AN ABSTRACT OF THE THESIS OF

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Title The Analysis of Present Plywood Gluing Techniques and a Method For the Development of Synthetic Data

Abstract approved Redacted for privacy
(Major Professor)

The basic principles of methods and time study have long been applied to the metal working industries, and have proven to be of considerable value. By comparison, their application to the wood products industries is relatively new. As a means of gaining an indication of the value of methods and time study techniques in their application to the wood products industries, they have been applied to the plywood gluing operation.

Before beginning the actual analysis, the over-all process for making plywood and the particular operation to be observed were described in detail, to provide a background for the detailed analysis which was to come.

The study was based upon the analysis of a motion-picture film of the gluing operation. The film was taken with a motor-driven, 16-millimeter camera at a speed of 32 frames per second, rather than the customary 16 frames per second, to provide for greater accuracy and ease in making the analysis. The actions of the core feeder, core layer, and sheet slingers were then traced throughout the entire 300 feet of film, and the frames were counted to determine the idle and working times for each member of the crew. These times were then plotted to show graphically the relationships existing between the men. One result of this portion of the study was the determination of the fact that almost one-third of the time of the sheet slingers is idle time spent in waiting for others in the operation. Elimination of this waste, then, became one of the primary targets of the study.

The motion and time study techniques which were used proved to be of considerable value. The material flow chart presented the overall process in general terms and pointed out very specifically the key position of the gluing operation in that overall process. The micromotion study carried on helped organize information about the operation as well as serving as an excellent means of familiarization with the operation. The ensuing multi-man chart very emphatically points out the weak spots within the gluing operation itself. The synthetic data which had been developed then provided a basis for comparing cycle times for the various alternative proposals as well as the cost analysis which followed.

The individual alternatives which were considered in this study, arranged in order of magnitude of estimated savings and showing savings, are as follows:

Prepositioning of sheets of veneer in rack over laying area	$5654
Sheet slinger laying first core until core layer returns to position	2000
Feeding cores first from one end and then from the other	2000
Rotating as core layer and sheet slingers	1460
Use of two core layers	468
Core layer taking the place of one slinger	252(incr.)
Pre-sorting of cores	515(incr.)
Edgegluing cores and clipping to standard width	2838(incr.)

In addition to these savings there were certain irreducible factors; such as the effects of increased production, effect of change on other operations in the process, and changes in indirect and overhead costs, which should also be considered.

Conclusions resulting from the study were stated in two parts. First it was recommended that four of the alternatives be considered for actual application, and, where possible, combinations of these proposals should be used to effect even greater savings. These four are; sheet slinger laying first core until core layer returns to position, feeding cores first from one end and then from the other, rotating as core layer and sheet slingers, and use of two core layers. Secondly, as it was determined that substantial savings in direct labor would also result from prepositioning sheets of veneer in a rack over the laying area, it was further recommended that it be studied more extensively and an attempt made to develop and put such a device to use.

The study which was made indicated that substantial savings can be made in the gluing operation but only by actually putting the proposals into practice can the true results become known.

THE ANALYSIS OF PRESENT PLYWOOD GLUING TECHNIQUES AND A METHOD FOR THE DEVELOPMENT OF SYNTHETIC DATA

by

HOWARD LLOYD HUFFMAN

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THE ANALYSIS OF PRESENT PLYWOOD GLUING TECHNIQUES AND A METHOD FOR THE DEVELOPMENT OF SYNTHETIC DATA

INTRODUCTION

The application of methods and time study principles to the various wood products industries is a relatively new development when compared with metal working industries. The problems are recognized continually, but the ways of attacking those problems may not be so easily recognizable. In presenting this discussion of the application of synthetic data and operation analysis to the plywood gluing operation, the intention is to show that these tools of the industrial engineer can be of value in the evaluation of several alternative solutions to a problem.

The problems to be presented here are timely ones; ones in which numerous people involved in the production of plywood are interested. In studying these problems, the gluing operation has been selected for two major reasons. The first of these is that it is a basic operation, and one which dictates the shape and flow of several other operations, both preceding and following. Secondly, it is an operation which will illustrate the use of the following methods and time study techniques:

1. Material flow chart
2. Multi-man activity chart
3. Micromotion study techniques
4. Development of synthetic data

5. Use of synthetic data to predict and compare cycle times of several proposed methods
6. Cost analysis procedures

If these techniques can be successfully applied to this operation, then they may also be used in analyzing many other operations. This paper is being written, then, in an attempt to evaluate these principles in their application to the plywood industry.

As stated previously, only one basic operation is being studied. Much of the actual study is based on a moving picture film taken in the plant of the Albany Plylock Company, Albany, Oregon. By taking the film at 32 frames per second, with a motor drive on the camera, it can be used in the determination of quite accurate times for the various movements which make up the manual part of the operation, as well as providing a basis for determining what changes and improvements can be made. It should be emphasized here that this report will be limited primarily to a Type 1 and Type 2 study. As defined on the accompanying sheet of definitions this will include the use of the human body and work place arrangement. The other four types of studies as defined will receive only the consideration necessary to complete the picture. Descriptions of the methods used in determining synthetic data and analyzing the operation, together with the results and recommendations, will make up the text of this paper.

In order to insure more thorough understanding of the material to be presented, some of the terms to be used are defined in a separate table.

The actual presentation of material will take the following form:

1. Material flow chart to show overall operations
2. Multi-man chart to describe the single operation studied
3. Micromotion study applied to the gluing operation to analyze effectiveness of elements of the gluing operation
4. Consideration of alternative methods
5. Development of synthetic data from micromotion study
6. Use of synthetic data to predict cycle time
7. Comparison of alternatives by use of synthetic data
8. Cost analysis
9. Conclusion

DEFINITIONS

caul board. A heavy plywood panel which is placed on the top and bottom of a bundle of unfinished panels to strengthen and protect the bundle during handling and pressing.

core feeder. The member of the plywood gluing crew who feeds the cores into the machine rollers for gluing.

core layer. The member of the plywood gluing crew who takes the glued cores from the gluing machine rollers and places them in position on the sheet of veneer.

cycle. The complete course of an operation from the start until all elements have been performed and the operator is ready to repeat the operation.

element. The subdivision of an operation which has been selected as being the most practical for use in making a time study.

material flow chart. A diagram of a plant which shows the routes taken by the materials used in the process as they progress from raw materials to finished product.

methods studies - six types.

Type 1 - Use of human body

Type 2 - Arrangement of workplace

Type 3 - Design and selection of tools and equipment

Type 4 - Sequence of operation

Type 5 - Design of product

Type 6 - Organization and control

micromotion study. The examination of predetermined subdivisions of an operation by use of a motion-picture film and a hand-cranked projector to count frames and determine times for the subdivisions.

multi-man chart. A graphic portrayal of the work performed by the participants in an operation and of the time relationships between their duties.

sheet slinger. One of the members of the plywood gluing crew who obtains the sheets of veneer from the storage area and places them in position on the glue spreading machine.

synthetic data. A compilation of the descriptions of standardized subdivisions of an operation together with the times which have been determined for these subdivisions.

THE MATERIAL FLOW CHART SHOWS THE PRESENT OVERALL OPERATION

In order that the analysis which is being made here can be followed more easily a brief description of the overall process involved, as well as a more detailed delineation of the individual operation being studied, seems in order. The flow of the materials used in the plywood-making process will be traced first, then, and the glue spreading operation will be segregated later for a more detailed account.

A material flow chart or diagram is presented in Figure 1. This chart shows the relative positions of the various operations in the plant, and is intended to show the overall process in general terms, as well as to indicate the key position of the gluing operation in this process.

The process starts, quite naturally, with the logs in the pond. Peeler logs are floated into the log well, where they are raised by crane to the working level. Here the bark is removed, and the log carried to the lathe. At the lathe, the log may either be turned down as much as possible, or may be only partly turned, with the remainder being stored for future use. As the veneer comes from the lathe, it is elevated into conveyor trays and moved to the clipper. The clipper cuts the veneer into the desired sizes and moves it out onto the green chain, where the pieces are sorted and stored until they can be run through the dryers. After drying, the majority of the veneer is placed in storage awaiting patching or gluing. Small pieces may go to the plug room, where patches are stamped out and some pieces are sent

