficiency could be absorbed readily by the market and without a reduction in selling price. The assumption does not appear to be unrealistic in view of the large and expanding pallet and box market in the Great Lakes Area and considering the estimate by management of the Peter's plant that at least ten times more cabin siding could have been used in the previous year than was produced.

Procurement of additional raw material for possible increased production is seen as no problem since Peter's mill has been assured long-term access to a large timber holding in the mill area.

Chapter II. Method of Study

Before any type of analysis of production problems could be accomplished, it was essential that the present status of the operation, with regard to products manufactured, plant layout, equipment specifications, and materials and waste handling methods, be thoroughly described, measured, and then examined to determine specific shortcomings and areas in which greatest efforts for improvement were warranted. This information was also needed to provide a basis for comparison of any systems subsequently proposed.

Measurements were taken of the entire mill layout; and all room dimensions, window and door locations, and locations of machinery were recorded. Completion of the measurement task was followed by a brief study of production to allow determination of present use of manpower and flow of materials. After more detailed study, process charts were constructed for all operations.

Attention was then focused upon measurement of factors in the actual production process. An attempt was made to use stopwatch techniques for work measurement; but because of the sporadic usage practices employed, it was very difficult to obtain data for any one machine. It was decided that the most practical and reliable method of factors measurement for this situation was work sampling, a technique devised by an Englishman, L.H.C. Tippett. To obtain the samples, a central location was selected from which all work stations could be observed at one time. Observations were made at intervals of one to three minutes, depending on the time required for one observation. Included in one observation was a check of all machines in the plant. A check of the headsaw, for example, was taken as the sweep hand of a stopwatch passed the beginning point of the dial. Succeeding machines in the production line would be observed at ten second intervals. A machine observation delayed to check the reason for a delay of the preceeding machine was made in the next minute at the same sweephand position that it was to have been taken originally. To facilitate the recording of data a work sampling sheet was designed (See Figure 1). After collection, all of these data were converted to percentage figures, showing the portion of time spent performing each activity on each machine.

A study of the headsaw was conducted next, along with an investigation of machine specifications and capacities. Cutting of a number of logs on the headsaw was observed and log diameters, lengths, and cutting times were measured and recorded. These data provided a basis for a daily production estimate and allowed determination of the average log size processed by the mill. By analyzing this "average log," the production estimate was converted from units of board feet to units of numbers of various lumber sizes produced; these units were then converted to actual yield of pallets and boxes produced in a day.

Feed speeds of each machine in the plant were determined by measuring the processing time for pieces of known length. Use of the feed speed data in connection with information pertaining to daily production requirements permitted calculation

Machine ↓ / Activity →	Cutting	Setup	Idle	Inspection	Aid Inspection	Tools Not Avail	Tool Trouble	Tool Handling	Maintenance	Confer with Other Worker	Confer with Foreman	Wait for Job	Remove Waste-Clean Table	Materials to Machine	Turn Log	Materials from Machine	No Operator
Head Saw																	
Edger																	
Cut-Off																	
Slat Saw																	
Re-Saw																	
Planer																	
Edger #2																	
Matcher Moulder																	
Planer #2																	
Cut-Off #2																	

Figure 1. Work Sampling Data Sheet

of the portion of time each machine must work to keep pace with the rate of production on the headsaw. The operations in progress a large portion of the time, which might cause difficulty in the case of increased headsaw production, were located and evaluated.

On the basis of all this information (process charts, work sampling data, feed speed data, and machine capacity calculations) difficulties were assessed and proposals for new systems were drafted. Final comparison of all methods was accomplished using expected production and cost figures.

Chapter III. The Present Operation - Description and Measurement

Raw Materials

A number of species are used in pallet manufacture at the mill, the most common of which are elm, oak, poplar, and aspen. Cabin siding is made from Northern White Cedar.

All wood is purchased in log form, and these range in size from a minimum of six to eight inches in top diameter to a maximum of about twenty-five inches.

Products

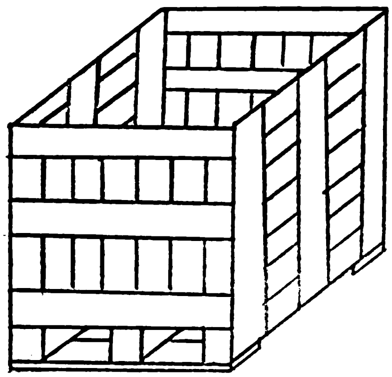
Three basic designs of pallets and boxes are produced in the Peter's mill as well as various sizes and modifications of them (Figure 2). Each of the product designs was described, with the most common sizes being analyzed as to shape and size of component parts; a listing of these elements can be found in Table A. Through such a product examination, it was possible to determine which machinery might be disposed of or replaced by more useful equipment. Shown in Figure 3 are the pallet and box components and the machines on which they are produced. Also shown in Figure 3 is the cabin siding product, which is produced in one width only but in varying lengths.

None of the pallet material is dried prior to final assembly. Cabin siding lumber is air dried after being rough cut on the head saw and prior to the planing and matching operations.

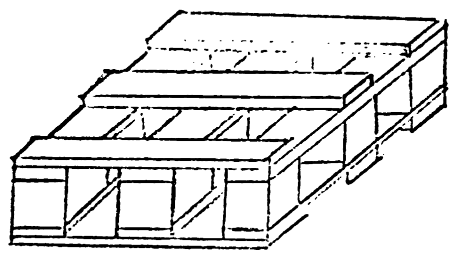
The Mill

The layout of machinery within the mill structure (Figure 4) seems, at first glance, to be one which affords

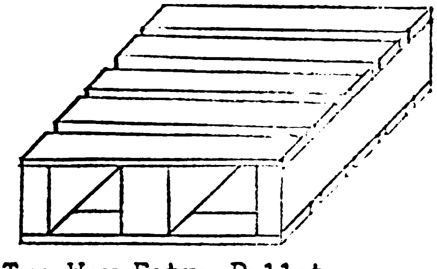
Figure 2. Basic Pallet Designs



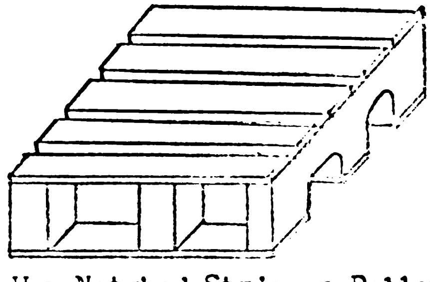
Palletized Crate



Block-Type Pallet



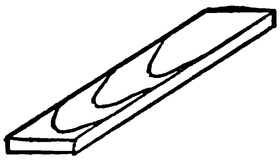
Two-Way Entry Pallet



Four-Way Notched Stringer Pallet

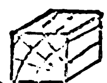
Figure 3

Elements and Machines for Production



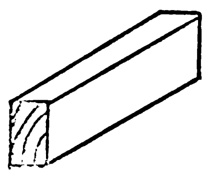
Deckboard:

Head Saw
Edger
Cut Off Saw
Planer
Slat Saw



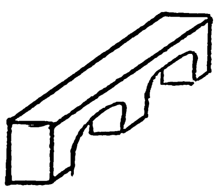
Block:

Head Saw
Cut Off Saw
Resaw
Cut Off Saw #2



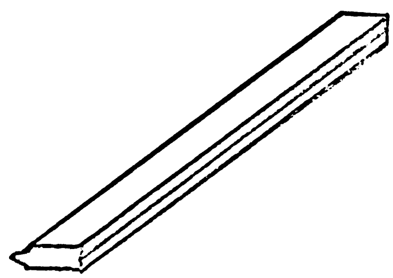
Stringer:

Head Saw
Cut Off Saw
Planer
Resaw



Notched Stringer:

Head Saw
Cut Off Saw
Planer
Resaw
Band Saw



Cabin Siding:

Head Saw
Planer #2
Edger #2
Matcher-Moulder
Cut Off Saw #2

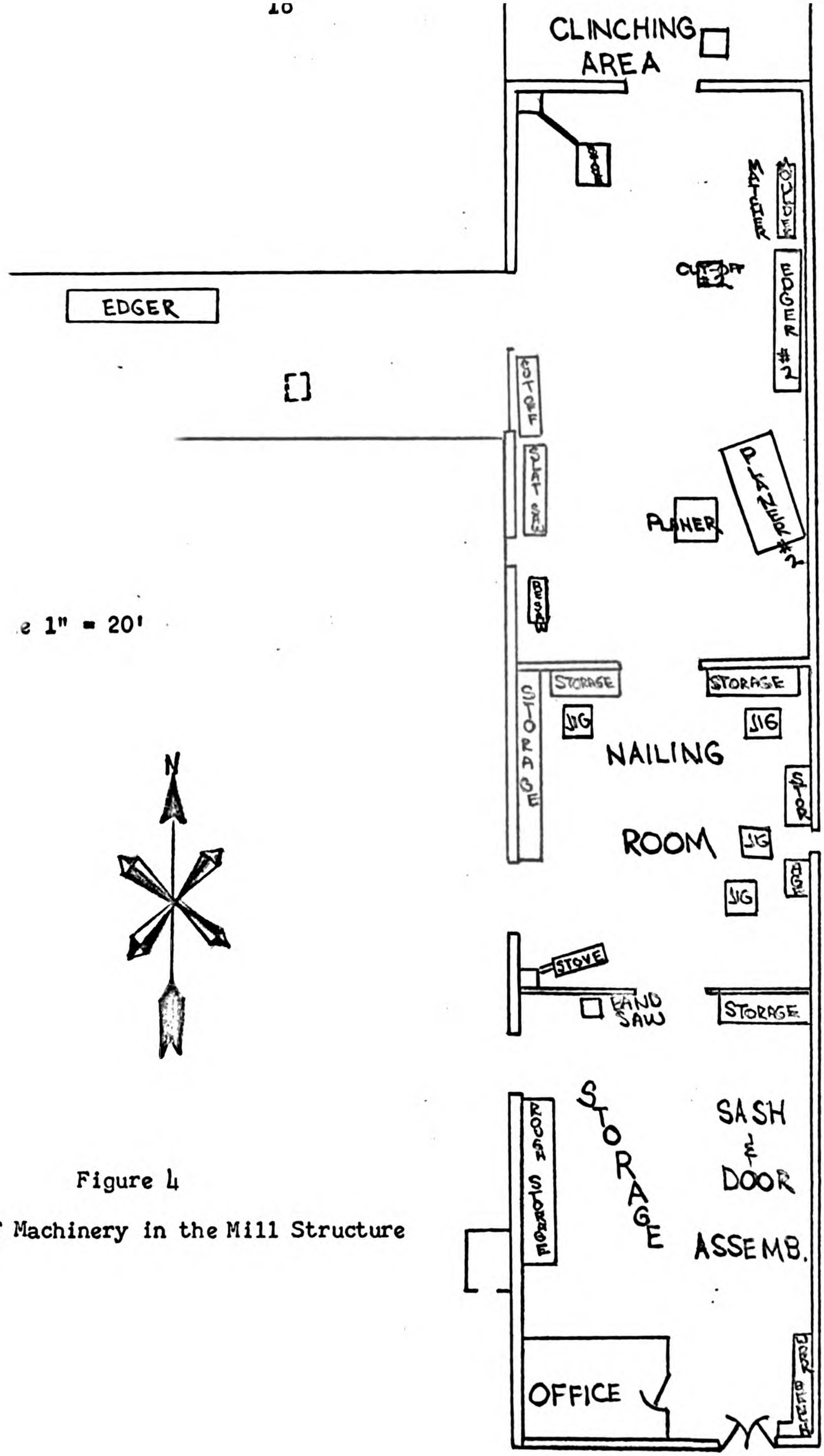


Figure 4

Layout of Machinery in the Mill Structure a rather smooth, efficient flow of materials through the mill. Equipment is apparently arranged so that subsequent steps of production lead material to assembly or shipping areas with minimized transport distances involved. It would also seem that the machining steps needed for most product components (Figure 3) are such that "backtracking"[1] of material is unnecessary, thus eliminating conditions wherein paths of flow might be constricted and flow of materials hampered.

Construction of a flow chart (Figure 5) revealed, however, that shortcomings of the layout did exist, some of which were quite serious. Despite the logical appearance of the machine sequence, a great amount of backtracking of material was noted to occur. For example, production of deckboards might proceed from the headsaw (1), to the edger (2), to the planer (6), to the small cut-off saw (7), and finally to the nailing room. In this case, material would have been transported over seventy feet further than if machinery were arranged so as to remove the need for this backward materials flow.

Observe also the production of notched stringers; the sequence here would be from the head saw (1), to the cut-off saw (3), to the planer (6), to the resaw (5), on to the band saw (11), and then to the nailing room, a materials

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[1] By backtracking the author is referring to the flow of a material back to a point previously passed during the production process.

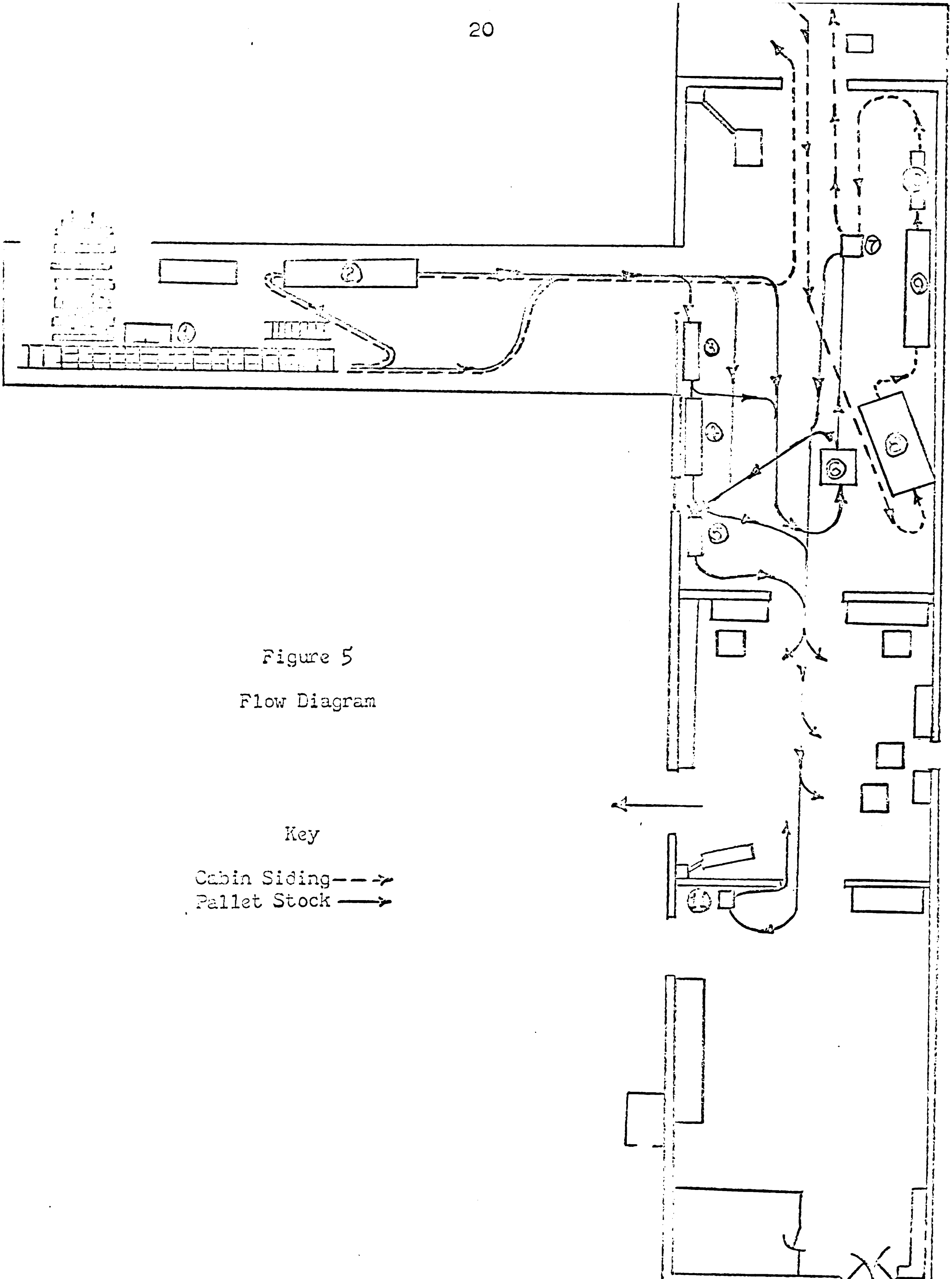


Figure 5

Flow Diagram

Key

Cabin Siding - - ->

Pallet Stock ——>

Use	Actual Size	Other Specifications
Stringers	1½" x 3" x L	Notched or Plain. Lengths to 4'.
Deckboards	3/4 x 2 3/4 x L	Various Lengths to 4'.
Expendible Deckboards	7/16 x 3 x L	" " "
Blocks	3 x 3 x 3½	
Box Siding	3/8 x 4½ x L	Various Lengths to 4'.
Box Stringer Spacers	3/8 x 3 x L	" " "

Table A

Components of the Pallet & Box Products

flow of 225 feet. It is evident that careful planning could greatly improve this situation.