MATERIAL FLOW CHART
ALBANY PLYLOCK PLANT

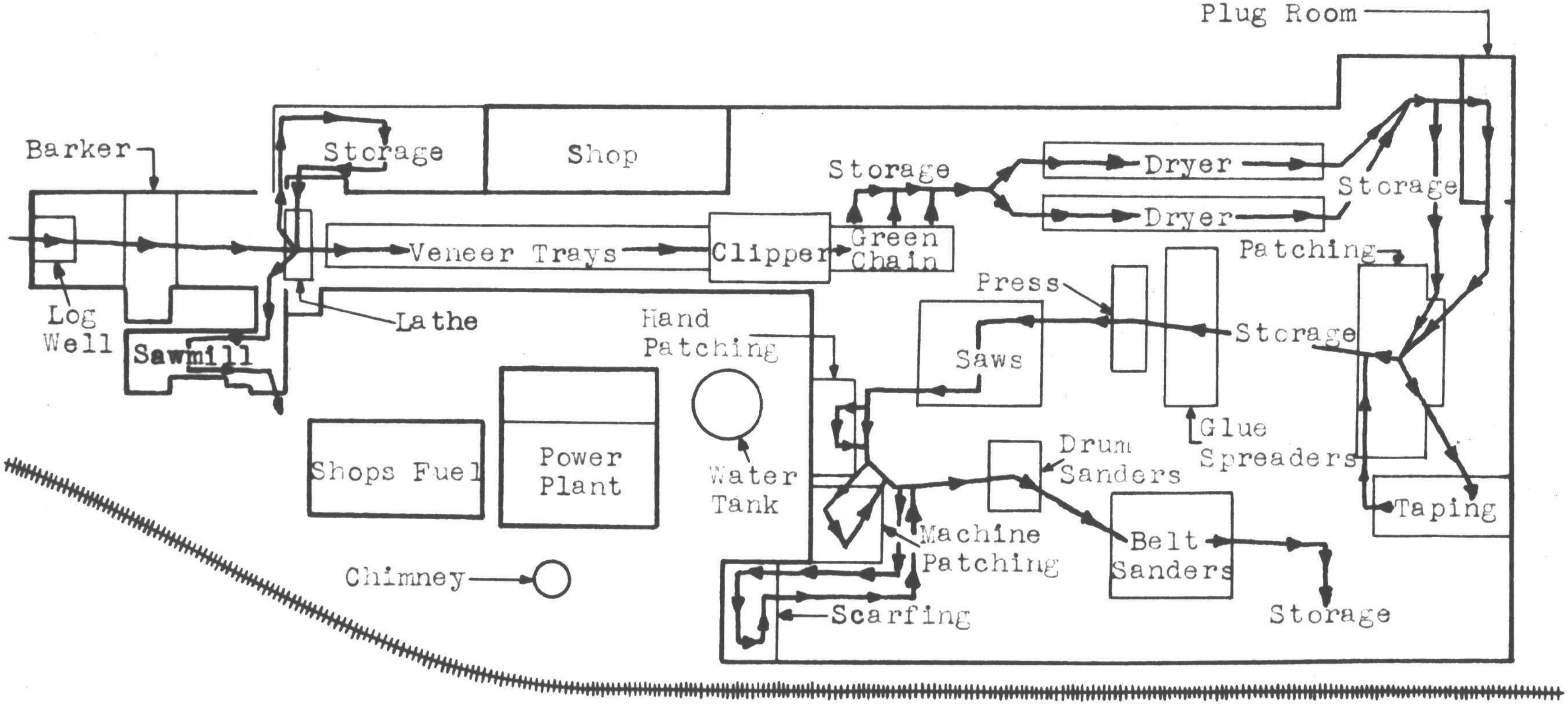


Figure 1

for taping into panel-size sheets. After any necessary patching or taping has been done, the veneer goes to the glue spreaders, where the cores are glued and the panels formed. When the required number of panels have been made, they are moved into the press, where the glue is set under pressure. The panels are then taken to saws where the sides and ends are finished, and the panels are trimmed to size. Panels with minor defects are then taken to the final patching section, where either hand or machine patches are made. Panels with major defects are sent to the scarfing section, where the good sections are joined together to form odd-sized panels. Finally, the panels are sanded to the final finish and stored for shipment.

The picture of the overall operations, as shown in the material flow chart, provides a major advantage when the analysis and evaluation stages of the study are reached. A basic understanding of the flow of materials through the plant and of the sequence and relationship of the various operations is needed to properly analyze any one operation. The effect of changes in one operation upon other related operations and upon the material flow may be of great importance, and must be considered in any study.

This can be illustrated, for example, by considering briefly some possible effects of an increased rate of production in the gluing operation. It can be seen from the flow chart that material being processed spends considerable time in temporary storage before reaching the glue spreaders. It could be entirely possible, then, that an increased production rate in the gluing operation would mean a drastic reduction in, or even complete elimination of, the necessity for temporary storage while awaiting gluing. With a reduction in storage requirements, then, material would move through the plant faster and more efficiently, and the space now taken up by storage could be utilized to greater advantage.

THE MULTI-MAN CHART DESCRIBES THE SINGLE OPERATION STUDIED

The operation upon which this study is based has been touched only briefly in the preceding description. In order to properly analyze this operation, however, it is imperative that a much more thorough understanding be gained. The glue spreading operation, as performed in the Albany Plylock plant, embraces the actions of four individuals. The actions of these four--the core feeder, core layer, and two sheet slingers, are shown graphically by means of a multi-man chart. Figure 2 presents such a chart of an average cycle of the glue spreading operation, while a multi-man chart of the operation during the complete period covered by the film is included in the appendix.

The operation can be described even more vividly by the use of a series of photographs and a brief written account. The photographs have been selected to show the general work sequence as well as the elements which are described and analyzed in the succeeding portions of this report.

Photographs were obtained directly from the motion picture film upon which the study is based. This was done by placing the motion picture film in a diffusion-type enlarger and projecting the image onto 3-3/4 x 4-1/4 inch sheets of film. This served to reverse the image from the original film and make a convenient size with which to work. Prints were then made from these negatives.

The gluing operation is performed in the following manner. The core layer and one sheet slinger get a caul board and the bottom sheet

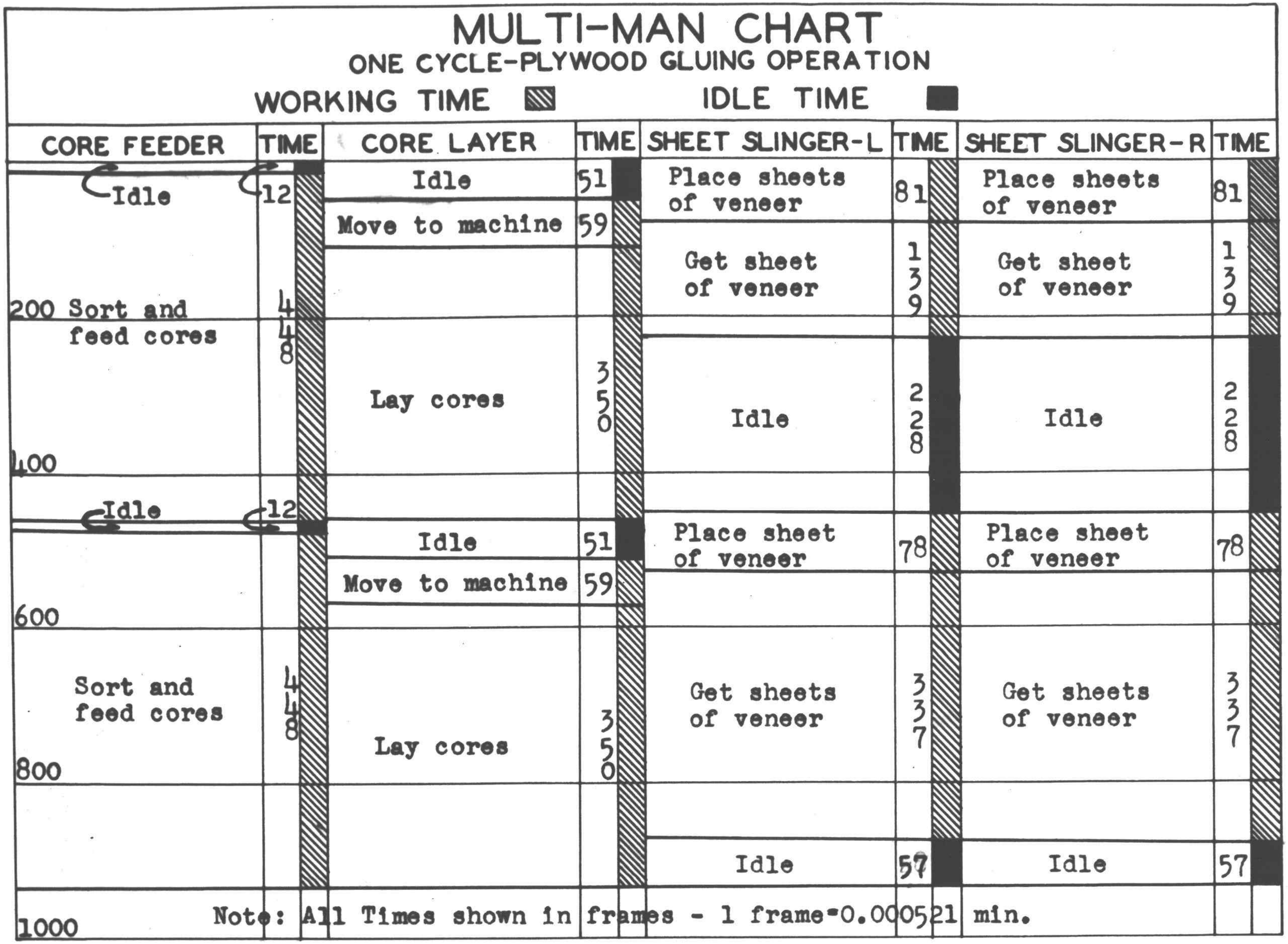

MULTI-MAN CHART
ONE CYCLE-PLYWOOD GLUING OPERATION
WORKING TIME
IDLE TIME
CORE FEEDER
TIME
CORE LAYER
TIME
SHEET SLINGER-L
TIME
SHEET SLINGER-R
TIME
Idle
12
Idle
51
Place sheets of veneer
81
Place sheets of veneer
81
Move to machine
59
Get sheet of veneer
139
Get sheet of veneer
139
200
Sort and feed cores
448
Lay cores
350
Idle
228
Idle
228
400
Idle
12
Idle
51
Place sheet of veneer
78
Place sheet of veneer
78
Move to machine
59
600
Sort and feed cores
448
Lay cores
350
Get sheets of veneer
337
Get sheets of veneer
337
800
Idle
57
Idle
57
1000
Note: All Times shown in frames - 1 frame=0.000521 min.

Figure 2

of veneer and place them in position on the machine while the other sheet slinger is pushing the previous bundle aside. Figure 3 shows the core layer and sheet slinger as they place the bottom caul board and first sheet of veneer in position. Next, the left sheet slinger

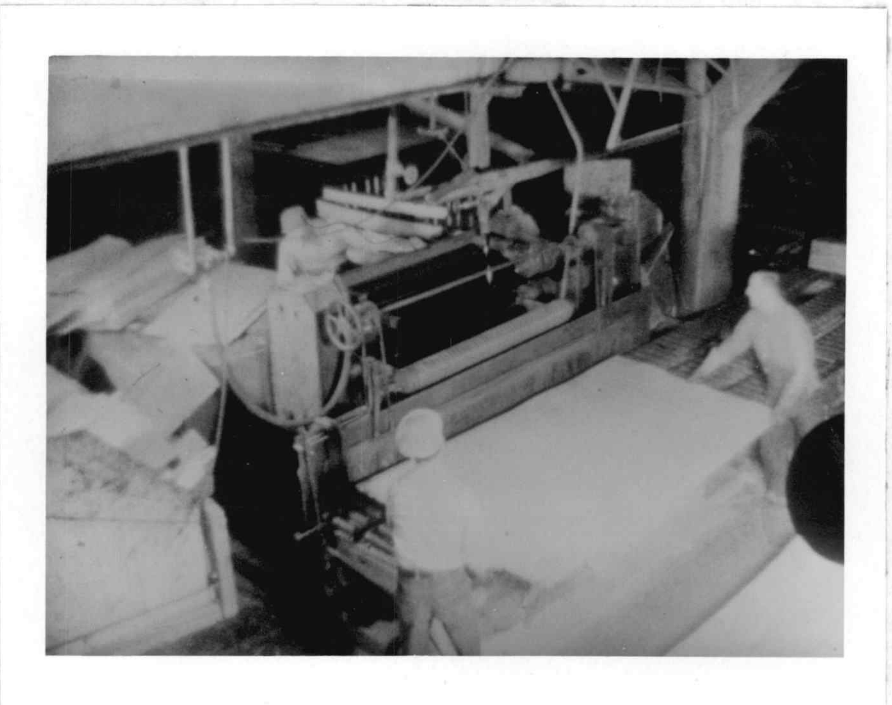


Figure 3

adjusts the machine for operation while the core layer gets into position to receive the first core, as shown in Figure 4. The core feeder then feeds the sections of core through the rolls of the machine, where they are glued. As the cores come out of the rolls, the core layer grasps them and places them in position on the sheet of veneer. Figure 5 demonstrates this particular part of the operation, showing the core feeder as he is getting ready to feed a piece of core

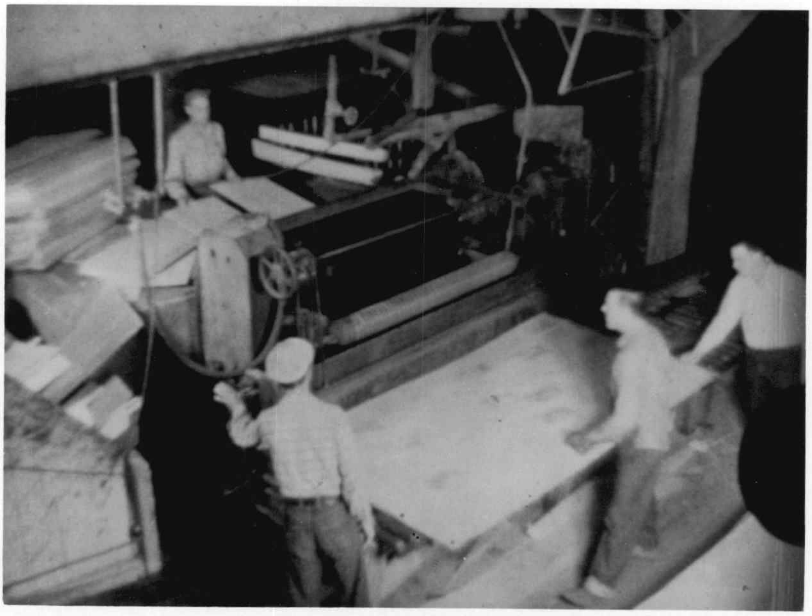


Figure 4

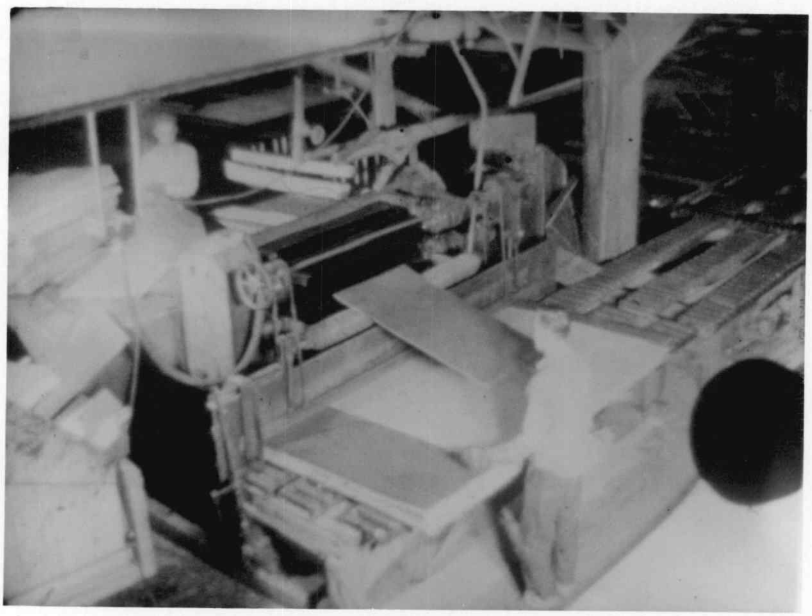


Figure 5

into the rolls and the core layer placing one core in position on the veneer as he accepts the next one from the machine. At the same time that the core feeder is feeding cores into the rollers, he is also inspecting the cores and discarding the ones which are defective and not suitable for use. The core feeder is shown in Figure 6 as he discards a defective piece of core into the waste box on his right.

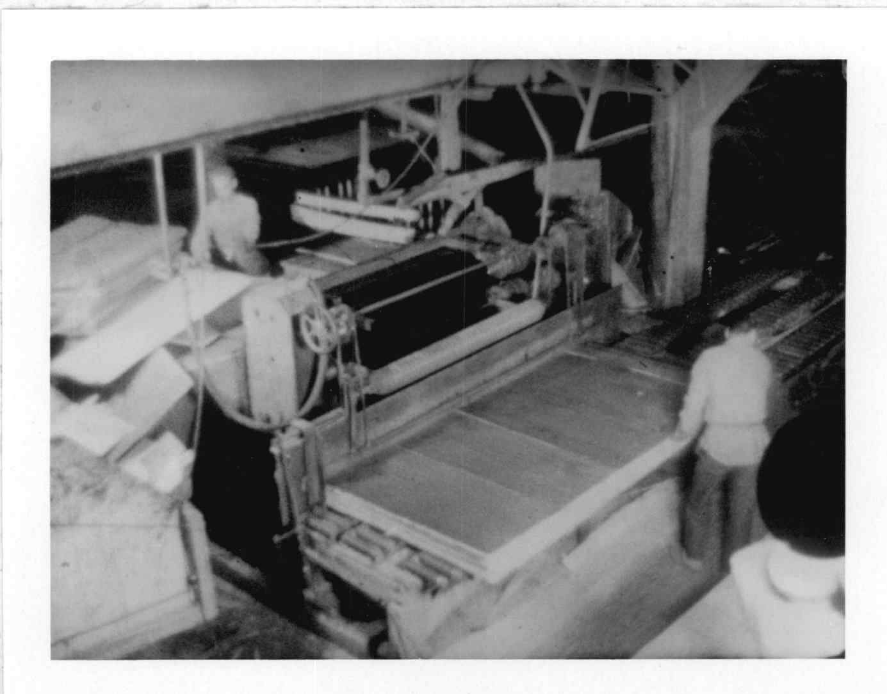


Figure 6

While the cores are being placed, the sheet slingers get another sheet of veneer for the middle ply in the panel, and, as soon as the layer of cores is complete, they place the sheet on the cores. In many cases the sheet slingers are forced to wait till the layer of core is completed, as shown in Figure 7. When the layer of cores has been completed the sheet of veneer is carried over the head of the stooping core layer and is placed in position on the machine. Figure 8 shows