Problems are also associated with production of cabin siding material. While backtracking of material is again part of the problem, the greatest difficulty appears to be in storage of materials near the planer, edger, and matching equipment prior to and during processing by this machinery. Quite often this storage hampers materials flow in pallet and box production; and likewise, flow of pallet and box materials often hampers cabin siding production. A revamped layout would, no doubt, eliminate many problems in this respect.

Methods of Materials Handling

General

Materials handling in the plant is accomplished using a system of carts. Materials to be processed are usually taken from a cart, moved to the work station, and then placed on another cart for movement to the next operation. All lifting and movement of material as well as the movement of carts is done manually.

Log Breakdown and Edging

Logs are brought to the log deck by fork lift truck and then moved to the head saw by hand. All log turning is also accomplished by hand. Material coming from the head-saw, which is in the form of four to ten inch width boards or four inch thick cants, is either stacked next to the edger or loaded directly on carts for movement to other areas of the plant.

Boards to be edged are picked from the pile, processed, and placed on a cart; two men are needed for this operation.

Cut-off and Slat Saw

Log-length cants are brought to the large cut-off saw by cart; they are lifted from the cart onto the saw and then separated by lengths onto other carts after cutting into pallet dimension sizes. This same material often goes next to the slat saw; and here again it is lifted from carts, placed on the saw, and then placed on carts, again according to size. Occasionally, material will be handed directly to the slat saw operator by the cut-off tailer. Two men generally are involved in each operation, although one man sometimes operates the cut-off saw.

Resaw

As with the slat saw operation, bolts of pallet use length are brought to the resaw by cart and lifted onto the saw table by hand. Pieces are cut to correct stringer dimensions and stacked on a cart. This machine is also used to size cut-off scraps for use as blocks in expendible pallets. These scraps, which are cut into three blocks each, are brought to the machine by cart, placed on the saw table, and cut to a 3½" width. As pieces are cut, they are allowed to fall to the floor until a later time when they are picked up by hand and placed on a cart. Only one man is used in each operation.

Second Cut-off Saw

When boards are cut to length on this saw, the operation is the same as for the larger cut-off saw. Manufacture of blocks is accomplished by taking materials from a cart, placing them on the saw table, and then letting them fall into a bin cart after cutting. One man is used for each operation.

Band Saw

Notching of stringers is done by one man who takes pieces from a cart, makes the necessary cuts, and places the finished pieces on a second cart.

Use of Manpower

Seven men, in addition to the foreman, are used in the pallet component portion of the operation. The headsaw, cut-off saw, and slatter saw are each operated by two men. One man is used to operate little-used machines, to perform odd jobs, and to dispose of waste materials. The foreman sometimes operates the resaw or cut-off saw #2. When cabin siding is to be processed, men are shifted from their usual tasks to operate the necessary equipment.

Additional help in production, when needed, is provided by a part of the nailing personnel, with these employees often being called upon to operate the planer or cut-off #2. Notching of stringers on the band saw is done exclusively by nailers; six nailers are employed by the mill.

Waste Disposal Systems

Methods of waste disposal in the plant are shown in Figure 6. Little mechanization is used for this task with waste from most machines being removed periodically by hand; such material is shoveled into a bin cart for transportation out of the mill.

Sawdust is removed from the headrig location by means of an elevated, ribbed, rubber conveyor. This waste is carried about six to ten feet from the mill structure before being dumped on a waste pile. Slabs and edgings are stacked on carts during sawing and are then moved by cart to a large waste pit behind the mill building for burning. Material which is placed in the pit is allowed to collect in the summer, with all burning taking place in the winter months.

A blower system is used to remove sawdust from several pieces of equipment. Large pipes attached to a blower run to the slat saw, the planers, and the second edger (used for cabin siding). The waste is directed out of the mill and allowed to collect in large piles. Sawdust is given away free of charge to anyone who will haul it away, and most of it is taken by local residents.

All other scraps are removed from the mill structure by cart and placed in the pit for burning.

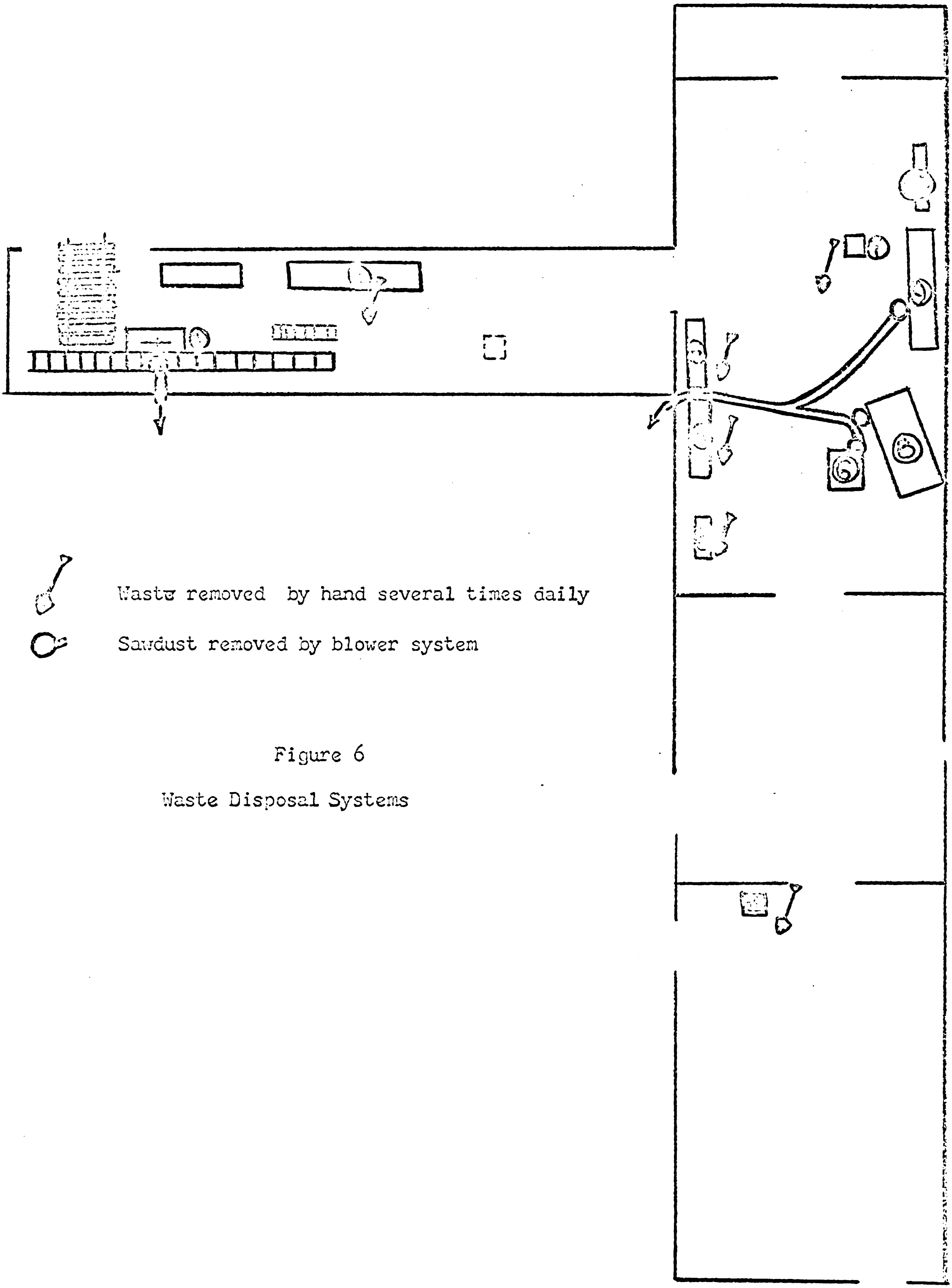


Figure 6

Waste Disposal Systems

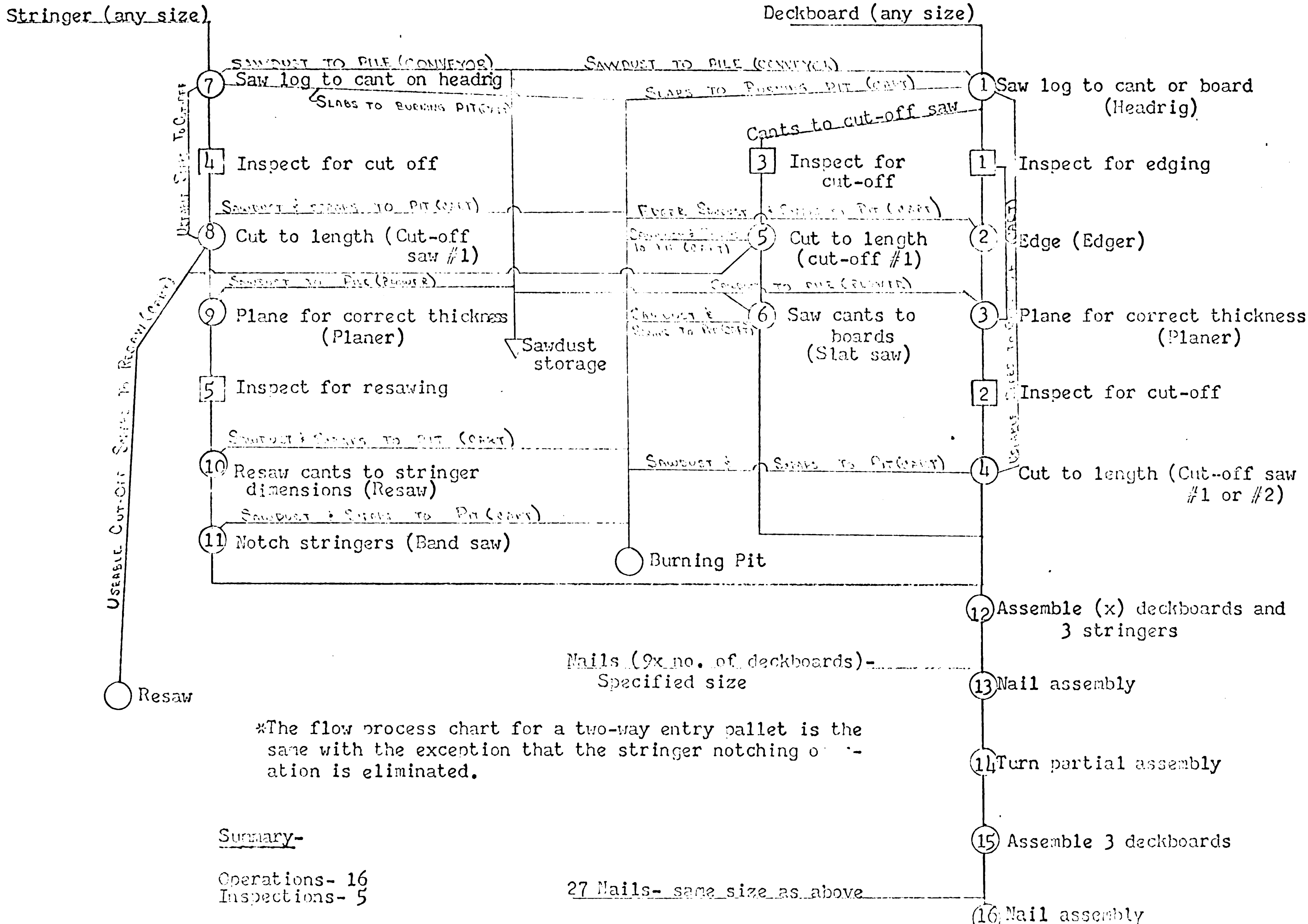
Analysis of the Production Process

Process Charts

In an effort to more clearly show the various operations and their relationships to one another, operation process and flow process charts were constructed. The operation charts are designed to show the relationship of all phases of production for a particular product; detail is necessarily sacrificed in these charts to prevent them from becoming unduly complex and only operations and inspections are shown in them. Operation process charts are shown for production of notched stringer pallets (Figure 7), block type pallets and cabin siding materials (Appendix A). Production of crates is not shown since this process is much the same as for pallet production.

Further detail, where needed, is provided by flow process charts constructed for each product component (Appendix A). These charts show sequences of operations, machines used, methods of materials handling, and transportation distances involved. Also recorded are all storages and delays. Times required for the different phases of the operation are commonly recorded; but since work sampling was used in this study, these times are not available. The charts should be studied with special note made of the summaries at the top of each page; a later comparison of the present and proposed methods will be made using these charts.

Notched Stringer Pallet*



*The flow process chart for a two-way entry pallet is the same with the exception that the stringer notching oper- ation is eliminated.

Summary-

Operations- 16
Inspections- 5

Work Sampling Measurements

Presentation of Data

As described in Chapter II, periodic observations were made of all work stations in an attempt to determine specifically the use of time in an average work day. Sampling was done in a four-day period, in which 750 observations were made.

During the study, data were divided into four time periods, each representing one day (4 - 8 hours) of work sampling. Raw data were converted to percentage figures for all periods, with information being compiled as to the amount of time each machine was attended by an operator (Table B) and then as to the proportion of the attended time given to various tasks (Tables C through G).

Limitations of the Data

When looking at the converted data figures, one might be somewhat surprised at the extreme variations in time usage from day to day. The portion of time spent actually cutting on the headsaw, for example, varies from 20 percent on the first day of observation, to 24.5 percent on the second day, to 36 percent on the third day, and up to 40.5 percent on the fourth day. Differences also were noted to occur between days for other machines and other classifications of time breakdown. It would seem logical to ask, then, why such differences occur.

Table B

Proportion of Time Each Machine Is Attended by an Operator

Machine	% of Time Attended by Operator
Head Saw	79
Edger	7
Cut-Off Saw	43
Slat Saw	63
Re-Saw	15
Planer	21
Edger #2	--*
Matcher-Moulder	--*
Cut-Off Saw #2	23
Planer #2	--*

*No usage noted during study. Equipment is operated only occasionally for short time intervals.

Table C

The first day of Observation

Mach \ Operation	Cutting	Setup	Mach. Idle	Wait-Insp.	Aid Insp.	Tools Not Avail.	Tool Trouble	Confer with Other Worker	Tool Handling	Mainten-ance	Confer with Foreman	Wait for Job	Remove chips Clean Table	Materials to Machine	Turn Log	Mat'ls fr. Mach
Head Saw	20.0		7.5						2.5	30.0	5.0			7.5	17.5	10.0
Edger																
Cut Off	35.7		7.1					7.1					7.1	7.1		35.7
Slat Saw	26.1		4.3							4.3		65.2				
Re Saw																
Planer	60.0		20.0													20.0
Edger #2																
Match-Mould																
Cut-Off #2																
Planer #2																
TOTAL OBSERVATIONS - - - - -												40				

Figures given represent percentage breakdowns of the time each machine is actually attended by an operator.