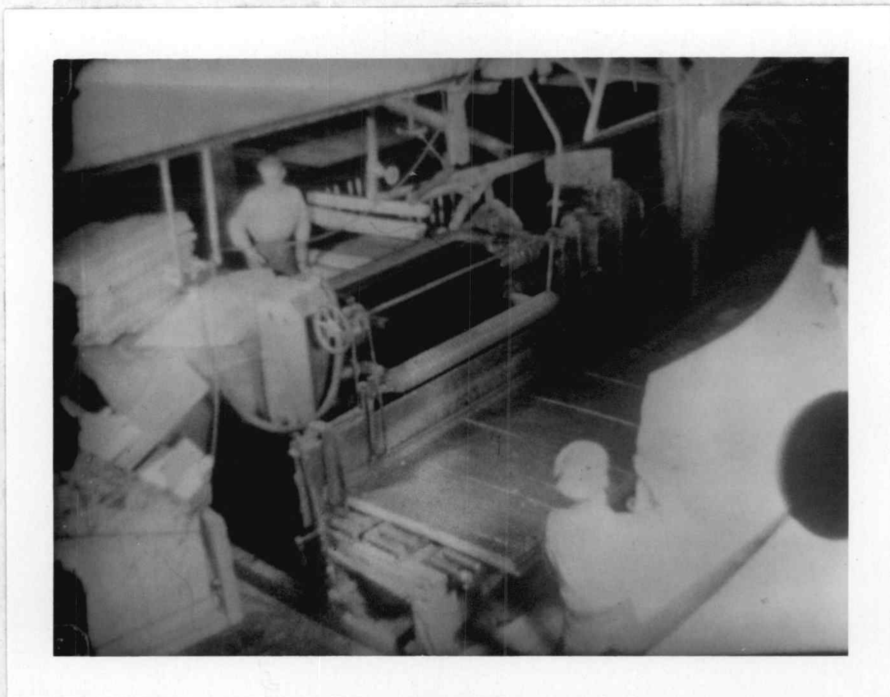


Figure 7

the veneer being carried over the head of the core layer to get it into position. Another layer of cores is then placed, after which two sheets of veneer, representing the top face of the first panel and the bottom face of the second panel, are placed in position by the sheet slingers. This routine is then continued until the required number of panels has been made. When the layup of this bundle is complete, it is pushed aside by the core layer and one sheet slinger, where it is held until it can be put into the press. The core layer and one sheet slinger are shown pushing a bundle aside in Figure 9.

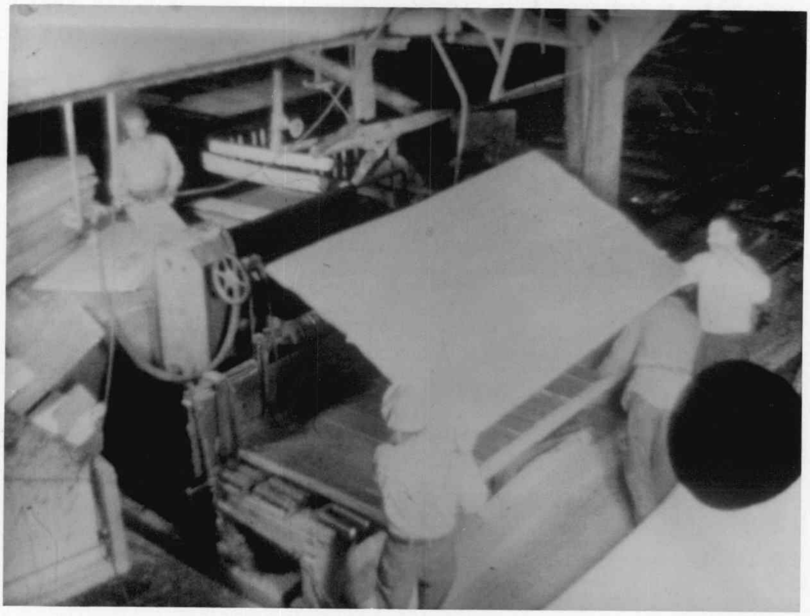


Figure 8

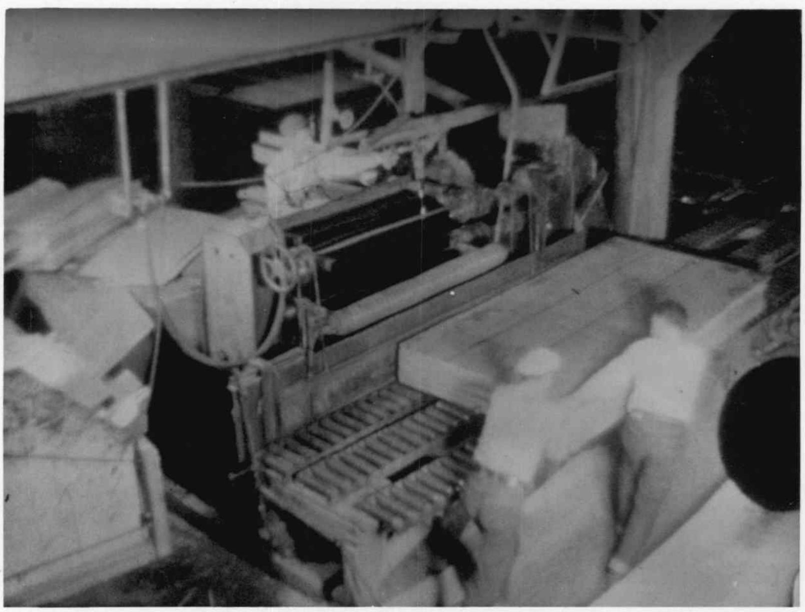


Figure 9

The motion pictures of this operation were taken while five-ply panels were being produced. Consequently, the multi-man chart is based on making five-ply panels. When panels of other construction are desired, there is no change in the basic operation. The change in type of panel means only that the number and type of veneer sheets placed by the sheet slingers will vary in sequence.

These descriptions have been intended as a background for the more intensive analysis to be presented later. With this background in mind, then, the next step may now be considered.

DESCRIPTION OF MICROMOTION STUDY

As a means of more thorough analysis of the glue spreading operation, a micromotion study was made. This study was quite extensive, and was made in the following manner.

The basis for the study was 300 feet of 16 millimeter film taken at a speed of 32 frames per second. The use of a slow-motion speed made possible much greater accuracy when the film analysis was made. The camera used was powered by a constant speed electric motor which eliminated the effect of variations in the power supply, and assured that all times obtained would be consistent. The camera was placed at a distance sufficient to insure that all four workers participating in the operation would be visible in the finished film.

Upon receipt of the completed films the actual, tedious process of analysis was begun. Equipment used for this analysis consisted of a hand-cranked, 16 millimeter projector and a screen upon which the film was projected.

The analysis was made using the following procedure. Each member of the crew was observed individually, and his actions were broken down into elements. The number of frames required to perform each of these elements was then determined and recorded, until the actions of each participant had been charted for the duration of the entire operation. Plotting of these actions, as shown on the multi-man chart in the appendix, thus provides a vivid picture of the operation and relationship between the activities of the men.

In making the analysis and plotting the results, one assumption was made. When the sheet slingers went after the sheets of veneer, it was usually necessary for them to leave the area which was being photographed. During these periods, of course, it was impossible to check their activities from the film. The time during which they were out of view has been considered as being constructively occupied, however, and has been shown that way on the multi-man chart. The validity of this method may seem questionable at first glance due to the apparent wide variation in time to get veneer, which could be an indication of additional idle time. Closer examination shows, however, that half of the times shown are for obtaining a single sheet of veneer while the other half are for obtaining two sheets of veneer, each sheet being from a separate pile. If the data is grouped according to these two factors the results are much more consistent, with considerably less variation from cycle to cycle.

Another explanation which should be made is that of what is included in the idle time, as shown in black on the multi-man chart. For purposes of this study a man was considered to be idle whenever he was not actively engaged in building up the plywood panels. For the most part this meant waiting while others were performing their duties. This was considered idle time even though the idle one may have been holding something during the waiting time as, for example, the sheet slingers waiting with sheets of veneer while a layer of cores was being placed. The results of the study are quite obvious. Only a glance at the multi-man chart is necessary to determine the relative effectiveness of the four people involved in the operation. A summary of working and idle times has been made in Table 1. Having developed the data to this point and determined where weaknesses lie in the present method, the next step was to determine and evaluate alternate methods of performing the operation.

Table 1

SUMMARY OF OPERATION TIMES
PLYWOOD GLUING OPERATION

Core Feeder

Element	Time In Frames
Adjust machine	260
Sort and feed cores	8188
Get core from rack	100
Get and position cores	708
Total Working Time	9256
Idle Time	572
Total Study Time	9828
Idle Time As A Percentage Of Total Study Time	5.8%

Core Layer

Element	Time In Frames
Get and place caul board and sheet of veneer	184
Move to machine	1219
Lay cores	6730
Total Working Time	8133
Idle Time	1695
Total Study Time	9828
Idle Time As A Percentage Of Total Study Time	17.2%

Sheet Slinger - L

Element	Time In Frames
Get and place caul board and sheet of veneer	288
Adjust machine	52
Get veneer	4819
Place veneer	1589
Get and place top caul board	136
Push finished work aside	100
Total Working Time	6984
Idle Time	2844
Total Study Time	9828
Idle Time As A Percentage Of Total Study Time	28.9%

Sheet Slinger - R

Element	Time In Frames
Get veneer	4819
Place veneer	1589
Get and place top caul board	136
Push finished work aside	196
Total Working Time	6740
Idle Time	3088
Total Study Time	9828
Idle Time As A Percentage Of Total Study Time	31.4%

Note: 1 Frame = 0.000521 Minutes

CONSIDERATION OF ALTERNATIVE METHODS

In the process of selecting alternatives for consideration, it soon became apparent that some limitation must be placed upon the number and types of changes which could be examined. If changes involving all six types of methods studies were considered, the number of such possible changes would be practically unlimited. By using only the first two types of methods studies and applying them to the operation studied, limits can be established and the scope decreased to practical proportions. This limitation has been made, then, with the result that a total of eight alternatives have been decided upon for further study.