Table D

The second day of Observation

Mach / Operation	Cutting	Setup	Mach. Idle	Wait-Insp.	Aid Insp.	Tools Not Avail.	Tool Trouble	Confer with Other Worker	Tool Handling	Mainten-ance	Confer with Foreman	Wait for Job	Remove chips Clean Table	Materials to Machine	Turn Log	Mat'ls f. Mach.
Head Saw	24.5		1.0	1.0			2.0	1.0			1.0			30.4	28.4	9.8
Edger													100.0			
Cut Off	14.8	2.5	1.2	28.4	2.5			3.7			4.9		8.6	25.9		7.4
Slat Saw	44.9		1.4							37.7	2.9		2.9	5.8		2.9
Re Saw	23.1			7.7				11.5					7.7	30.8		19.2
Planer	88.9															11.1
Edger #2																
Match-Mould																
Cut-Off #2				28.6									28.6	14.3		28.6
Planer #2																
TOTAL OBSERVATIONS - - - - - 120																

Figures given represent percentage breakdowns of the time each machine is actually attended by an operator.

Table E

The third day of Observation

Mach / Operation	Cutting	Setup	Mach. Idle	Wait-Insp.	Aid Insp.	Tools Not Avail.	Tool Trouble	Confer with Other Worker	Tool Handling	Mainten-ance	Confer with Foreman	Wait for Job	Remove chips Clean Table	Materials to Machine	Turn Log	Mat'ls fr. Mach.
Head Saw	36.0	1.4		1.1			0.4		2.2	7.2	0.7			30.2	13.7	7.2
Edger	31.0	9.5	14.3				7.1	2.4					7.1	28.6		
Cut Off	15.2	2.4	5.6	23.2				1.6			3.2		11.2	19.2		18.4
Slat Saw	52.6	0.4	3.6				0.4	1.6		27.9	2.4		3.2	6.0		2.0
Re Saw	35.2			2.8				8.5					7.0	31.0		15.5
Planer	60.6		13.5	2.2										11.2		12.4
Edger #2																
Match-Mould																
Cut-Off #2	21.8	10.3		19.5							1.1	1.1	1.1	33.3		11.5
Planer #2																
TOTAL OBSERVATIONS - - - - - 400																

Figures given represent percentage breakdowns of the time each machine is actually attended by an operator.

Table E

The fourth day of Observation

Mach \ Operation	Cutting	Setup	Mach. Idle	Wait-Insp.	Aid Insp.	Tools Not Avail.	Tool Trouble	Confer with Other Worker	Tool Handling	Mainten-ance	Confer with Foreman	Wait for Job	Remove chips Clean Table	Materials to Machine	Turn Log	Mat'ls fr. Mach.
Head Saw	40.5	1.2	2.3	2.9					1.2		1.2		0.6	30.6	13.9	5.8
Edger		100.0														
Cut Off	11.3	4.7	2.8	27.8				1.9			4.7		7.5	19.8		18.9
Slat Saw	59.5	2.3	0.8				0.8	0.8		12.2			11.5	4.6		7.6
Re Saw	6.7												26.7	6.7		60.0
Planer	77.2						1.8							7.0		14.0
Edger #2																
Match-Mould																
Cut-Off #2	27.2	2.5	3.7	25.9			1.2				3.7			19.8		16.0
Planer #2																
TOTAL OBSERVATIONS - - - - - 190																

Figures given represent percentage breakdowns of the time each machine is actually attended by an operator.

There are several explanations as to why data were not uniform from day to day. One of these explanations is simply that the work schedule at Peter's is not uniform from day to day, or hour to hour, for that matter. Different products are produced, as well as different sizes of them; and in different portions of a week, a day, or an hour, various component mixes, requiring varying cycle times to produce, are in production.

Another explanation of this lack of uniformity is that production characteristics and rates may vary by the day of the week merely because of the way employees feel. The weather, or an upcoming vacation, or any one of a host of circumstances has an effect on this.

A third explanation might be that the individual collecting information caused inconsistencies in the data. Failure to use the same procedures in data collection from day to day, or lack of accurate recording of observations could affect test results. Another possibility is that the mere presence of an observer caused the work pace to be faster or slower than is normally the case.

The most likely cause or causes of variation can be easily determined by reasoning. In Chapter II, an explanation of the methods used in collecting data was made. All observations were taken from one spot in the plant and spacing of observations was carefully, impartially regulated. A standard form was used on which to record data. In other words, steps were taken to minimize variation which might

Table G

Observation Totals

Operation / Mach	Cutting	Setup	Mach. Idle	Wait-Insp.	Aid Insp.	Tools Not Avail.	Tool Trouble	Confer with Other Worker	Tool Handling	Mainten-ance	Confer with Foreman	Wait for Job	Remove chips Clean Table	Materials to Machine	Turn Log	Mat'ls fr. Mach
Head Saw	34.2	1.0	1.3	1.5			0.5	0.2	1.5	5.4	1.2		0.2	28.8	16.5	7.4
Edger	25.5	9.8	11.8				5.9	2.0					21.6	23.5		
Cut Off	14.7	3.1	3.7	25.2	0.6			2.5			4.0		9.2	20.6		16.6
Slat Saw	52.1	0.8	2.5				0.4	1.1		23.8	1.7	3.2	5.3	5.3		3.6
Re Saw	28.6			3.6				8.0					9.8	27.6		22.3
Planer	68.1		8.1	1.3			0.6							8.8		13.1
Edger #2																
Match-Mould																
Cut-Off #2	23.4	6.3	1.7	22.9			0.6				2.3	0.6	1.7	26.3		14.3
Planer #2																
TOTAL OBSERVATIONS - - - - 750																

Figures given represent percentage breakdowns of the time each machine is actually attended by an operator.

occur merely because of methods used in data collection.

The possibility of observations being affected by the presence of an observer was largely eliminated by the method of tabulating data after collection. While it is possible that the length of a given work cycle might be shortened due to increased effort by the worker, the chances are good that the length of time used to perform each element of the cycle will be reduced a proportional amount. Thus, when elemental times are expressed as a percentage of the total cycle time, the results should be the same regardless of whether the cycle has been performed faster or slower than normal.

The conclusion, therefore, is that variation was caused possibly to a small degree by observation error, to a small degree by routine daily influences, and to a larger degree by actual variation of the work procedure.

Since the work pattern does vary from day to day and since one set of representative figures is needed to describe the operation, it is desirable to use combined figures for the greatest length of observation time possible. In this particular study, for example, it would be unwise to look at the data collected in a single day and attempt to make a statement about production in general. Rather, the averages for all four days should be examined as they are more likely to give an authentic picture of production.

Discussion of Sampling Results

Referring to the observation totals (Table G), a number of interesting facts become immediately apparent. Note that in most instances, the portion of time used in getting materials to or from a machine is about the same as the portion of time used in actual processing by that machine. Notice also the large portion of time used for waste disposal.

In the case of the headsaw, 34.2 percent of the time the machine is attended by an operator is spent in cutting, while 28.8 percent is spent in transporting logs to the log deck or rolling logs along the deck to the saw carriage. Additional time is used in manually turning the log or in removing materials from the carriage. In total, over 52 percent of the attended time of the saw is spent in materials handling alone. Little time is needed (0.2 percent) to remove sawdust from the saw area because of the waste conveyor which carries dust outside the mill from the saw pit.

The edger, with no automated waste removal system, is tied up 21.6 percent of the attended time because of waste removal work. The amount of time spent in getting materials to the machine is again quite high.

With the re-saw and both cut-off machines, time spent in unstacking and stacking carts, before and after the operation, takes well over twice as much time as the actual production process. Times required for waste removal are substantial, especially for the cut-off saws.

The slat saw setup, which is one of the most efficient of the operations, permits cutting to take place over 52 percent of the attended time. The big problem here seems to be in down time for maintenance as 23.8 percent of the time is spent in this way.

More than 68 percent of the time is spent in actual processing with the planer. Waste removal is no problem and setup time is negligible. Here again, however, almost 20 percent of the attended time is spent in materials handling.

Feed Speeds and Other Stopwatch Data

Daily Production Estimation

The use of work sampling data made it possible to locate excessive delays, inefficient and sometime unnecessary operations, and other problem areas. The ultimate test of a production method, however, is not in the number or length of delays, in the number of operations, or in the length of transportation distances involved; this information is only used to locate areas for improvement. The value of a particular production method, and its advantages or disadvantages in relation to another method, are determined by the output of finished product each system can generate at a given cost. Thus, comparison of systems on the basis of production is essential.

In order to obtain a basis for a realistic estimate of daily production, the headsaw operation was closely observed for approximately a one-hour period. During this time, each log diameter, length, and cutting time were measured and recorded (Table H). The volume of lumber yield was estimated using the International $\frac{1}{4}$ inch log rule.

Using figures from Table H, computation of daily production was done in the following manner:

$$\text{Production} = \frac{450}{64.26} \times .79 \times .80 \times 1203 = 5324 \text{ board feet/day}$$

Where,

450 is the number of working minutes in an eight hour day. (Two 15 minute rest periods are allowed.)

.79 is the portion of time the headsaw is attended by an operator (Table B).

.80 is the portion of attended time devoted to the process of moving a log to the carriage, cutting, turning the log, and removing the dog board. Normal delays are also included in this figure. Since time used in saw maintenance, or in bringing logs to the deck by fork lift truck was not included in the headsaw study, this portion of time was removed from the calculations.

Once production has been determined in terms of board feet, it is then necessary to find some way of expressing this figure in terms of units of finished product; in this case, pallets, boxes, and cabin siding. To do this, the data given in Table H were first rearranged to show the average times used in cutting up logs of various sizes (Table I). The average log size was computed and then a theoretical lumber yield was determined for the rough sawn log. Then, by knowing the time required to cut up this size of log, the number of logs which could be processed in one day was figured, and this was multiplied by the lumber yield per log to give the rough lumber yield per day. Once in this form it was an easy task to convert daily yield to a pallet per day figure.

Note that in all component production processes, the headsaw is the first machine in the sequence (Figure 3); thus, the output rate of each process is dependent on the production rate of this single machine. It has been estimated that the production rate averages over five thousand feet per day. In Table K, the average log diameter handled by the mill is shown to be 13.7 inches, or 14 inches if rounded to the nearest whole inch. The average cutting time for this size log is a little over four minutes (Table I) using the mill equipment.

Assuming now, for the purpose of simplicity, that only logs of 14" diameter are handled by the mill, then $\frac{450}{4} \times .79 \times .80 = 71$ logs could be cut up in an eight hour day. With an average volume of 74.7 board feet per log, $71 \times 74.7 = 5304$ board feet of lumber would be produced daily. This figure is somewhat less than the daily production figure derived earlier but is sufficiently close to it for illustrative purposes.

Continuing the illustration, the 14" average size log is considered to yield two cants, 4½" x 9" x 9.3', six boards, 8" x 3/8" x 9.3', and one board, 8" x 1" x 9.3' (See Figure 8). One-fourth cant per log (or about 10% of the volume) is considered lost to defect so that the actual number of cants produced per log is 1 3/4. The board foot yield per cut up log is 74.9.

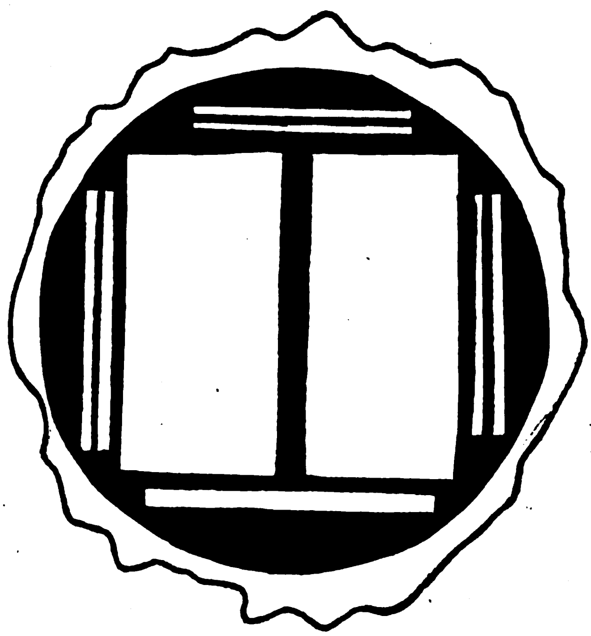


Figure 8

Breakdown of the Standard 14" Log

Table H

Log Breakdown on the Headsaw

Log	(") Diameter	(') Length	(minutes) Sawing Time	(bd. feet) Log Volume*
1	13	10	3.40	70
2	20	12	9.76	210
3	13	10	4.61	70
4	12	9	2.84	50
5	13	9	4.74	62
6	11	8	2.20	35
7	14	9	4.71	72
8	12	10	2.65	55
9	14	9	4.40	72
10	15	11	5.80	105
11	18	12	6.21	170
12	11	9	2.80	40
13	13	9	3.84	62
14	13	10	2.90	70
15	14	10	3.40	80
	206	150	64.26	1203
	$\bar{X}$ = 13.7	10.0		80.2

*Volume by International $\frac{1}{4}$ inch scale.

Table I

Headsaw Cutting Times for Various Log Diameters

Number of Observations	Log Diameter (inches)	Sawing Time* (minutes)
2	11	2.50
2	12	2.75
5	13	3.90
3	14	4.17
1	15	5.80
-	16	--
-	17	--
1	18	6.21
-	19	--
1	20	9.76

*Sawing time as used in this sense includes the activities of moving the log to the carriage, sawing, turning the log, removing the dog board, and returning the carriage to its original position.

The yield per day can then be expressed as follows:

71 logs/day x 6 boards/log	= 426- 8" x 3/8" x 9.3' boards/day
71 logs/day x 1 board /log	= 71- 8" x 1" x 9.3' boards/day
71 logs/day x 1 3/4 cants/log	= 125- 4½" x 9" x 9.3' cants /day

These figures were converted to show the actual yield of units of finished product. One-half of the volume of 3/4" boards (220 board feet) and one-half of the volume of 3/8" boards (490 board feet) as well as 145 board feet of cants was assumed used for palletized crate production. With an average board foot requirement for each box of 30 (including a 25% adjustment for waste) then $\frac{220 + 490 + 145}{30} =$ 28 boxes, could be constructed each day. At a selling price of \$5.22, daily sales of this product would amount to \$146.

Similarly, yield of block-type expendable pallets (26" x 26") was computed. One-half of the volume of the remaining cants (1874 board feet) and the other half of the 3/8" boards (490 board feet) were considered to go into production of expendable pallets. The volume of wood needed to make each pallet is 6.9 while the actual volume per nailed-up pallet is 5.2 board feet. The number of pallets which can be produced per day is $\frac{1874 + 490}{6.9} = 343$. With a sales price of \$0.13 per board foot, daily sales of this product would be 343 x 5.2 x 0.13 = \$232.

Daily production of notched stringer pallets was also computed. All of the remaining cants (1874 board feet) and the other one-half of the 3/4" boards (220 board feet) are used for this product. A volume of 15.2 board feet is needed for each pallet and the actual nailed-up volume is 12.3 board feet. The number of pallets which can be produced per day is $\frac{1874 + 220}{15.2} = 138$. With a sales price of \$0.13 per board foot, daily sales of this product would be 138 x 12.3 x 0.13 = \$221.

Total daily sales is thus \$599 (146 + 232 + 221). This total is somewhat larger than actual mill sales; but because cutting of cedar logs was not considered in the calculations, some degree of error was expected. In the actual operation, cedar comprises about one of every five or six logs cut; most of these logs are used in cabin construction and do not enter directly into the daily sales figures.

Machine Capacity Evaluation

To assess the degree to which all other machines must be utilized to keep up with this production rate, it was first necessary to determine feed speeds for each piece of equipment. Since no records were available as to the factory specifications for each machine, it was necessary to obtain this information from stop watch data. The average time required to pass an appropriate form of raw material, of known length, through a given machine was recorded (Table J). The machine speed was then computed by the formula,

$$S = \frac{L}{12T}$$

Table J

Feed Speeds for Machines Used in Pallet and Box Production

Machine	Length of Piece (inches)	Time Required for Each Pass (min.)	Feed Speed (feet/min.)	Average Passes to Process One Piece	Production Rate (pieces/minute)
Edger	110	.064	143.0	1	15.9
Slat Saw	36	.078	38.5	14(3/8" stock)	0.9
				9(3/4" stock)	1.4
Resaw	36	.059	51.0	3	5.7
Planer	96	.190	42.0	1	5.3
*Cut-Off	110(4" thick)	.980	—	1	1.0
*Cut-Off #2	3(block)	.134	—	1	7.5
*Band Saw	—	.333	—	1	3.0

*Since figures expressed in feet per minute are somewhat meaningless for these machines and the operations performed by them, feed speed data has been ommitted. In the case of the band saw, the length of the piece being processed is irrelevant since two cuts of the same size are made no matter what the stringer length.

where,

S = feed speed in feet per minute
L = length of the piece in inches
T = average time required to process one piece in the machine under study (minutes)

Evaluation of each machine was then done in the following manner:

Edger

Of the 497 boards being produced per day on the head-saw, about two-thirds of them, or 331, must go through the edger. The production rate for this machine (Table J) is 15.9 pieces per minute; therefore, the time needed to process these 331 boards is $\frac{331}{15.9} = 20.8$ minutes. The portion of time needed for processing is then given by $\frac{20.8}{450} = .046$. The edger operates only 4.6% of the time; increased production would cause no problem with this machine.

Planer

All 497 boards must be processed on the planer, but with a production rate of 5.3 pieces per minute, processing could be completed in 94 minutes. Also, 20 cants must be processed, this operation requiring only four minutes. The planer operates only 22 percent of the time and would be no problem if production were increased.

Cut-Off Saw

On cut-off saw #1, all 124 cants must be cut into three 36" bolts requiring four cuts per cant. At one minute per cant, this process could be completed in 124 minutes.

Also, all 497 boards produced per day must be cut to length. Brief observation revealed that several such boards may be cut at one time so that processing is done at a rate of about three boards per minute. The time required for processing here is 165 minutes. The total portion of time needed for production by this machine is $\frac{289}{450} = 64\%$. Some problem might develop here if a higher production rate were effected.

Slat Saw

One hundred and eighty bolts must be cut into 3/8" material per day. With a capacity of 0.9 cants per minute, processing time for this number of bolts would be $\frac{180}{.9} = 200$ minutes. One hundred and forty-one cants must be cut into 3/4" material per day. The capacity for cutting in this case is 1.4 cants per minute; 101 minutes would be needed for the processing of these bolts. Thus, 301 minutes per day are needed for processing by the slat saw. This means that the machine is needed in production $\frac{301}{450} = 67\%$ of the time; since down time for this machine is considerable, it might present a problem should production be increased.

Re-Saw

On this saw 51 cants must be cut into stringer material. With a production rate of 5.7 cants per minute, only 8.9 minutes would be needed to perform this operation. Also, end trimmings from cants must be sized into blocks. About ten such end trimmings may be sized per minute. Each trimming contains about three blocks; and with 3087 blocks needed per day, approximately 100 minutes would be needed to complete this job. Thus, the machine would be needed in production 109 minutes for a percentage of 24 percent. This machine presents no problem in connection with increased production.

Band Saw

On the band saw 414 stringers must be notched daily. With a processing rate of three pieces per minute, the task would require 138 minutes. Production time would thus occupy 31 percent of the work day. Increased production would cause no difficulty with this machine.

Cut-Off Saw #2

On this saw, all 3,087 blocks must be cut to length. With a production rate of 7.5 per minute, 411 minutes, or 91 percent of the time would be required for processing. Increased production would inevitably cause trouble with this machine.

Summary of Problems Associated with the Present System

Analysis of the operation has revealed the existence of a number of problems, most of which have been heretofore mentioned. Work sampling data showed that a large portion of time was used in materials handling and in waste disposal. It was concluded that reduction of the time needed for these activities would make available additional man-hours for performing more productive tasks.

From stopwatch data, it was determined that the head-saw was the machine limiting increased production; speedup of the log breakdown cycle could be accommodated to some degree by all other machines in the plant. The cut-off and slat saws were noted to be the most likely machines to cause difficulty in the case of increased production.

An excessive number of delays and excessive transport distances were found using process charts. Elimination of these problems should smooth the production process and possibly decrease production costs.

Another problem, not previously mentioned, is that the cart system now in use causes considerable plant congestion. Often, the movement of one particular cart to a new location involves the movement of not only that one cart, but five or six carts; an even flow of materials is prevented and a large usage of time is involved.

Still another problem is that employees are shifted from one operation to another in the course of a day or of a week. Because of this, certain personnel are unable to become as efficient at a given task as they might if allowed to work continuously at it. By reducing shifts to a minimum, overall efficiency might be increased.

Chapter IV. Proposals and Suggestions

General

One of the major considerations in formulating a revised layout plan is the cost of making improvements. Before any improvement may be made, the money for it must be procured; after the improvement is made, it must improve efficiency, lower per unit costs, improve safety conditions, or in some way have an effect on production such that this improvement "pays for itself" in a given number of years.

Money is sometimes difficult to obtain for improvement of a small business and generally, the more the money needed, the more difficulty there is in getting it. Therefore, in formulating a plan for a revised layout, an attempt was made to allow improvements to be made over a period of several years, rather than all at one time. A graduated improvement plan of this kind permits the financier to gauge the effect of improvements before committing extremely large amounts of capital; such a plan also allows the investor to pay for changes in his business as they occur, rather than assuming a large, long-term debt.

It was further realized, while planning layout revisions, that the total investment, whether graduated or not, must be relatively small. The reason for this is that the annual sales figure for the plant is relatively small, and unless improvements generate a huge increase in production potential, the expense to sales ratio would be intolerable with a large investment.

Proposed Layout #1 - The Modified Cart System

Increasing Production Potential

Since all machines are presently able to keep pace with the headsaw production rate, the first step in increasing production is to increase the productivity of the headsaw itself. Perhaps the most convenient method of increasing production at the headsaw is to find some way of reducing the duties of the headsaw personnel, so that they may spend 100 percent, rather than 79 percent of the time at the headrig. By so doing, 95 minutes (1½ hours) can be added to the headsaw production time in each eight-hour day.

The portion of attended time devoted to the process of moving a log to the carriage, cutting, turning the log, and removing the dog board is considered to be .80.[1] Thus, the gain in production, due to an increase in the attended time of the headsaw can be computed by:

$$\frac{95 \text{ minutes x .80}}{4 \text{ minutes to cut up an "average" log}} = 19 \text{ average logs.}$$

With 74.9 board feet per "average" log, this means that daily production is increased 1423 board feet merely because of the change made in manpower usage.

Assuming that the 21 percent of each day, used by both the sawyer and saw tailer in doing something other than operating the headrig, was used in performing other necessary tasks, provision must be made for additional manpower to

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[1]It was assumed that the portion of time used in all phases of time breakdown will remain constant with increased headsaw usage. The .80 figure was used in evaluating production with the present mill setup (Page 40).

perform these tasks. For the moment, it will merely be noted that 2 x 21 or 42 percent of a man-day is needed for these other jobs, with an analysis of this to be done later (page 69).

Further increases in headsaw productivity can be brought about by installation of an automated log deck. In total, effort being spent in getting logs to the saw in the present operation amounts to 28.8 percent of the total time the headsaw is attended by an operator. About 10 percent of the total attended time (about 1/3 of this 28.8 percent figure) is used in rolling logs along the deck to the saw carriage and positioning the log prior to cutting. Through the use of the automated deck, this 10 percent figure is expected to be reduced to about 3 percent.[1] Therefore, 7 percent of the total attended time (which is now 100 percent of a work day) has been changed from non-productive, to potentially productive time. Added daily production in this case is

$$\frac{(.07) \times (450 \text{ minutes/work day}) \times .80}{4} = 6 \text{ average logs.}$$

The added board footage of production here is 449, for a total added production of 1922 board feet per day.

As before, to allow evaluation of other machines in the production sequence and to allow production to be expressed in terms of actual units of finished product manufactured in a day, production was defined in terms of actual board yield:

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[1]While time-consuming hand rolling of logs can be completely eliminated, positioning of logs on the saw carriage and setting of the dogs must still be done.

96 logs/day x 6 boards/log = 576-8" x 3/8" x 9.3' boards/log

96 logs/day x 1 board /log = 96-8" x 1 " x 9.3' boards/log

96 logs/day x 1 3/4 cants/log = 168-4½" x 9 " x 9.3' boards/log

Using the same procedure as was used in evaluation of the present operation (Page 45), daily board yield figures were converted to show the actual yield of units of finished product. Again, it was assumed that one-half of the volume of the 3/4" boards (298 board feet) and one-half of the volume of the 3/8" boards (662 board feet) were used for box manufacture. Also, 190 board feet of cants was assumed used for the manufacture of this product.

Allowed for production of expendable pallets was the remaining one-half of the 3/8" boards (662 board feet) and one-half of the remaining cants (2543 board feet).

Production of notched stringer pallets was again considered to require all of the remaining cants (2543 board feet) and the other one-half of the 3/4" boards (298 board feet).

Output of boxes, expendable pallets, and notched stringer pallets is then increased to 38, 464, and 187 units respectively. Using the same selling price as in the previous calculations, the total daily sales figure becomes $811 (198 + 314 + 299), or $212 more than it is at present.

Machine Capacity Evaluation

Machine Use Calculations

To determine if this production rate is feasible, a check of all other machinery was necessary to see if they could keep up with the production rate maintained at the headrig. The same method of evaluation as was used previously is used here, but the results have been condensed into table form for brevity (Table K).

Evaluation of Cut-Off Saw #2

To determine where specific improvements might be made in the block cutting operation, reference is again made to Table G. Of the total attended time of cut-off saw #2, 23.4 percent is used in cutting, 22.9 percent for inspection prior to cutting, 26.3 percent in getting materials to the machine, and 14.3 percent for moving these materials from the machine. Another 1.7 percent of the total attended time is used in removing waste materials from the work site, and 6.3 percent is used in set-up operations.

Inspection of materials prior to cutting is needed so that (1) the smooth side of the piece to be cut is aligned with the guide block, and (2) the block is positioned so as to be cut to correct dimensions; the majority of inspection time is used to accomplish the latter objective. By conspicuously marking the point on the sawtable to which materials must be moved for cutting to correct size, the inspection time is expected to be reduced at least 10 percent. The operator must no longer spend time in each cycle searching for a faint cut-off line, nor must he try to estimate the cut-off point for each block.

Involved in the "materials to machine" classification is the movement of partially cut pieces to the cut-off saw

Table K

Machine	Pieces to be Processed Per Day	Production Rate (pieces/minute)	Percent of Machine Use
Edger	384	15.9	5.4
Planer	576	5.3	24.2
Cut-off Saw	168 Cants 576 Boards	1.0 3.0	80.0
Slat Saw	243 Cants to 3/8" 195 Cants to 3/4"	0.9 1.4	90.9
Re-Saw	66 Cants 4176 Blocks	5.7 30.0	33.5
Band Saw	561	3.0	41.6
Cut-off #2	4176 Blocks	7.5	123.8*

*This machine cannot keep up with the production rate of the headrig. An investigation is needed to see if productivity of the machine can be increased; if not, a third cut-off saw is needed.

table. To perform this task, the saw operator must turn to his left, grasp a partially cut piece, and then move it to the saw table while turning back to the right. While using the cart transportation system, this motion sequence can be little improved as the movement from cart to saw table is necessary no matter what the work station layout.

The time used for movement of materials from the machine can be almost entirely eliminated. Pieces are merely pushed off the saw table into a bin cart after cutting, with little time used in doing this; however, after the bin cart has been filled, the cut-off saw operator must move it to the nailing room and then locate a cart for replacement, an operation which requires about 14 percent of his time. This situation can be corrected by having two bin carts available at the cut-off saw at all times. The resaw operator will then be responsible for movement of blocks to the nailing room.

The resaw operator is also to have the responsibility of moving pieces from the resaw to cut-off #2. This will remove most of the 6.3 percent of the attended time used for setup of the cut-off operation. Further, the 1.7 percent of the attended time used in waste disposal will be completely eliminated through use of the automated waste disposal system.

Therefore, by correcting inefficiencies in certain aspects of the block cutting operation, the cycle time for the operation has been reduced 32.3 percent, allowing all block cutting to be done without purchasing another cut-off saw.

Changes in the Mill Layout

The layout for this proposal is shown in Figure 9. In this setup, the headsaw, saw carriage track, nailing room, and all heaters remain in the same position as in the original layout (Figure 4); the positions of the edger, cut-off saw, and slat saw are changed only slightly.

An extended, automated log deck is to replace the present setup and a pole-supported roof is to cover the portion of it protruding beyond the existing building. A slightly larger deck will allow more logs to be kept on hand at all times, thus simplifying to some degree the job of maintaining an adequate supply of logs on the deck.

Perhaps most noticeable of the recommended changes is the movement of the office to a different location in the mill structure. This move permits a distinct separation of machinery used in building component production and machinery used in pallet component manufacture. Supervision of both phases of the operation is made easier; and plant congestion, due to attempted concurrent operation of cabin siding and pallet component production lines, is reduced considerably.

Note that the planer has been moved to a position directly behind the edger. This re-positioning allows the

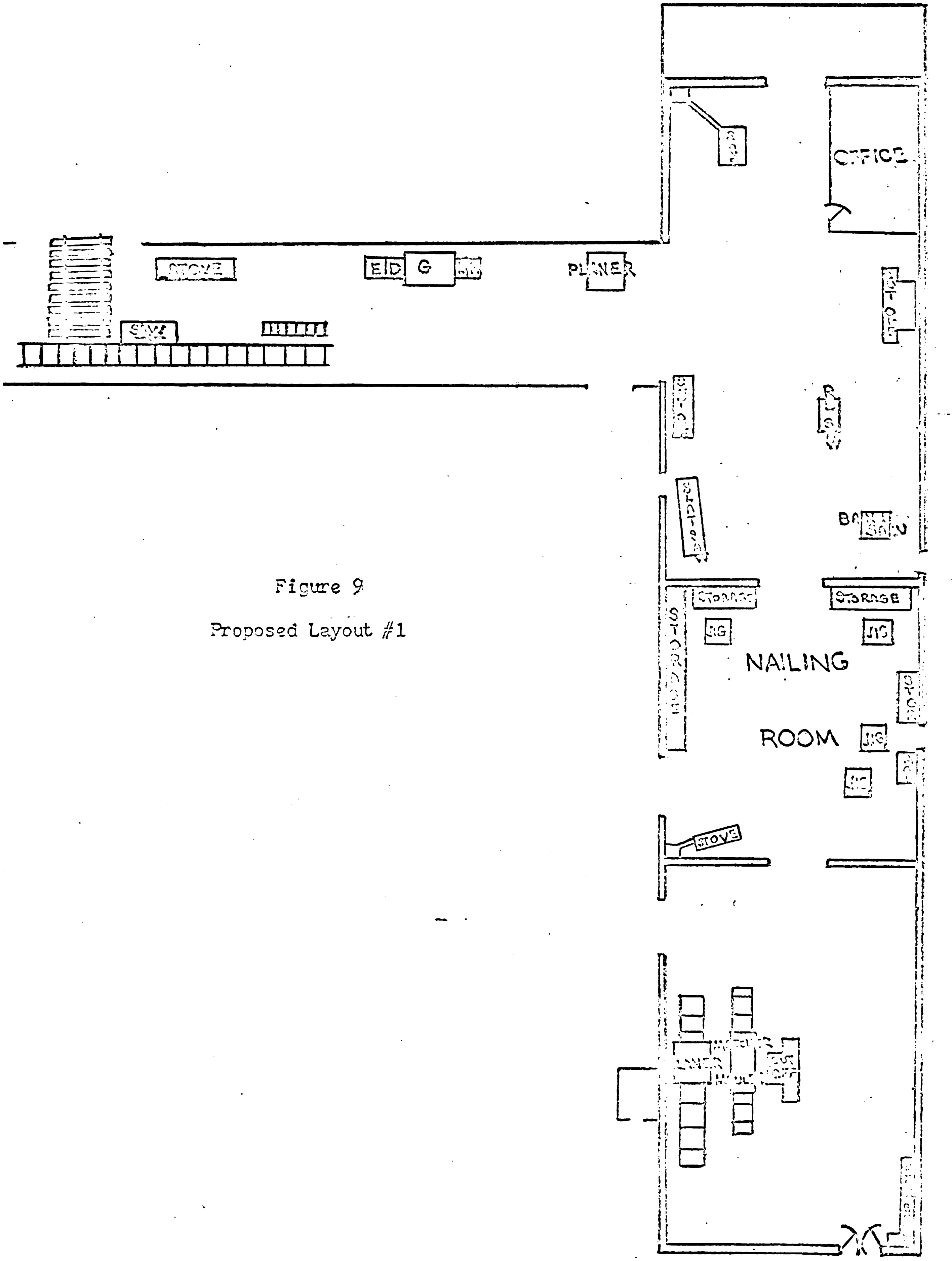


Figure 9

Proposed Layout #1

edging and planing processes to be done simultaneously using three men. Stacking of material after edging is eliminated (except in the case of cabin siding material). The superior feed speed capacity of the edger is largely offset by the fact that two or three boards may be passed through the planer at one time.