The alternatives decided upon are shown in the following list in order of degree of change required:

1. Sheet slinger laying first core until core layer returns to position
2. Feeding cores first from one end and then from the other
3. Rotating as core layer and sheet slingers
4. Pre-sorting of cores
5. Core layer taking the place of one slinger
6. Use of two core layers
7. Prepositioning of sheets of veneer in rack over laying area
8. Edgegluing cores and clipping to standard width

The description of each individual alternative method will be made in three parts. The change involved will be described and the advantages and disadvantages of the change will be listed and discussed. Final evaluation of the individual changes will be made later after the development of the synthetic data has been described.

The operation, as presently performed, involves a certain amount of idle time while the sheets of veneer are being placed in position. A brief description of the change involved and some resulting advantages and disadvantages are given in Figure 10.

The second alternative to be considered is, in reality, another attempt to eliminate the idle time while the core layer is moving back into position. The proposed change is described briefly in Figure 11 while a sketch showing the operation under this proposal is included in Figure 12.

The third alternative to be considered would involve a more widespread change than those previously proposed. Under the present method of operation, each member of the crew has a job to do and sticks to that one job. This is true even though the workload of the individuals may vary greatly. The sheet slingers place the sheets of veneer and then return to the storage area for more while the core layer is laying cores. In most cases, the sheet slingers are back and waiting while the core layer is still working. The change under this proposal is described briefly in Figure 13. This description is augmented by the sketch of the proposed workplace arrangement in Figure 14.

DESCRIPTION OF CHANGE

Alternative No. 1

COMPARISON

Present Method

Description: The core layer finishes a layer of core and then bends over while the sheet slingers carry the next sheet of veneer over his head and into position. He then straightens up and returns to working position at the other end of the machine.

Proposed Method

Description: The left sheet slinger, who is already in receiving position, would lay cores until the core layer was back in working position. After laying the first core, the sheet slinger would then go back to his regular position.

EVALUATION OF PROPOSED METHOD

Advantage:

The time spent in waiting for the core layer to get back into position would be eliminated.

Disadvantages:

1. Sheet slinger would be delayed in going after the next sheet of veneer.
2. The sheet slinger, who does not wear gloves as does the core layer, would be forced to grasp the freshly-glued core in his bare hand. A buildup of glue on his hands might hamper him when handling the sheets of veneer.

Figure 10

DESCRIPTION OF CHANGE

Alternative No. 2

COMPARISON

Present Method

Description: The core feeder feeds cores from his right to left, returning to the right side after completing each layer of cores and forcing the core layer to walk from one end of the machine to the other after each layer is completed.

Proposed Method

Description: The core feeder would feed cores by alternating the end from which he would start feeding. Each layer of cores would be started from the end at which the previous layer was completed.

EVALUATION OF PROPOSED METHOD

Advantage:

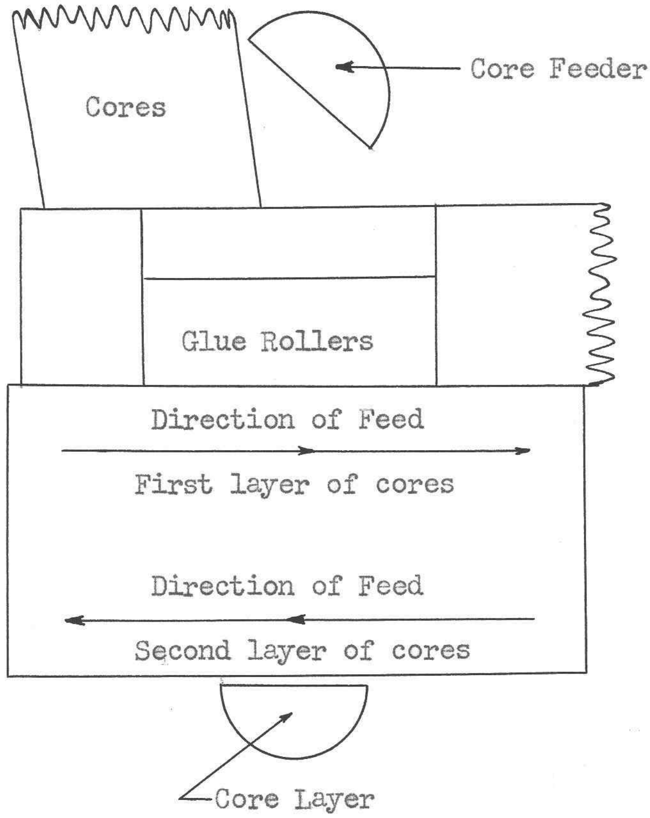
Elimination of the waiting time while the core layer is moving back into position.

Disadvantages:

1. Additional uneven ends or panels would result.

2. Additional handling would be required to position panels for trimming the edges.

Figure 11



Workplace Arrangement - Alternative No. 2

Figure 12

DESCRIPTION OF CHANGE

Alternative No. 3

COMPARISON

Present Method

Description: The two sheet slingers place the sheets of veneer in position on the machine and then return to the storage area to obtain the next veneer needed.

Proposed Method

Description: The core layer and two sheet slingers would rotate on their jobs, each one working as core layer for one layer of cores and then serving as sheet slinger for the next two layers.

EVALUATION OF PROPOSED METHOD

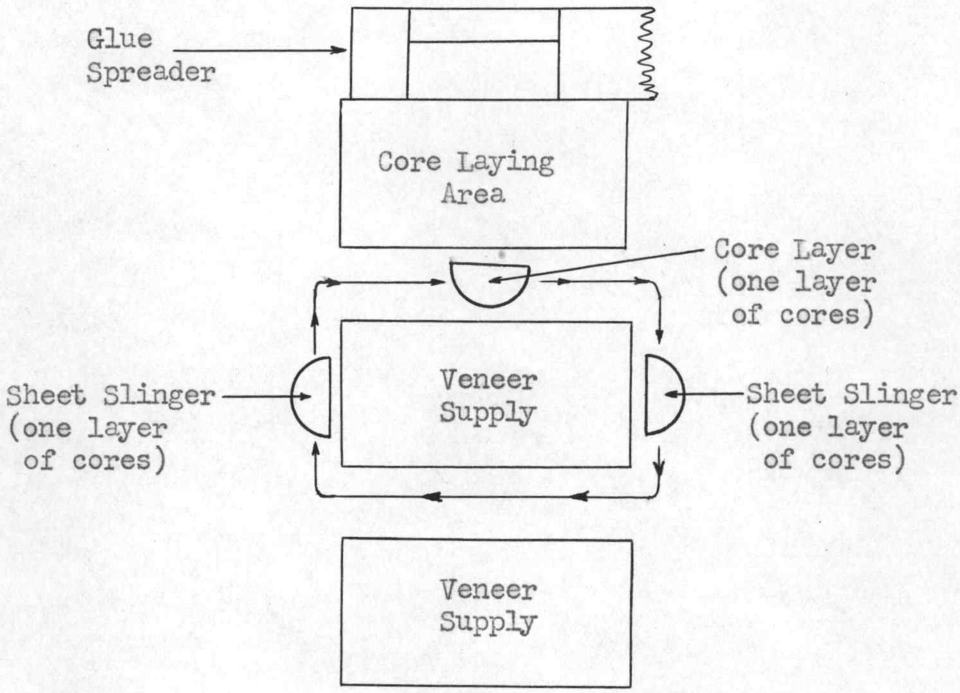
Advantages:

1. Elimination of waiting time while core layer walks from one end of the machine to the other.
2. More variety would be introduced into the work, with a probable lessening of fatigue effects.

Disadvantages:

1. Possible union objections to men performing jobs other than their own and resulting insistence that all be given higher rates as more versatile operators.
2. Possibility of breaking the rhythm on the job by the constant rotation of men.
3. The core layer works with gloves while the sheet slingers do not.

Figure 13



Workplace Arrangement - Alternative No. 3

Figure 14

The fourth alternative would take a somewhat different angle of attack. When observing the core feeder, one is immediately impressed by the number of cores which he discards as not being up to standard quality for use in plywood. During the period recorded in the film upon which this study is based, approximately thirteen percent of the cores handled by the core feeder were rejected. The sorting involved naturally takes time on the part of the core feeder, and becomes much more important when it means that three other men are idle while the sorting is taking place.

DESCRIPTION OF CHANGE

Alternative No. 4

COMPARISON

Present Method	Proposed Method
Description: The core feeder inspects cores as he feeds them into the gluing rolls, discarding defective ones as he goes.	Description: The cores would be inspected and sorted before they reach the gluing operation, thus allowing the core feeder to feed continuously.

EVALUATION OF PROPOSED METHOD

Advantages:	Disadvantages:
1. Elimination of waiting time while the core feeder sorts cores.	1. Provision must be made elsewhere for inspection and sorting of cores.

Figure 15

To combat this situation, it is proposed that the cores be presorted as described in Figure 15.

Probably the biggest change so far would result from putting the fifth alternative method into practice. As previously described, the sheets of veneer are placed in position on the machine bed while the core layer bends over and allows the veneer to be carried over his head. At other times, the sheet slingers are waiting and idle almost one-third of the time. To partially balance this uneven workload the problem would be handled as illustrated in Figure 16.

The sixth alternative proposed for consideration suggests a somewhat radical change in the operation, and would call for major changes in the work routine of both the core feeder and core layer.

Under this system, two layers would be used rather than one, as at present. The method proposed under this alternative is described briefly in Figure 17. The workplace arrangement for the proposed method of operation is sketched in Figure 18.

The seventh alternative is concerned primarily with correcting the situation where almost a third of the sheet slingers' time is idle. As has been stated previously, the sheet slingers' time is the most inefficiently utilized. This portion of the operation, then, offers the most lucrative area for improvement.

This alternative method would improve the operation by eliminating the sheet slingers altogether. The elimination of the sheet slingers would be accomplished by using the method described in Figure 19. Further explanation of the proposal is given by the sketch in Figure 20.

DESCRIPTION OF CHANGE

Alternative No. 5

COMPARISON

Present Method

Description: After completing a layer of cores, the core layer bends and allows the sheet slingers to carry the next sheets of veneer over his head into position on the gluing machine.

Proposed Method

Description: After completing a layer of cores, the core layer would turn to a pile of veneer behind him, grasp the required sheet or sheets, and assist in carrying it to the machine.

EVALUATION OF PROPOSED METHOD

Advantages:

1. Elimination of one sheet slinger with resultant savings in direct labor.
2. Waiting time of the core layer would be utilized by assisting in placing the next sheet or sheets of veneer.

Disadvantages:

1. Elimination of one member of the crew would probably result in union objections.
2. Sheets of veneer would need to be "paired up" before use, thus requiring additional work prior to the gluing operation.

Figure 16

DESCRIPTION OF CHANGE

Alternative No. 6

COMPARISON

Present Method

Description: The core layer begins feeding cores from his right, working across to the left side of the machine. After completion of a layer he shifts the action back to his right and repeats the procedure.

Proposed Method

Description: The core layer would begin feeding cores at the center of the gluing rolls and work toward each end simultaneously. Two core layers would then start at the middle and one would work toward each end of the machine. Upon completion of a layer of cores, they would return to the center and repeat the process.

EVALUATION OF PROPOSED METHOD

Advantages:

1. The core feeder would be allowed to fulfill two principles of motion economy: both hands should begin and complete their motions simultaneously with no idle time except during rest periods and motions of the arms should be made simultaneously in opposite directions over symmetrical paths.

Disadvantages:

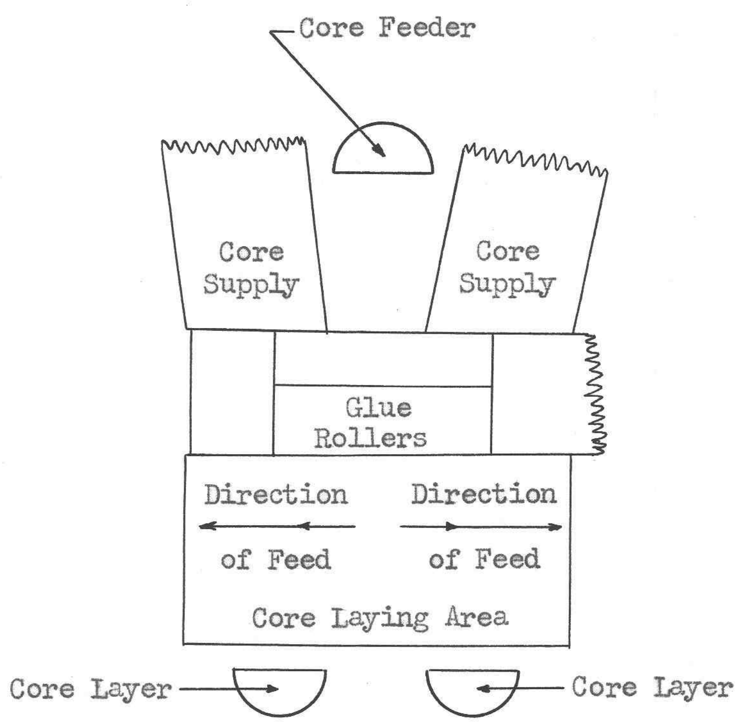
1. The necessity for adding another member to the crew, with a resulting increase in direct labor costs.

2. Core sorting would be made more difficult for the core feeder, as well as increasing the difficulty in selecting the correct width of core with which to finish the ends of a layer.

2. The time for placing a layer of cores would be reduced considerably.

3. Two ragged ends would be left on each sheet, rather than one, necessitating additional trimming and handling of panels.

Figure 17



Workplace Arrangement - Alternative No. 6

Figure 18

DESCRIPTION OF CHANGE

Alternative No. 7

COMPARISON

Present Method

Description: The two sheet slingers secure veneer from the storage piles, wait until the layer of cores is completed, carry the veneer over the head of the core layer, and position it on the machine. They then return to the storage area for more veneer.

Proposed Method

Description: The veneer supply would be positioned on a rack over the working area so that the sheets of veneer could be lowered into position by mechanical means as needed.

EVALUATION OF PROPOSED METHOD

Advantages:

1. Elimination of two sheet slingers would mean a sizeable reduction in direct labor costs.

2. The time interval between layers of core could be reduced by the elimination of the human element in placing sheets of veneer.

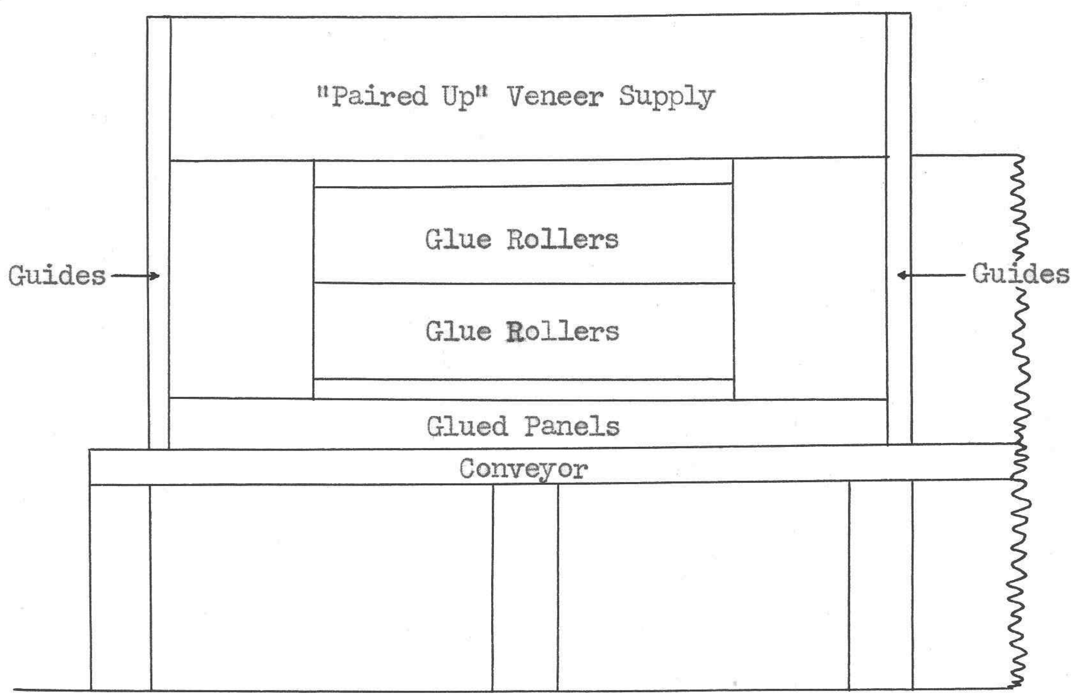
Disadvantages:

1. Organized labor would protest the elimination of both sheet slingers.

2. The sheets of veneer would have to be "paired up" or placed in order of use before reaching the operation.

3. A device to hold and feed the sheets of veneer would have to be developed or adapted.

Figure 19



Front View

Workplace Arrangement - Alternative No. 7

Figure 20

The last alternative to be considered deals with one of the worst features of the gluing operation as it is presently performed. This feature is the use of core material having wide variations in width, as well as a sizeable quantity of inferior quality, which are rejected. This sorting and choosing involves a certain amount of hesitation in the performance of his job on the part of the core feeder, and idle time for the core layer and sheet slingers as they must wait while the sorting is taking place.

To do away with the hesitation and waiting just described, this alternative proposal would have the cores edgeglued and cut or clipped to a standard width, as explained in Figure 21.

The preceding discussion of some possible alternative methods for performing the gluing operation has been intended primarily to show the multitude of factors which must be considered in analyzing the operation. To properly evaluate the various proposals, synthetic data was developed. A description of the development follows in the next section of this report.

DESCRIPTION OF CHANGE

Alternative No. 8

COMPARISON

Present Method

Description: The core feeder inspects and sorts cores as he feeds them into the gluing rollers and at the end of a layer must select the proper width core to finish the layer.

Proposed Method

Description: Cores would be edgeglued and cut or clipped to a standard width, thus allowing the core feeder to feed without inspecting each individual piece of core. The core width would be one which would build up to the correct panel length.

EVALUATION OF PROPOSED METHOD

Advantages:

1. Sorting of cores by the core feeder would be eliminated and more efficient use made of his time.
2. The time to lay cores for a panel would be reduced, as the use of narrow cores would be eliminated and fewer cores would be required per layer.

Disadvantages:

1. Facilities would have to be provided for edgegluing and clipping cores prior to use in the gluing operation.
2. Where more than three-ply panels were being made, the panels would be weakened unless the joints in the core were staggered in alternate layers so that the joints would not coincide with each other.