The band saw was moved from the sash and door assembly area to the pallet component production room. The obvious advantage here is that machinery is more tightly grouped and transport distances are reduced.

In moving the cabin siding production line to a new location, edger #2 was eliminated from the machine sequence, with all edging to be done henceforth on edger #1. Performing all edging on this one machine should cause no undue burden, even in the case of increased production, as edger #1 is used only seven percent of the time at present. Added to the siding production equipment is a new cut-off saw, made necessary by the change in location. Installation of an eighteen-foot door in the side of the headsaw wing is suggested for removal of cabin siding material from the plant.

No addition to the nailing room is planned, as it is felt the increased volume can be handled in the existing facilities.

Methods of Materials Handling

Transportation Equipment

All equipment currently owned by the mill, which is used for materials handling, is to be utilized in the new system. The fork lift truck, presently in use, is adequate for movement of material in the yard, and within plant transportation can be handled entirely by the existing supply of carts.

Log Breakdown and Edging

Shown in Figure 10 is a flow chart for the new layout. Logs are brought to the log deck using the fork lift truck and then logs are moved to the carriage by the live deck mechanism. After cutting on the headsaw (1), material is separated into boards of various sizes, cedar boards for siding, and cants and is piled onto carts. All boards (including pallet material and cedar stock) are passed through the edger (2). Cedar siding is stacked on carts following this operation while pallet stock is fed directly through the planer (3) and then stacked.

Planer

As mentioned, boards are passed through the planer following edging and are then stacked on carts according to size. The planer is also used to size cants and this material is moved to the edger by cart, lifted onto the machine, processed, and stacked again on a cart.

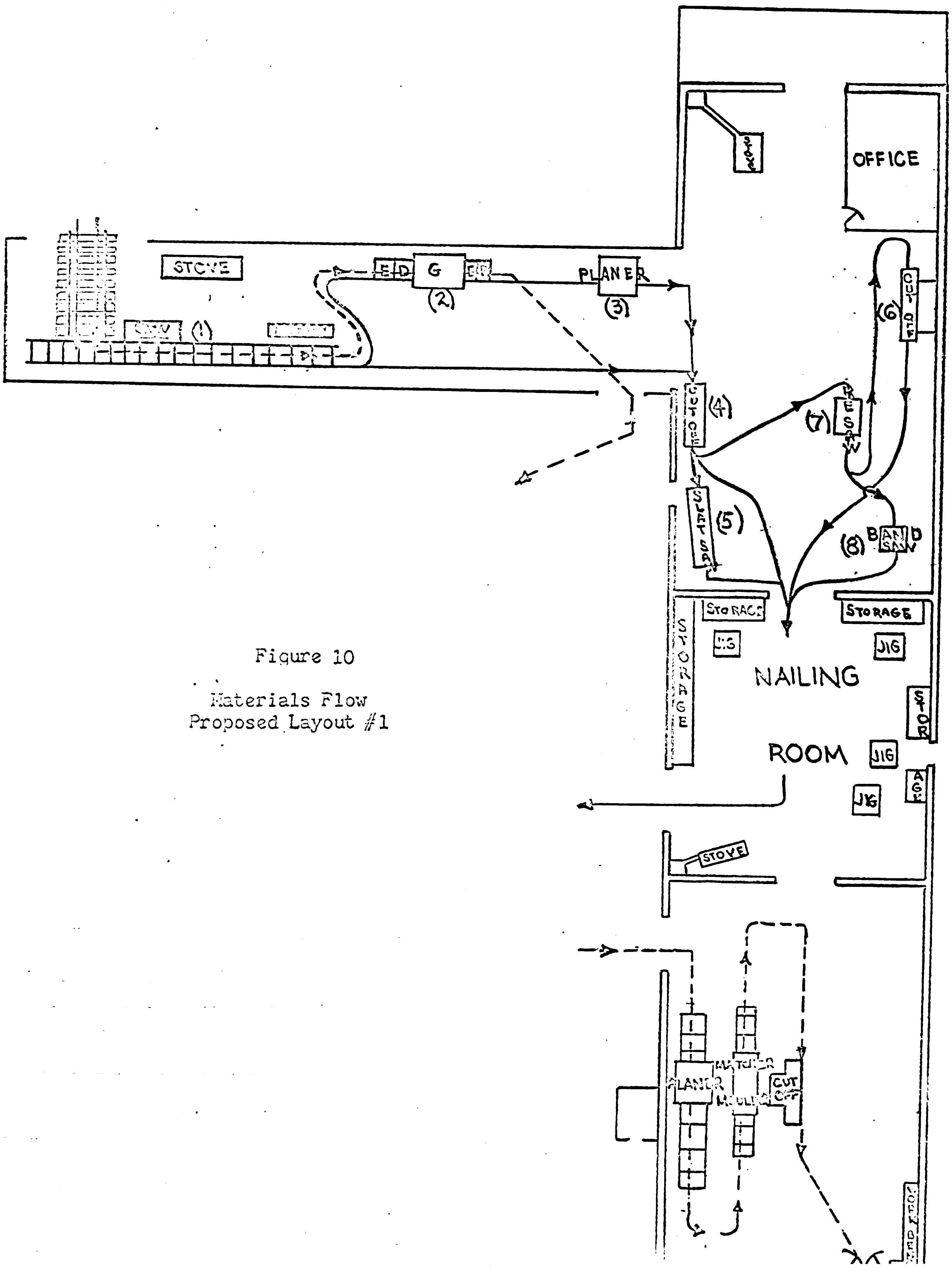


Figure 10

Materials Flow
Proposed Layout #1

Cut-Off Saw #1 and Slat Saw

In the cut-off saw operation, boards are cut to length, stacked on carts, and then moved to the nailing room. Cants are cut to bolts of various lengths and then stacked on carts according to size. After the cut-off operation, most cants go to the slat saw (5); stringer material is moved to the resaw (7). On the slat saw, bolts are cut into boards and then stacked on carts and moved to the nailing room.

Resaw and Band Saw

Bolts to be made into stringers are transported by cart from cut-off #1 to the resaw where they are taken from the cart, cut to boards of correct width, and then piled on carts. Movement is then to the nailing room or to the bandsaw if stringers are to be notched.

Cut-Off Saw #2

To this saw goes all cut off scraps and other material to be made into pallet blocks. Material is taken from a cart, cut to size, and dropped in a bin before movement to the nailing room.

Cabin Siding Production Equipment

Cabin siding material, after passing through the edger, is transported by cart out the opening to the rear of the headsaw, and taken to the yard for drying. When dry, several months later, the cedar is processed using three men (Figure

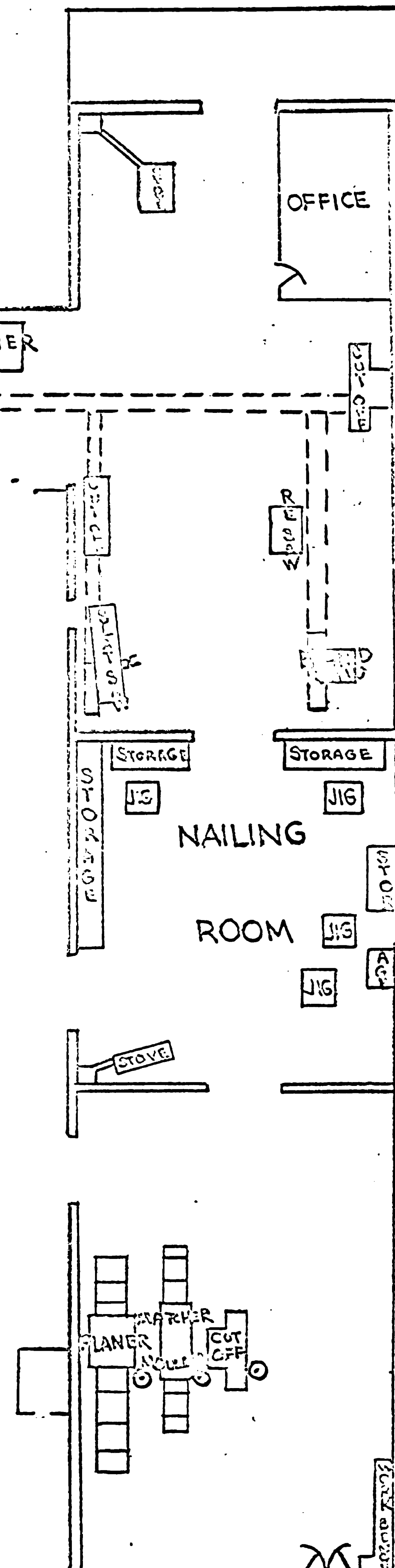
10) and the finished product is moved out of the mill through the south door of the room.

Waste Disposal Systems

The new waste disposal system is shown in Figure 11. In this plan, disposal of waste is accomplished using two blower systems (one of which is already installed in the mill) and a conveyor system.

Some movement of the existing blower equipment will be necessary to handle sawdust coming from the planer, resaw and slat saw, and about 120 feet of conducting pipe must be added to the system. Pipes will go to each of the machines listed, with sawdust being picked up and carried to the west end of the headsaw wing of the building where it is dumped onto the conveyor. To allow an option as to the use of the sawdust, the last section of pipe is to be movable so that sawdust may be directed into a pile or a container, rather than being sent to the waste burner.

The conveyor system is to consist of a two and one-half foot width by three foot depth trough equipped with a two foot wide, smooth, endless, rubber conveyor at the bottom. This conveyor runs to all machines with the exception of the planer and carries trimmings, sawdust, edgings, and the like to a new burner located at the west end of the mill structure; the conveyor is elevated after leaving the mill to a height of ten feet before waste is dropped into a waste burner. Conveyor used on the elevated



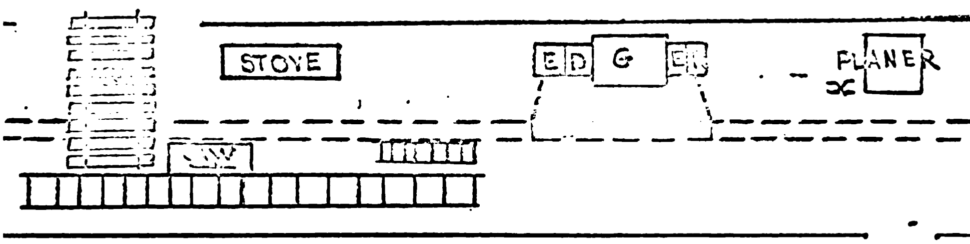


Figure 11

Waste Disposal
Proposed Layout #1

Key

- - - - - Rubber Conveyor below floor level (Covered)
_ _ _ _ _ Rubber Conveyor (Uncovered)
⟗ Blower Takeoff for Sawdust
⊙ Blower Takeoff for Sawdust and Shavings (Cedar)

section is to be ribbed. The majority of the conveyor length within the plant is to be covered by movable concrete slabs, but provision is made for some open areas to allow placing of scraps on it. The open areas around the edger, cut-off saw, and slat saw will be fenced for safety.

Since there is presently some demand for cedar shavings for various uses, it is recommended that possibilities for marketing of mill waste be investigated by the management. Should it happen that an outlet for this material does exist, then it should be collected in a concentration area where it can be packaged for shipment. If no market exists, then some method of disposing of these shavings is needed. In either case, the most efficient means of disposal seems to be one involving the use of a blower takeoff system. Shavings could be picked up from the machine and transported by pipe to a small shed or bin outside of the mill; bagging, if desired, could be done here or, if the scraps were to be burned, they could be taken by bin cart or palletized bin to the burner. Because of the small production volume and small amount of other forms of waste involved with cabin siding manufacture, this material is to be removed by hand.

Manpower Usage

Eight men (not including the foreman) are used in pallet component production with the new system; this is one more man than is needed in the present operation. Two men are needed to operate the headsaw, cut-off saw #1, and the slatter saw. One man will be used to run the band saw; one man will operate cut-off saw #2; and the foreman will operate the resaw.

Processing on the edger and the planer is handled by the operators of cut-off saw #1 and the band saw operator. Each of these men has at least 20 percent of a day's time free for duties other than their primary tasks.

Work formerly accomplished by the headsaw crew in their spare time (.42 man days) is to be taken care of by the band saw operator.

Four men are needed for cabin siding production. When a large amount of material to be processed has accumulated, men are taken from pallet production to complete siding manufacture.

Increased needs for headsaw personnel were considered proportionate to the increase in dollar volume generated by the proposal. However, since duties of the nailers have been reduced with the new system only one (not two) additional nailer is felt needed.

Comparison of Efficiency with Present Methods

Process Charts

Operation process charts for the proposed method of operation were not constructed since basic processes for all products remained very nearly the same with the new plan. However, flow process charts were constructed. (Appendix B) and comparison of these with the flow process charts for the present operation reveals several advantages and disadvantages of the new system.

Production of deckboards from a cant requires the same number of operations, transportations, inspections, delays, and storages as in the present operation, but the total transportation distance of material from log form to the form of pallets loaded on a truck, is reduced twelve feet. Likewise, the number of various operations required is the same as in the present operation for stringer production, but in this case, transportation distances of material through the mill are reduced eighty-nine feet.

Block production, in the new system, requires one less operation to be performed and involves one less delay. In addition, transportation distances involved, from the time of end trim removal at the cut-off saw (Cut-off saw #1) to the arrival of blocks in the nailing room is reduced forty-three feet.

Cedar cabin siding is made using one more transportation, one less delay, and using fourteen additional feet of transportation distance than with the present system.

The result of reductions in transportation distances is less time needed in within-plant transportation of materials and much less congestion of the plant. A reduction in the number of operations also saves time, manpower and machinery and reduces costs.

Cost Considerations

Additional company income and increased profits are the primary aims of most plant improvement programs. Reductions in process cycle times, elimination of certain operations, delays, or transportations, or shortening of transportation distances which might be brought about by plant improvements are, for the most part, only incidental; the important consideration is as to the effect these improvements have on profitability of the business.

In the following analysis, costs brought about because of the improvements and because of the increased production are examined in relation to the added yearly sales. Examination of the entire cost structure was thought to be unduly burdensome and unnecessary.

Capital Expenditures

1 Air operated automatic cut-off saw	$1,079[1]
15 H.P. Drive motor for cut-off saw and extra saw blades	250
210 feet of two-foot width, smooth, rubber endless conveyor @ $40.00/foot	8,400[2]
200 feet of two-foot width, ribbed, rubber outdoor use, endless conveyor @$48.50/foot	9,700
Power source for waste conveyors	350
32 feet of two-foot width, dead roll conveyor @$82.50 per 10 foot section	264

[1] Price based on 1960 figures of Irvington Machine Works.

[2] The prices indicated for rubber conveyor, power source for waste conveyors and the dead roll conveyor are as quoted by the Corely Manufacturing Company, 1965.

Waste burner	$3,000
Installation of 210 feet of 3' depth x 2 foot width concrete ditching in mill structure	1,400
100 foot wooden, elevated, waste conveyor support	500
Ten-foot extension of roof over log deck	100
Movement of the office to the new location	75
Installation of an eighteen-foot door in the headsaw wing	300
Installation of an outside door to the office	80
Cost of moving machinery, waste ducts, etc.	200
Live deck equipment	1,210[1]
Cyclone blower system	1,000[2]
Total	$27,908

Cost of Additional Goods Sold

1,922 additional board feet of material needed per day @$40/M	$18,451
Additional expense for nails (27,768 additional pounds needed @$9/50#)	4,998
2 Additional employees @$1.75/hr.	6,720
Total	$30,169

[1]Price quoted by Renco Products, Lapeer, Michigan, 1965.

[2]All prices not specifically quoted were estimated.

Additional Overhead

Additional social security paid (3½% of first $3000 of each employee)	$ 210
Additional state and federal unemployment tax	200
Additional workmans compensation	538
Additional insurance (.355% of additional value)	99
Increased delivery costs ($13/M)	6,000
Increased power costs	1,000
Increased depreciation (5 years)	5,582
	$13,629

Additional Selling and General Expenses

There should be only a negligible increase in selling and administrative expenses with the new layout; these will not, therefore, be considered.

Summary

Increase in Sales ($212/day x 240 days)	$50,880
Cost of Additional Goods Sold	30,169
Gross Profit	20,169
Additional Overhead	13,629
Net Profit (before tax)	7,082

Thus, the improvements can be made with a resulting net profit of over $7,000 which gives a return on investment of over 25 percent before tax.

Proposed Layout #2 - Carts and Conveyors

Increasing Production Potential

Examination of proposed layout #1 reveals that, once again, the key to increased production is the headsaw. However, substantial production increases will necessitate improvements to be made in a number of operations, if addition of new employees and new machinery is to be minimized.

In the present system 28.8 percent of an operator's time is used in moving logs to the saw carriage. Addition of an automated log deck in proposed layout #1 reduced this figure to 21.8 by eliminating the need for hand rolling of logs along the deck to position them for sawing. By eliminating the need for the sawyer to periodically venture into the yard area to bring logs to the log deck, the portion of the sawyer's time used in bringing materials to the saw could be reduced to about 3 percent. Therefore, the employment of a full-time fork lift operator is recommended.

By the same method as was used previously, the increase in productivity at the headsaw, attributable to the change, can be evaluated as follows:

$$\frac{(21.8 - 3.0) \times 450 \text{ minutes/work day} \times .80}{4} = 17 \text{ average logs}$$

Production is increased 1273 board feet per day over production estimates for proposed layout #1.

Another boost can be given to headrig production by estimating the log turning process. At present, 16.5 percent of the total time the saw is attended, is spent manually turning logs on the saw carriage, and it is not unreasonable to assume that this figure could be cut in half using an automatic log turner.[1] If this were the case, added production would amount to the following:

$$\frac{.085 \times 450 \times .80}{4} = 8 \text{ average logs}$$

With a board footage per log of 74.9, added production is 599 board feet for a total increase of 1872 board feet over proposed method #1.

Amother stimulation can be given to headsaw production by installation of a conveyor system which carries lumber from the headsaw to subsequent operations. In the present operation 7.4 percent of the attended time is spent in removing materials from the saw carriage; there is often a time lag between the removal by the saw tailer of the last cut board and the "dog board" or remaining cant. By eliminating the need for manual carrying of material away from the saw this time lag can be shortened appreciably. Assuming that this aspect of time usage can be reduced by two-thirds (from 7.4 to 2.4 percent), then production can be increased by this amount:

$$\frac{450 \times .05 \times .80}{4} = 5 \text{ average logs}$$

[1]This is an estimate only, but in discussions with individuals familiar with sawmill operation, it was agreed that this figure would probably be realistic for a situation in which medium-sized logs were handled.

Added board footage in this case is 375 for a total increase in daily production over proposed method #1 of 2247 board feet (1273 + 599 + 375). Compared to the present setup, overall production shows an increase of 4169 board feet per day.

Daily board yield can now be expressed as follows:

126 logs/day x 6 board/log	= 756 - 8"x 3/8" x 9.3' boards/log
126 logs/day x 1 board/log	= 126 - 8"x 1" x 9.3' boards/log
126 logs/day x 1 3/4 cants/log	= 221 - 4½" x 9.3 boards/log

Assuming that the proportion of material going into manufacture of various product types is the same as in the present and proposed #1 systems, daily output of boxes is 50, output of expendable pallets is 596, and output of notched stringer pallets is 241. Daily sales thus becomes $1049 (261 + 403 + 385); this figure is $238 more than sales forecast with proposed method #1, and $450 more than it is at present.

Machine Capacity Evaluation

Machine Use Calculations

Evaluation of the entire machine sequence was then completed in order to locate other problem areas which might have arisen with the production increase; this is shown in Table L.

Evaluation of the Slat Saw

Two important categories of time usage associated with the slat saw are maintenance (23.8 percent of the attended time) and removal of waste (5.3 percent of the attended time); by lessening the portion of time needed for these tasks, daily usage of the saw can be reduced to a workable level.

All of the time noted in the maintenance category was used in sharpening of saw blades. When a saw blade becomes dull, the slat saw is shut down and the blade is removed and sharpened. One or both of the slat saw operators are either idle during this period or they find some task to perform for the duration of the shut-down time. An easy way to prevent this idleness and confusion is to make use of more than one of each saw blade size. In this way, the operation can proceed with interruption only for changing of saw blades; all sharpening for an entire day can be performed at one time by the mill foreman. Thus, lost time attributable to maintenance can be reduced to at least 5.0 percent.

Table L

Machine	Pieces to be Processed Per Day	Production Rate (pieces/minute)	Percent of Machine Use
Edger	507	15.9	7.1
Planer	756	5.3	31.7
Cut-off Saw	221 cants	1.0	49.1
Slat Saw	313 bolts to 3/8" 246 bolts to 3/4"	0.9 1.4	116.3*
Re-Saw	104 bolts 5364 blocks	5.7 30.0	43.8
Band Saw	723	3.0	53.6
Cut-off #2	5364 blocks	11.1**	107.4*

*This machinery must be improved or additional equipment must be added in order for them to keep pace with headsaw production.

**The figure given here represents the new production rate after all improvements in the block cutting operation as suggested in proposal #1 have been made.

Use of the automated waste disposal system will reduce the portion of time presently spent for waste removal to a negligible amount.

In summary, the cycle time at the slat saw can be reduced 24.1 percent by merely improving two aspects of the operation. This reduces the percent of machine use to 86.6% and allows increased production without addition of another slat saw.

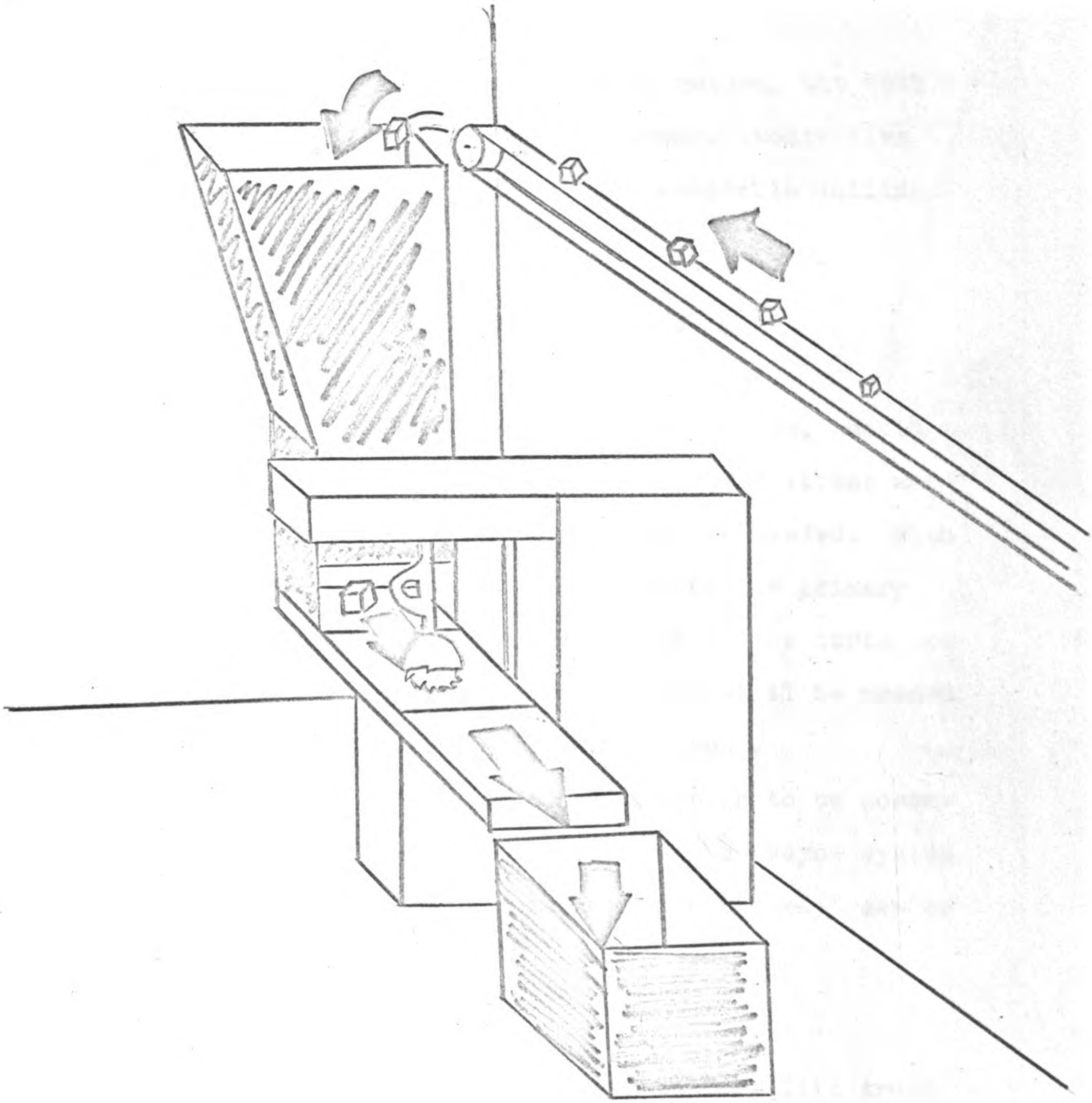
Evaluation of Cut-Off Saw #2

With partially cut blocks coming to the cut-off saw by conveyor, a stationary storage device can be used to hold these blocks prior to final processing (Figure 12).

Blocks drop into the top of the hopper device which, if necessary, can hold enough material at one time to sustain production for an entire day. As blocks are moved from the hopper outlet to the saw, other material is allowed to fall to the saw table. Turning and lifting motions on the part of the cut-off saw operator are eliminated. At present, 26.3 percent of the attended time is used in getting materials to the machine; and well over half of this time is involved in turning, lifting, and transporting material to the saw table. By installing the hopper, the time requirement for all of these time classifications should be substantially reduced. Therefore, all block cutting work can be done on the existing machine.

Figure 12

Block Storage Device



Changes in the Mill Layout

Figure 13 shows the plant layout for proposal #2. As was the case for proposed layout #1, the log deck, headsaw, saw carriage track, and the heating system remain in the same position as in the present layout. Movement of all other machinery is planned.

To accommodate large increases in volume, the west wall of the nailing room is to be extended twenty-five feet for a two-thirds increase in the available nailing space.

Methods of Materials Handling

Transportation Equipment

The single fork lift truck, in present use, should continue to adequately serve the expanded facilities and no additional fork lift equipment should be needed. With the discontinuation of the use of carts as the primary means of transportation about two-thirds of the carts now owned will be eliminated; some carts will still be needed for movement of material to the nailing room.

The major means of material movement is to be accomplished using a two-foot width, live roll conveyor system which moves material from the head saw to the slat saw or planer.

Log Breakdown and Edging

Movement of logs to the log deck by fork lift truck, and conveyance of logs to the carriage is accomplished as

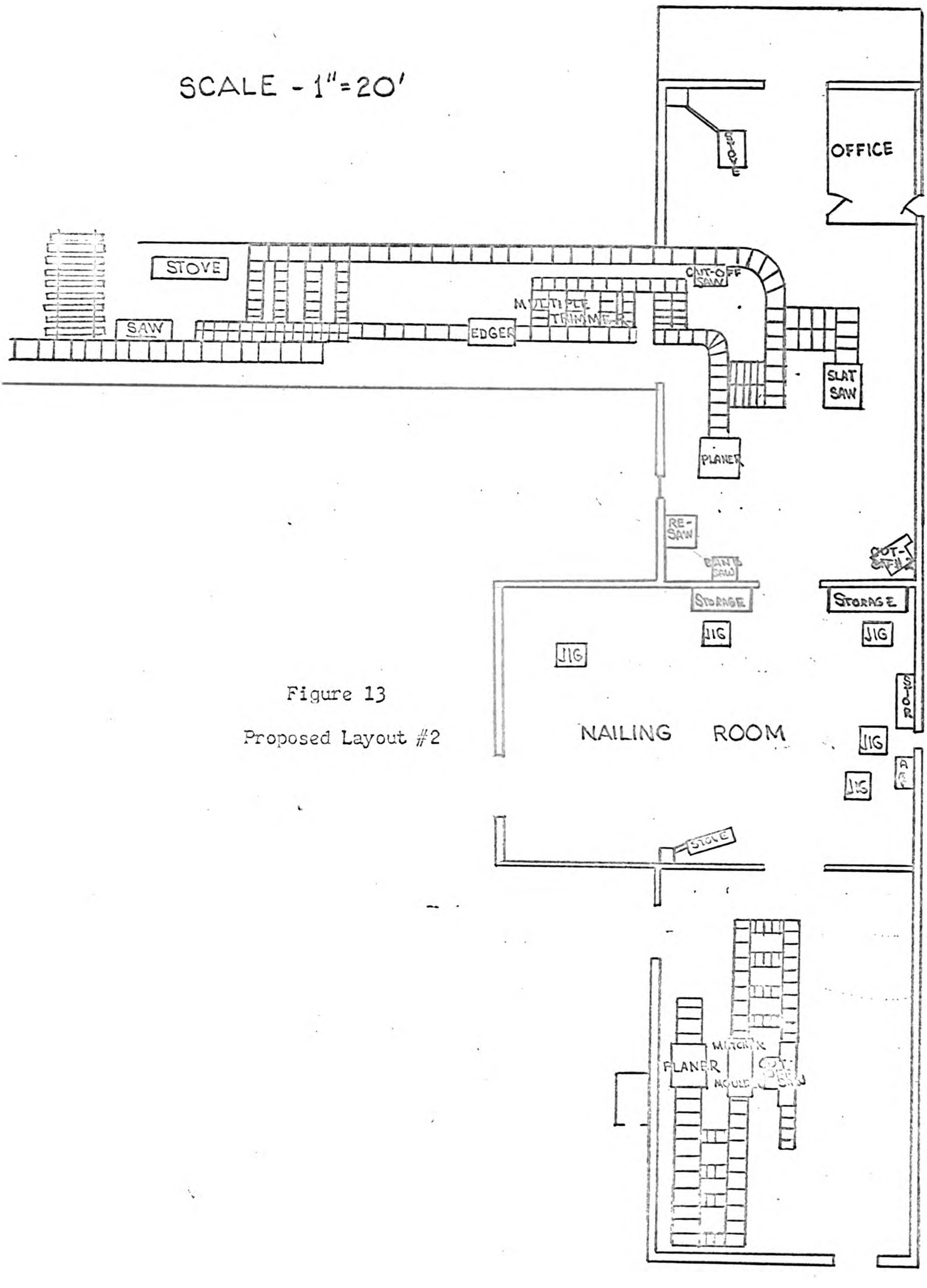


Figure 13

Proposed Layout #2

in proposed layout #1 (Figure 14). Once on the carriage, logs are positioned by the automatic turner. After log breakdown, boards are allowed to continue on to the edger while cants are carried by transfer chain to a separate conveyor. The selection of the material route is to be done mechanically. Boards to be edged are correctly aligned on the conveyor by the saw tailer, who is also responsible for the positioning of edger saws. Boards which do not require edging are merely passed through the left side of the edger where no cutting takes place.

Cutting to Length and Planing

After planing, boards are moved across a multiple trimmer where they are cut to proper lengths in one pass over the machine. Adjustment of saws is done by remote control. After cutting to length, boards are carried by conveyor to the planer; material is manually stacked on carts following planing.