Figure 21

A METHOD FOR THE DEVELOPMENT OF SYNTHETIC DATA FROM MICROMOTION STUDY

With the completion of the multi-man chart, the basis for the synthetic data was also established. It soon became apparent, however, that synthetic data developed from this study must be of a modified nature.

The main argument for modification lies in the film which served as the basis for the study. In recognized synthetic data systems now in use, the common movements have been broken down into comparatively minute segments, and times set for these segments. Some of these, for example, are reach, move, turn, grasp, and release. These are in turn broken down still further by weights, distances, degrees or other applicable factors. The film of the plywood gluing operation, however, was taken at a distance sufficient to bring the entire working area into view in the pictures. This increased distance has resulted in some indistinctness in the basic movements, and made necessary the use of larger elements for greater accuracy. Accuracy of the element times found by micromotion study could also have been checked by comparing them with results of actual stop-watch time studies. This would have provided the shortest and easiest way to check the micromotion study data but, inasmuch as a large part of the study has been carried on in locations far removed from the original location, it was impractical to make such a comparison.

The synthetic data which has been developed here, then, is based on longer elements which are more easily distinguished. These elements have been defined, and the time for each determined by converting the number of frames per element over into minutes per element. As the film was taken at 32 frames per second, one minute becomes equal to 1920 frames or one frame takes 0.000521 minutes.

The discussion of synthetic data will include three factors for each element studied. First, the individual elements will be identified. Then, the starting and stopping points for each element will be described and set. This is of great importance in any time study, as the lack of correctly identified beginning and ending points makes the study practically worthless for further use. The last factor in the discussion of the synthetic data will be a description of the way in which the time for each element was determined. The basic data for the development of elemental times is included in the appendix.

The basic elements for which times have been set were chosen for one reason. They are the elements which control the over-all time for the operation. Other work is often performed in conjunction with these elements, but those described here are the ones which, when combined, determine the cycle time for the operation. A list of the elements to be included follows:

1. Secure and place bottom caul board and first sheet of veneer
2. Adjust machine
3. Move to machine
4. Lay cores
5. Discard bad cores

6. Place sheet of veneer in position

7. Secure and place top caul board

8. Push finished bundle aside

The first element to be discussed, then, is composed of the movements necessary for the left sheet slinger and core layer to get the bottom caul board and first sheet of veneer from their respective piles and place them in position on the machine.

The beginning and ending points for the element have been established and identified in the following manner. The time for the element starts when the left sheet slinger takes his hands from the completed bundle after pushing it aside, and ends when the bottom caul board and first sheet of veneer are in position and the left sheet slinger releases them.

The time for this element was established by simply counting the frames between the starting and ending points previously established, and making the conversion over into time in minutes. The time arrived at for this element is 0.1458 minutes.

As this element occurred only once during the time interval covered by the film, it appeared desirable to use some means of verifying the time established from the film analysis. Some methods which might be used for such verification include presently recognized systems of synthetic data, stop watch checks, and existing company standards. Of these, the Methods-Time Measurement (MTM) system of synthetic data was chosen as a convenient method of checking times. This system was also selected because of a desire to apply it to an operation, such as the glue spreading operation, in the hope of determining how well it would apply to such work.

Use of the MTM data (6, pp. 42, 43, 112) resulted in a time for the first element of 0.2021 minutes. The procedure for obtaining obtaining this time is included in the appendix. Of the four element times checked by means of MTM data, the greatest difference between the times obtained from micromotion study and those using MTM data was noted for this first element. The time obtained by the use of the synthetic data was approximately 39% greater than that developed from the film analysis. This difference in times may possibly be explained by analyzing the manner of determining the motions upon which the MTM times were based. The motions which make up each element were determined by observation of the original film with distances moved being estimated, also from film observation. In the case of this first element, however, the situation differed considerably from the other three. Two men were involved in the performance of the element but only the one whose movements controlled or limited the time was studied. During part of the element this worker, a sheet slinger, was out of the field of the camera. Consequently, the pattern of motions which would normally be required to complete the element was used. With two men working together, however, there is a distinct possibility that one of the pair had the first sheet of veneer in position for an easier grasp by the other, thus eliminating the times required for bending and for arising from the bend. If this were so, then, the element time determined from using the MTM data would become

0.1655 minutes; a difference of approximately thirteen per cent when compared with the time obtained by micromotion study. From this viewpoint, then, the film analysis time seems to be more within reason. The MTM system makes no specific provision for adjustment of the time for an operation when two men are dependent upon each other in the performance of the task but it seems certain that there would be some effect.

During the analysis of any operation the problem of rating the performance of the operators arises. In this particular case it was obvious that pictures taken in slow motion would not be satisfactory for determining the performance level of the operators. To compensate for this inability to rate from the film, then, the crew selected as the subject for the film was the group which the company management felt would be most representative of all crews on the operation. The times obtained from the observation of this representative crew can be considered as normal, then, and any rating of performance by other means will be unnecessary.

The second element for which a time was set consists of the adjustment of the glue spreading machine. This occurs whenever a new bundle of panels is started.

The following terminal points were established for this element. The element starts when the left sheet slinger releases the caul board and first sheet of veneer, and ends when his hand leaves the machine after making the adjustment.

The time established for this element was also based on only two observations. The number of frames between the beginning and ending points was counted, converted to time in minutes, and the time of 0.0273 minutes set for the element.

The fact that only two observations were available for use in the analysis again emphasizes the desirability of having additional data or of confirming the time by one or more of the methods previously mentioned. A comparison with MTM data for this element brought a value much closer to the study time than was obtained for the first element. A time of 0.025 minutes was obtained by the use of synthetic data, as shown in the appendix. When this value is compared with the time obtained by film analysis the difference is only 7.4%. There was, however, a wide variation between the times obtained from the two observations made for this element. One of the two values obtained was actually less than the time established by the use of the MTM data while the other was considerably higher. This variation, from 45 frames in one case to 60 frames in the other, indicates that the actual time cannot be standardized and thus is not an appropriate subject for the application of the synthetic MTM data.

The third element to be timed consists of motions necessary for the core layer to move back into position at the machine after finishing one layer of cores.

Limits were set on this element so that it would fit in with the others with no overlapping. Timing was started after the sheets of veneer were in place, and the core layer was starting back to his working position. The element was considered as ended when the core layer was back in position and ready to grasp the first core from the machine.

Twenty observations were available for use in setting this time, giving a great deal more accuracy to this time than to those previously discussed. Frames were counted for each occurrence, and an average value found and converted into minutes. The time established in this case was 0.0317 minutes for the element.

The next element considered was the simple one of taking the glued core from the rolls and placing it in position on the sheet of veneer.

Limits were placed on this element in the same way as on the others. The element was considered to begin when the core layer grasps a core coming from the rollers of the machine, and ends when his hand is in position just prior to grasping the next core.

More data was available for timing this element, and the results were quite consistent. Approximately one hundred occurrences were observed, and the frames counted, to establish a base for the element times. Of this number, seven were discarded because of certain factors which caused excessive variation in the observed times. The dominant factor affecting these discarded times was interference while waiting for the core feeder to sort out and discard bad cores. Having eliminated these questionable readings, a series of quite consistent times was obtained. The use of these times resulted in an average figure of 0.0210 minutes to lay a core.

As an additional comment upon this value, it is interesting to note that it was compared with times found from stop watch studies at the Albany plant, and was found to check quite closely when allowances for such factors as rest and fatigue were not included.

A question also arose concerning any difference in times which might exist as a result of differences in core widths. Times for cores under 12 inches in width were compared with cores whose width was greater than 12 inches, but no appreciable difference was found to exist.

The fifth element to be considered was the discarding of bad cores by the core feeder.

This element was considered to start when the core feeder grasps the defective piece of core, and ends when his hand is in position just prior to grasping another core.

Seventeen observations were made of this element, and frames were counted. In this case, however, two average values were found. A definite variation was found in times for various widths, with the result that an average time of 0.0160 minutes per core was established for cores of widths less than 12 inches, while an average value of 0.0203 minutes per core was set for those over 12 inches in width.

The next element for which a time was set is composed of the motions necessary for the two sheet slingers to carry one or two sheets of veneer to the machine and place the veneer in position.

The following limits were set for this element. The element was considered to start when the sheet slingers started to move the sheet or sheets of veneer and to end when the veneer was released after positioning it on the machine.

During the study of this element, 19 observations were made, and frames were counted for each. The observations were then averaged and converted to give a final value of 0.0468 minutes for the element. This element was also one for which stop-watch data was available, and the results from the two sources agreed quite closely.

The seventh element to be considered was that of getting the top caul board from the pile and placing it in position on top of the bundle of panels. This element is performed by the two sheet slingers.

The following end points were established for this element. The element is considered to start when the left sheet slinger's hands leave the top sheet of veneer, and ends when movement ceases, and the caul board is in position.

In determining the time for this element, frames between the two end points were counted and converted, with a resulting time of 0.0667 minutes. As the time set for this element is also based on only one observation, it again appeared desirable to confirm the value by the use of synthetic data.

The use of the MTM data, as described in the appendix, resulted in a time of 0.0674 minutes or a difference of only 1% when compared with the results of the micromotion study.

The eighth and last element studied is made up of the actions necessary to push the finished bundle of panels aside to a point where it will not interfere with the layup of the next bundle.