Handling of Cants

Cants move to the cut-off saw after being transferred to a heavy duty conveyor which runs along the north side of the headsaw wing. Here, cants are cut to bolts of various sizes. The majority of the bolts will go to the slat saw, with that material to be converted into stringers going to the planer. Material is stacked on carts according to size after both operations.

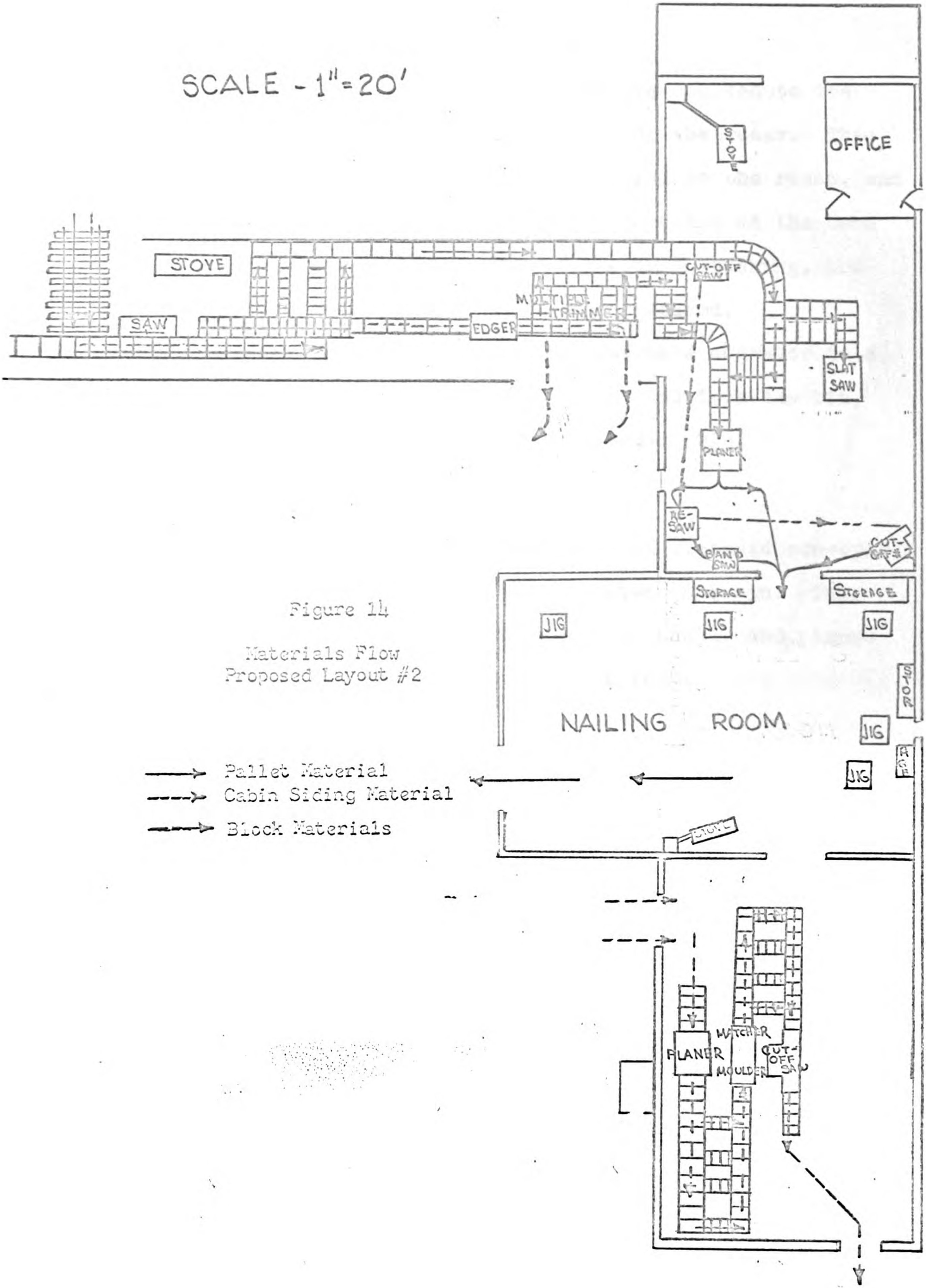


Figure 14

Materials Flow
Proposed Layout #2

Resawing and Notching of Stringers

Bolts passed through the planer are stacked to the left of this machine, or to the right of the resaw. These bolts are picked from the pile, processed on the resaw, and stacked to the left of the machine. Notching on the band saw is done in much the same manner with unstacking, processing, and restacking of materials involved.

Cut-off scraps are carried by overhead conveyor to a bin by the resaw. This material is picked from the bin, processed, and allowed to fall in a second bin.

Cutting of Blocks (Cut-off #2)

Partially cut blocks are carried by overhead conveyor to the location of cut-off #2 and placed in a bin. This material is taken from the bin, cut to length, and placed in a cart for movement to the nailing room.

Cabin Siding Production

Cedar to be made into cabin siding is removed from the mill building by fork lift truck after edging and is stacked in piles for drying. Once dry, lumber is brought into the mill through the west door of the sash and door assembly room and processed, beginning with the planing operation. Only two men are needed for this operation. Completed siding is removed from the mill through the south door of the sash and door room.

Waste Disposal Systems

The same waste disposal system as is planned for proposed layout #1 can be used with this system. Means of access to the recessed waste conveyor will be slightly changed in the vicinity of the edger to allow the edger tailer to work from a position at the left rear of the edging machine.

Movement of the blower system is again necessary, but ultimate disposal of the waste carried by the system is the same as in the previous proposal.

Manpower Usage

Ten men (exclusive of the foremen) are needed for pallet component production in proposed layout #2. As before, two men each are needed for the headsaw and slat saw operations. One man is needed to operate the multiple trimmer and to act as the edger tailer; another is needed for operation of the cut-off saw; and another is needed for stacking of material after planing.

Still another man is to function in operating the resaw and the band saw, and one man will be used for block cutting on cut-off saw #2. A full-time fork-lift operator is to be hired.

Again, increased need for nailing personnel was computed on the basis of increased volume. Two more nailers will be needed than with proposed layout #1; a total of nine nailers is now to be employed.

Comparison of Efficiency with Present Methods

Process Charts

Examination of flow process charts for proposed layout #2 (Appendix C) reveals significant changes in the processing and material handling sequences for all the elements produced.

In the manufacture of deckboards, materials are transported ninety-four feet further than in proposed layout #1. However, movement of materials by hand (i.e. carts) amounts to only thirty feet. Further, the number of times that materials flow is delayed in movement through the mill is reduced from eight to four.

As with deckboard manufacture, materials flow in notched stringer production covers a longer distance (61 feet longer) than with proposed layout #1; in this case, only six feet of the proposed materials flow is accomplished using carts. In addition, the number of transportations is reduced from eight to six, and the number of delays is cut from eleven to only five.

The new method of producing blocks eliminates one delay and reduces the length of materials flow by nine feet.

Cost Considerations

For purposes of this cost analysis, it will be assumed that all of the changes suggested in proposal #1 have been made. Therefore, cost figures given represent sales and expenses over and above those incurred in the operation as outlined in proposal #1.

Capital Expenditures

110 feet of heavy duty, two-foot width, live roll conveyor	$4,590[1]
24 feet of heavy duty, five-foot width, live roll conveyor	2,032
160 feet of medium duty, two-foot width, live roll conveyor	4,770
1 Transfer chain, 16 feet wide x 8 feet long	150
2 Three-chain transfer chains, 16 feet wide x 5 feet long	180
3 Two-chain run-off mechanisms	2,400
2 Three chain run-off mechanisms	2,000
1 Automatic adjusting, multiple saw trimmer	5,000
Block conveyor system	300
1 Automatic log turner	950[2]
Power source for live rolls	350
Movement of dust take-off system and movement of machinery	200
Addition to nailing room ($2.50/sq. ft.)	2,500
Total	$25,422

[1]Prices of all live roll conveyors, run-off mechanisms, and power source for live rolls quoted by Corely Manufacturing Company, 1965.

[2]Price quoted by Renco Products, Lapeer, Michigan, 1965.

Cost of Additional Goods Sold

2,247 additional board feet of material needed per day @$40/M	$21,571
Additional expense for nails (30,163 additional pounds needed @$9/50#)	5,429
4 Additional employees @1.75/hour	13,440
Total	$40,440

Additional Overhead

Additional social security paid (3½% of first $3000 of each employee)	$ 420
Additional state and federal unemployment tax	400
Additional workmans compensation	1,072
Additional insurance (.355% of additional value)	81
Increased delivery costs	7,000
Increased power costs	1,500
Increased depreciation (7 years)[1]	3,632
Total	$14,105

Additional Selling and General Expense

As with proposed method #1, selling and administrative effects are considered to be negligible.

Summary

Increase in Sales ($238/day x 240 days/yr.)	$57,120
Increase in Cost of Goods Sold	40,440
Gross Profit	16,680
Additional Overhead	14,105
Net Profit (Before Tax)	2,575

[1]A seven year depreciation is used in this case as the primary expenditure is for conveyors and a building addition; such investments should have a much longer life than machinery.

Proposed system #2 can be installed with a profit of over $2,500 before tax for a before tax return on investment of 10.1 percent.

When figures for the two proposals are combined, over-all return on investment becomes 18.1 percent; commitment of funds can be easily justified at this rate of return.

Chapter V. Summary

The Analysis

In this work, the application of several useful tools of work measurement and evaluation to small manufacturing processes has been demonstrated. Through the use of work sampling, a simple technique once understood, it was shown how those associated with the operation can locate problem areas and areas warranting the most attention toward improvement. It was further demonstrated how examination of this and other information may suggest possible solutions to these problems. Some of this other information included a description of the existing mill site, as well as a description of the role of each employee and the role of each piece of machinery in the processing sequence. In addition, feed speed data for each machine, which is obtainable from records or by simple measurement, proved to be useful.

Two interrelated, proposed solutions were formulated on the basis of the mill studies and then these were evaluated through use of the "average log" concept. By formulating the dimensions of the typical log for the particular mill being studied and determining the time required to cut it up, time savings due to increased efficiency were expressed in terms of the common denominator, the "average log." From this point, daily output of boards and cants was obtainable from which study of machine capacities was made. Problems encountered at this stage of the analysis were examined, changes were suggested, and re-evaluation was made of the improved operation. Also by using the average log concept, actual output of units of finished product, and thus dollar sales, were determined. Finally, by using this dollar sales in a complete financial analysis in which proposed additions to overhead, investment, and material costs were evaluated, the feasibility was determined. By using this type of analysis, realistic estimates of system performance can be made before the firm has made a commitment of capital.

It should be mentioned that the analysis outlined in this study is by no means the only method available for evaluating a small manufacturing operation. However, it is thought to be a method which is simple to use and which gives fairly accurate results with a minimum investment in time and money.

Suggestions for Further Research

It is the contention of the author that further research is needed in pallet and box design. Most operators do not know exactly what the strength characteristics are for various species and sizes of boards in different pallet designs. As a result, a significant amount of material is produced with some safety factor applied to assure product durability. A great deal of added material cost is involved when component dimensions are increased only a small amount; should research show that such material thicknesses as are now being used are unnecessary, producers could realize substantial cost savings.

Studies in inventory control related to the wood industry and studies of raw material purchasing would also prove helpful in further efficiency studies.

Bibliography

1. Anglo-American Council on Productivity. Materials Handling in Industry. New York, 1950.

2. Anonymous. "How Can Time Be Saved at the Headrig?" The Lumberman, 80(3): 84-85, 1953.

3. ________. "How to Make a Profit Out of Pallets," Southern Lumberman, 202(2514):33, 1961.

4. ________. "Layouts and Sheds for Small Mills," U.S. Forest Service, Forest Products Laboratory Mimeograph 899-10, (n.d.).

5. ________. "Materials Handling," Consulting Engineer, 14(4): 103-126, 1960.

6. ________. "Uses for Slabs, Edgings, and Trims," U.S. Forest Service, Forest Products Laboratory Report No. D-1666-2, (n.d.).

7. Boltz, Harold A. and Hagemann, George E. Materials Handling Handbook. New York: The Ronald Press Company, 1958.

8. Compton, Kenneth C. "Increasing Sawmill Efficiency," Forest Products Journal, 6(1):19-27, 1956.

9. Field, Peter. "Residues From the Sawmill...Making Smoke or Profit?" Forest Products Journal, 8(11): 27A-30A, 1958.

10. Heebink, Thomas B. and Fobes, Eugene W. "Hardwood Pallet Manufacturing," U.S. Forest Service, Forest Products Laboratory Report No. 2132, 1958.

11. Koch, Peter. "Using Low-Grade Hardwood - A Proposed Integrated Plant Design," Michigan State University Cooperative Extension Service Bulletin No. 460, 1964. (Revised) originally Agriculture Experiment Station Bulletin 413.

12. Laughner, V. H. (ed.). The Modern Materials Handling Manual No. 1. Boston: Boston Publishing Company, Inc., 1955.

13. ________. The Modern Materials Handling Manual No. 2. Boston: Boston Publishing Company, Inc., 1957.

14. ________. The Modern Materials Handling Manual No. 3. Boston: Boston Publishing Company, Inc., 1958.

15. Mater, M. H. "Management Decision: Automate the Sawmill?" Forest Products Journal, 9(10): 33A-35A, 1959.

16. Nelson, A. M. "Streamlining Materials Flow," Northwest Wood Products Clinic Proceedings, 9:25-30, 1954.

17. Niebel, Benjamin W. Motion and Time Study. 3rd ed. Homewood, Illinois: Richard D. Irwin, Inc., 1962.

18. Pauley, W. N. and Batdorf, R. O. "Practical Production Analysis," Forest Products Journal, 8(5): 27A-30A, 1958.

19. Reed, Ruddell, Jr. "An Engineering Look at Material Handling Costs," Material Handling Engineering, 18(12): 57-59, 1963.

20. Rose, H. A. "Automation in the Lumber Industry," Northwest Wood Products Clinic Proceedings, 9:34-41, 1954.

21. Saunders, D. K. "Development of a Sawmill Layout," Forest Products Journal, 4(6):22A-24A, 1954.

22. Schwartz, George (ed.). Science in Marketing. New York: John Wiley and Sons, Inc., 1965.

23. Simmons, F. C. and Bond, A. R. "Sawmill 'Waste' in Maryland," U.S. Forest Service, Northeastern Forest Experiment Station, Station Paper 74, 1955.

24. Telford, C. J. (Revised by F. B. Malcolm). "Sawmill Conveyor," U.S. Forest Service, Forest Products Laboratory Report No. 899-21, 1958.

25. ________. "Slab Disposal Devices for Portable Mills," U.S. Forest Service, Forest Products Laboratory Report No. 899-29, 1946.

26. ________. "Small Sawmills: A Pocket Guide," U.S. Department of Agriculture Handbook No. 70, 1954.

27. ________. "Small Sawmill Operators Manual," U.S. Department of Agriculture Handbook No. 27, 1952.

28. Waldo, R. J. "Production Requires Consideration of Machines," Southern Lumberman, 184(2300):36-42, 1952.

29. Wert, E. C. "Design and Planning of a Montana Sawmill," Forest Products Journal, 5(5):40-41A, 1955.

A P P E N D I X A

FLOW PROCESS CHART

Subject Charted: Deckboard (From cant)

Chart Begins: Log to log deck   Chart Ends: Loading pallet for shipment

Summary Totals:

Operation	Transport	Inspection	Delay	Storage	Distance in feet
5	6	1	8	1	256

Operation	Transport	Inspection	Delay	Storage	Distance in feet	Notes
					100	Move log to deck
						Logs on deck
					10	Move log to carriage
						Saw log to boards and cants-stack on cart
						Material on cart
					50	Cart to cut-off saw
						Material on cart
						Inspect for cut-off
						Cut to length-stack on cart
						Cut stock on cart
					6	Cart to slat saw
						Material on cart
						Cut cants to boards-stack on cart
						Material on cart
					30	Movement to nailing room
						Material on cart
						Use material in pallet-stack
						Pallet in stack
					60	Move pallet to yard area by fork lift
						Stack pallets in yard
						Load truck for shipment

Subject Charted Stringer

Chart Begins Log to log deck Chart Ends Pallet to yard area

Summary Totals:

6	8	2	11	0	366	
Operation	Transport	Inspection	Delay	Storage	Distance in feet	**Notes**
					100	Move log to deck
						Logs on deck
					10	Move log to carriage
						Saw log to boards and cants-stack on cart
						Material on cart
					80	Cart to planer
						Material on cart
						Plane rough cants-stack on cart
						Material on cart
					20	Move cart to cut-off saw
						Material on cart
						Inspect for cut-off
						Cut stock to length-stack on cart
						Material on cart
					26	Move cart to resaw
						Material on cart
						Inspect for resawing
						Resaw cants-stack on cart
						Material on cart
					65	Move cart to band saw
						Material on cart
						Notch stringers-stack on cart
						Material on cart
					5	Move cart to nailing room
						Material on cart
						Use material in pallet stock
					60	Move pallet to yard area by fork lift truck

FLOW PROCESS CHART

Subject Charted: Block

Chart Begins: Move trims from cutoff / Chart ends: Blocks to nailing room

Summary Totals:

Operation	Transport	Inspection	Delay	Storage	Distance in feet	Notes
3	3	1	5	0	125	
					30	Move end trimmings from cut-off to resaw
						Trimmings on cart
						Inspect for resawing
						Cut trimmings to heighth and width
						Pieces on floor
						Pick pieces from floor-place on cart
						Pieces on cart
					15	Move pieces to small cut-off saw
						Pieces on cart
						Cut pieces into blocks-let fall in bin cart
						Blocks in bin
					50	Move blocks to nailing room

FLOW PROCESS CHART

Subject Charted: Cedar Cabin Siding

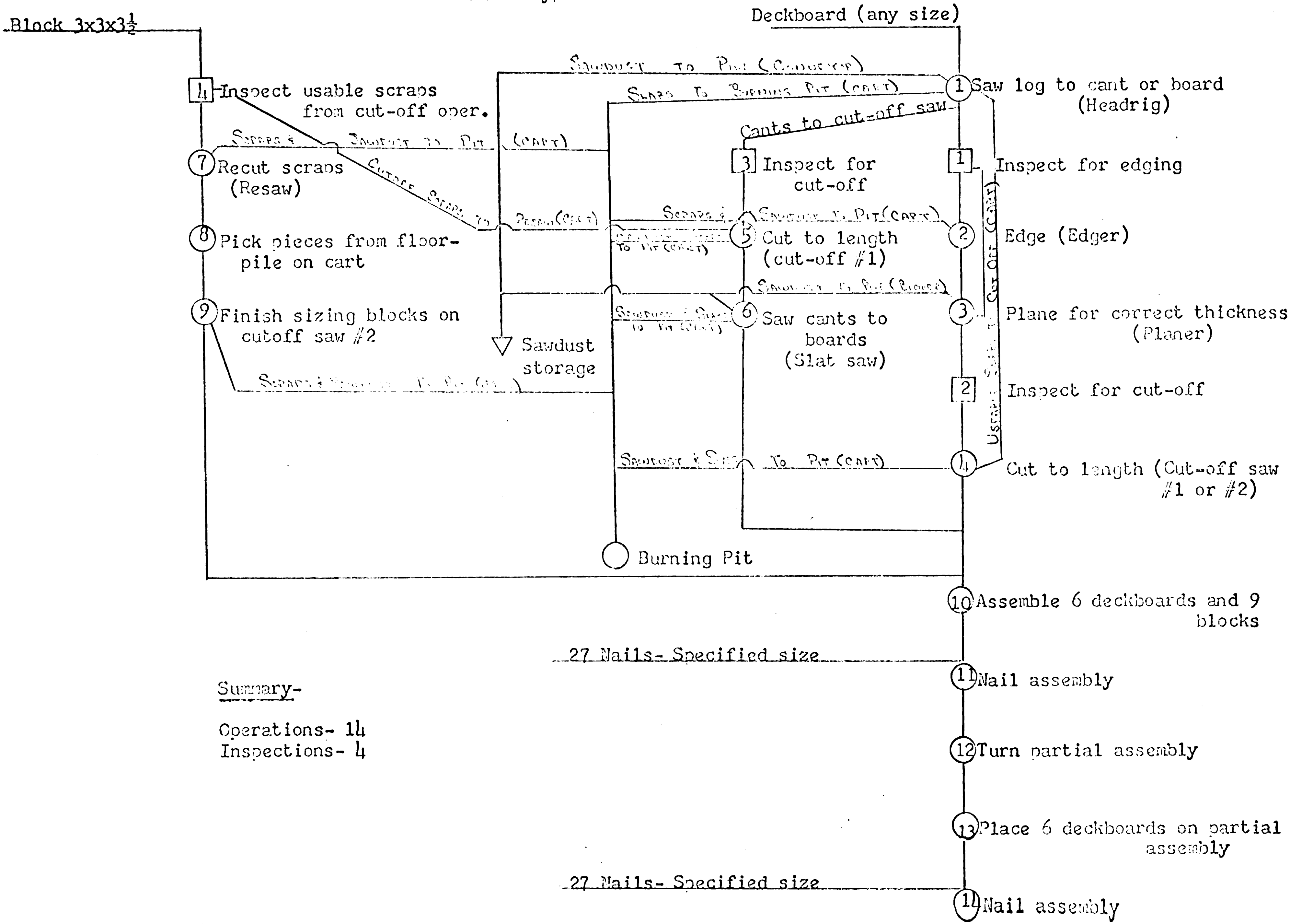
Chart Begins: Log to log deck   Chart Ends: Loading product for shipment

Summary Totals:

Operation	Transport	Inspection	Delay	Storage	Distance in feet	Notes
6	6	2	6	1	283	
					100	Move log to deck
						Logs on deck
					10	Move log to carriage
						Breakdown logs on saw-stack boards on cart
						Material on cart
					120	Move to special planer
						Material on cart
						Plane siding material-stack on cart
						Material on cart
						Inspect for edging
						Edge siding material
					3	Move to matcher-moulder
						Match siding material-stack on cart
						Material on cart
					20	Move to cut-off saw
						Material on cart
						Inspect for cut-off
						Cut to length-stack on cart
					30	Move siding material out of building
						Store in yard
						Load truck for shipment

OPERATION PROCESS CHART

Block Type Pallet

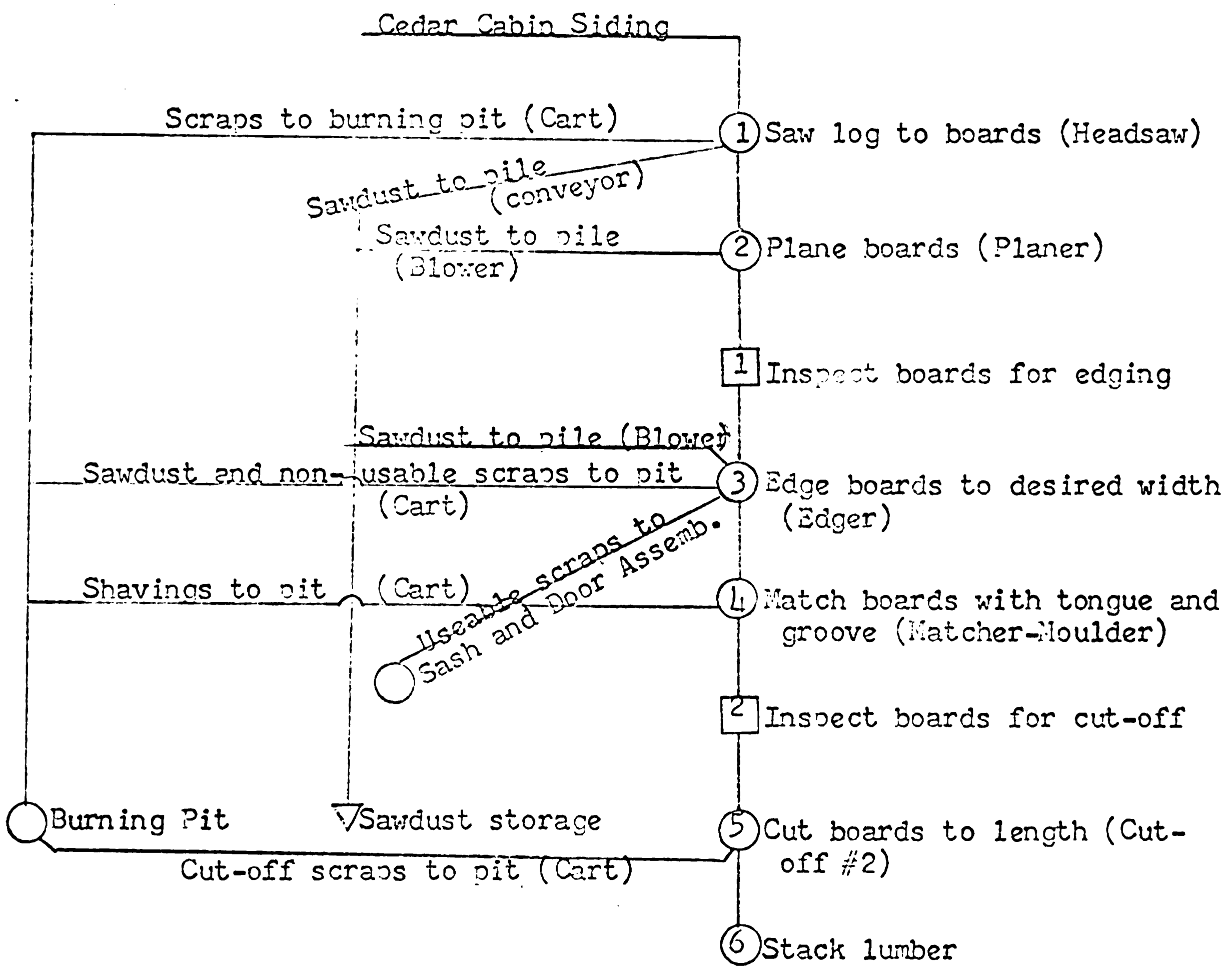


Summary-

Operations- 14
Inspections- 4

OPERATION PROCESS CHART

Cedar Cabin Siding



Summary-

Operations- 6
Inspections-2

APPENDIX B

FLOW PROCESS CHART

Subject Charted Deckboard (from cant) Operation: Proposed #1
Chart Begins Log to log deck Chart Ends Load pallet for shipment
Summary Totals:
5 6 1 8 1 248

Operation	Transport	Inspection	Delay	Storage	Distance in feet	Notes
					100	Move log to deck
						Logs on deck
					10	Move log to carriage by live deck mechanism
						Saw log to boards and cants-stack on cart
						Material on cart
					50	Cart to cut-off saw
						Material on cart
						Inspect for cut-off
						Cut to length-stack on cart
						Cut stock on cart
					6	Cart to slat saw
						Material on cart
						Cut cants to boards-stack on cart
						Material on cart
					12	Movement to nailing room
						Material on cart
						Use material in pallet-stock
						Pallet in stack
					60	Move pallet to yard area by fork lift
						Stack pallets in yard
						Load truck for shipment

FLOW PROCESS CHART

Subject Charted Notched Stringer Operation Proposed #1
Chart Begins Log to log deck Chart Ends Pallet to yard area
Summary Totals:

Operation	Transport	Inspection	Delay	Storage	Distance in feet
6	8	2	11	0	277

Operation	Transport	Inspection	Delay	Storage	Distance in feet	Notes
					100	Move log to deck
						Logs on deck
					20	Move log to carriage by live deck mechanism
						Saw log to boards and cants-stack on cart
						Material on cart
					36	Cart to planer
						Material on cart
						Plane rough cants-stack on cart
						Material on cart
					16	Move cart to cut-off saw
						Material on cart
						Inspect for cut-off
						Cut stock to length-stack on cart
						Material on cart
					22	Move cart to resaw
						Material on cart
						Inspect for resawing
						Resaw cants-stack on cart
						Material on cart
					13	Move cart to band saw
						Material on cart
						Notch stringers-stack on cart
						Material on cart
					10	Move cart to nailing room
						Material on cart
						Use material on pallet stock
					60	Move pallet to yard area by fork lift truck

Subject Charted Block Operation Proposed #1

Chart Begins Move trims from cutoff Chart Ends Blocks to nailing room

Summary Totals:

Operation	Transport	Inspection	Delay	Storage	Distance in feet
2	3	1	4	0	82

Operation	Transport	Inspection	Delay	Storage	Distance in feet	Notes
					22	Move end trimmings from cut-off to resaw
						Trimmings on cart
						Inspect for resawing
						Cut trimmings to heighth and width
						Place pieces in a bin
						Pieces in bin
					20	Move pieces to small cut off saw
						Pieces on cart
						Cut pieces into blocks-let fall in bin cart
						Blocks in bin
					40	Move blocks to nailing room

Subject Charted Cedar Cabin Siding Operation Proposed #1
Chart Begins Logs to log deck Chart Ends Load pallet for shipment
Summary Totals:
6 7 2 5 1 297

Operation	Transport	Inspection	Delay	Storage	Distance in feet	Notes
					100	Move log to deck
						Logs on deck
					20	Move log to carriage by live deck mechanism
						Breakdown logs on saw-stack boards on cart
						Material on cart
					10	Move cart to edger
						Material on cart
						Inspect for edging
						Edge material-stack on cart
						Material on cart
					130	Move cart to sash and door assembly room via
						outside shuttleway
						Material on cart
						Plane siding material
					6	Move to matcher-moulder
						Match siding material
					6	Move to cut-off saw
						Inspect for cut-off
						Cut boards to length-stack on cart
					25	Move siding material out of building
						Store in yard
						Load truck for shipment

A P P E N D I X C

FLOW PROCESS CHART

Subject Charted: Deckboard (from cant) — Operation: Proposed #2

Chart Begins: Log to log deck — Chart Ends: Load pallet for shipment

Summary Totals:

Operation	Transport	Inspection	Delay	Storage	Distance in feet	Notes
5	6	1	4	1	344	
					100	Move log to deck by forklift
						Logs on deck
					10	Log to carriage by live deck
						Saw logs to boards and cants
					94	Cant to cut-off saw by conveyor
						Inspect for cut-off
						Cut cants to length
					30	Bolts to slat saw by conveyor
						Cut bolts to boards of correct thickness-stack on cart.
						Material on cart
					30	Move cart to nailing room
						Material on cart
						Use material in pallet-stack
						Pallet in stack
					80	Move pallet to yard area by fork lift
						Stack pallets in yard
						Load truck for shipment

FLOW PROCESS CHART

Subject Charted: Notched Stringer Operation: Proposed #2
Chart Begins: Log to log deck Chart Ends: Pallet to yard area
Summary Totals:

Operation	Transport	Inspection	Delay	Storage	Distance in feet	Notes
6	6	1	5	0	348	
					100	Move log to deck by fork lift
						Logs on deck
					20	Move log to deck by livedeck mechanism
						Saw log to boards and cants
					94	Cants to cut-off saw by conveyor
						Inspect for cut-off
						Cut cants to length
					48	Bolts to planer by conveyor
						Plane bolts to correct thickness-stack on platform
						Material on platform
						Resaw bolts to stringer size-stack on platform
						Material on platform
						Notch stringers-stack on cart
						Material on cart
					6	Move cart to nailing room
						Material on cart
						Use material in pallet stock
					80	Move pallet to yard area by fork lift

Subject Charted Block Operation Proposed #2
Chart Begins Move trims from cutoff Chart Ends Blocks to nailing room

Summary Totals:

Operation	Transport	Inspection	Delay	Storage	Distance in feet	Notes
2	3	1	3	0	73	
					33	Move end trimmings from cut-off to resaw by overhead conveyor.
						Trimmings in bin
						Inspect for resawing
						Cut trimmings to height and width-place on conv.
					30	Move pieces to cut-off by overhead conveyor
						Pieces in bin
						Cut pieces to blocks-let fall in bin cart
						Blocks in bin cart
					10	Move blocks to nailing room