Limits were established so that the element time starts just after the top caul board is in position, and ends when the left sheet slinger takes his hands from the bundle after pushing it aside.

The time for this element was also established after only one observation. Frames were counted during this one occurrence, and a time of 0.0563 minutes was set for the element.

Here again, as in other cases where only one observation is available, further confirmation of the time is believed to be desirable. In this instance the element time was again synthetized by the use of MTM data, as illustrated in the appendix. A value of 0.0523 minutes was found by this method. This is a difference of approximately 7% when compared with the study time from film analysis. Although the difference between the times obtained by the two methods is somewhat greater for this element than for the previous one, it is comparable with the others and is believed to be reasonably accurate. The force required to push the bundle aside depends largely upon the friction present in the conveyor system and may vary widely; depending upon the types of bearings and their condition. As a result of this possible variation the element time, as obtained by the use of MTM data, would also vary, so that the time obtained should be considered only as a rough approximation.

The method of analysis used in this study has been intended to insure a high degree of accuracy in the resulting elemental times. The selection of a representative crew for observation has meant that a standard performance was approached, and that the regular method of performing the operation has been followed. This, coupled with a careful determination of times, means that the results should be quite accurate. To make the element times more easily available for future reference, they have been tabulated in Table 2. Having established these times and, using them in conjunction with other data available from the film and multi-man chart, cycle times can be predicted and comparisons made between the various alternatives previously discussed.

Table 2

TABULATION OF SYNTHETIC DATA
DEVELOPED FROM MICROMOTION STUDY

Element	Time in Minutes
1. Get and place bottom caul board and first sheet of veneer	0.1458
2. Adjust machine	0.0273
3. Move to machine	0.0317
4. Lay cores	0.0210
5. Discard bad cores: Under 12 inches wide	0.0160
Over 12 inches wide	0.0203
6. Place sheet of veneer in position	0.0468
7. Get and place top caul board	0.0667
8. Push finished bundle aside	0.0563

The use of the accumulated data to predict cycle times for the alternative methods under discussion will give one basis for comparison. The time to lay up a given quantity of plywood panels will be available, and the effects of the alternative methods on production can be compared. To obtain this base for comparison, cycle times will be determined by tabulating element times. The basic unit used for a cycle will be a single five-ply panel.

Before a valid comparison can be made, however, the present method of performing the operation should be analyzed and a cycle time computed for it on the same basis as the proposed alternatives. The cycle for the present method will be shown in a modified time study form, and the alternatives will be described by enumerating the differences from the present cycle. The elements and times which make up the present method are shown in Table 3. Other data gathered from the film and multi-man chart includes the information that there are ten panels per bundle, that the average number of cores per layer is 6.4, and that the core feeder discards 1.05 cores per layer. An average time was

Table 3

PRESENT METHOD - CYCLE TIME
(PLYWOOD GLUING OPERATION)

Element	Element Time (minutes)	Occurrences Per Cycle	Total Time (minutes)
1. Get and place bottom caul board and first sheet of veneer	0.1458	0.1	0.0146
2. Move to machine	0.0317	2	0.0634
3. Lay cores	0.0210	12.8	0.2688
4. Discard bad cores	0.0182	2.1	0.0382
5. Place sheet of veneer in position	0.0468	2	0.0936
6. Get and place top caul board	0.0667	0.1	0.0067
7. Push finished bundle aside	0.0563	0.1	0.0056
		Total Cycle Time	0.4909
		Add 40% Allowance	0.1964
		Allowed Cycle Time	0.6873

used for discarding bad cores, as there was no way to predict the widths to be used other than to assume that they would be about the same as during the study period.

In order that the cycle times developed could be put on a workable basis, it was necessary to determine an appropriate allowance for fatigue, personal and unavoidable delays. This was determined by comparing actual production with theoretical production developed from the times found in this study. An estimate from the company management indicated that daily production of three-ply panels would be approximately 37,000 square feet. Converting this to an equivalent amount in five-ply panels gives a daily production of approximately 22,200 square feet or 694 panels. Using the cycle time found in this study, the daily production could be as high as 979 panels. Taking the difference between these two figures and dividing by the present production gives an allowance of 41%. For purposes of this study, then, this figure will be rounded off and an allowance of 40% will be used throughout.

The first alternative, as previously described, would have one sheet slinger lay the first core until the core layer returned to position. This would eliminate the time for the core layer to move back into working position, and would reduce the cycle time by the time for that element. With the elimination of that element, however, an allowance would have to be made for the adjustment of the machine by the sheet slinger, so that a pro rata share of the time for this element would have to be assigned to the cycle time for this alternative. Making these two changes, then, the cycle time for the first alternate method was developed as shown in Table 4.

For all practical purposes, the cycle time just determined can be used for the next two alternative methods. Both the suggestion that cores be fed first from one end of the work area and then from the other end and the suggestion that the core layer and sheet slingers rotate on their jobs would affect the cycle time in the same way as the alternative just discussed. The elimination of the time for the core layer to move back into position, and the addition of a share of the time for adjusting the machine, would be the only changes in cycle times for all three alternative methods.

Table 4

DEVELOPMENT OF CYCLE TIME
FIRST ALTERNATIVE METHOD

	Minutes
Present Method Cycle Time	0.4909
Subtract time for moving to machine	0.0634
	0.4275
Add time for adjusting machine	0.0027
Total Cycle Time	0.4302
Add 40% Allowance	0.1721
Allowed Cycle Time	0.6023

The fourth proposed alternative would have a somewhat different effect upon the cycle time. The proposal that cores be sorted before being brought to the core feeder would eliminate the time spent in sorting by the core feeder, and would reduce the cycle time accordingly. The subtraction of the time for the sorting element from the original cycle time gives the cycle time for this alternative, shown in Table 5.

Table 5

DEVELOPMENT OF CYCLE TIME
FOURTH ALTERNATIVE METHOD

		Minutes
Present Method Cycle Time		0.4909
Subtract time for sorting cores		0.0382
	Total Cycle Time	0.4527
	Add 40% Allowance	0.1811
	Allowed Cycle Time	0.6338

The most important result of the fifth alternative would be the elimination of one sheet slinger, rather than a reduction in cycle time. As a matter of fact, the cycle time would be increased slightly, due to the increased time for positioning the sheets of veneer on the machine. The increase in time would come, of course, from having the core layer turn around and assist the remaining sheet slinger in positioning the sheets of veneer. Under this method, the time required for obtaining and positioning the sheets would be approximately the same as for getting and placing the top caul board. In view of this fact, the latter time has been used in determining the cycle time for this alternative method. The new cycle time was found, then, by taking the original cycle time and substituting the element of getting and placing the veneer for the previous one of simply placing the veneer in position. Making this substitution, then, the cycle time was found as shown in Table 6.

Table 6

DEVELOPMENT OF CYCLE TIME
FIFTH ALTERNATIVE METHOD

	Minutes
Present Method Cycle Time	0.4909
Subtract time for placing veneer	0.0936
	0.3973
Add time for getting and placing veneer	0.1334
Total Cycle Time	0.5307
Add 40% Allowance	0.2123
Allowed Cycle Time	0.7430

The use of two core layers, as proposed in the sixth alternative, would have a variety of results, both good and bad. From the standpoint of changing the cycle time, however, the results would definitely be good. Studies have shown that the simultaneous use of both hands results in an increase in time of from 30% to 40% when compared with an operation performed with one hand (1, pp. 588-590). Using 40% as a reasonable figure, then, the time per unit would actually be decreased by 30%. Applying this reduction to the time for feeding and laying cores and assuming that the time for the core layers to return to their starting positions would be halved, the original cycle time would be reduced as shown in Table 7. Such a change would mean, however, that other factors would need to be considered. Would two core feeders be required, for example, to handle the work? As indicated previously, it is believed that one core feeder would be adequate, even though he would be slowed down somewhat by the necessity for feeding cores with both hands. Little would be gained if the use of two core layers meant that an additional core feeder would also be required. Another question which might be asked concerns the need for prepositioning cores before the core feeder begins working. It seems almost certain that cores would have to be prepositioned in order for the core feeder to feed with both hands simultaneously. This could probably be done, however, in much the same manner that the core feeder uses for obtaining cores under the present system. If the cores were stacked near him, as is presently done, then the core feeder should be able to preposition them during the time he is waiting for the sheet slingers to place the veneer and the core layers to move into position for the next layer of cores.

Table 7

DEVELOPMENT OF CYCLE TIME
SIXTH ALTERNATIVE METHOD

	Minutes
Present Method Cycle Time	0.4909
Subtract 30% of core laying time	0.0806
	0.4103
Subtract one-half time to move to machine	0.0317
Total Cycle Time	0.3786
Add 40% Allowance	0.1514
Allowed Cycle Time	0.5300

The next alternate to be considered would effect the cycle time much the same as the first three proposed alternatives. If the sheets of veneer could be prepositioned in a rack over the work area and fed automatically, there would probably be little change in the actual time for getting the veneer into position. If the veneer were guided down from above, however, the core layer could return to his position while the veneer was being positioned. The net result, then, would be the elimination of the time for the core layer to return to the other end of the machine. Consequently, the cycle time for this alternative would be approximately the same as for the first three. Although the change in cycle time does not indicate it, there would be other time savings involved, also. It will be shown later that where "pairing up" of veneer is required, as it would be for this proposal, two men working full time at such "pairing up" could supply two gluing machines and furnish approximately two-thirds of the material required by a third machine. As a result, then, the two sheet slingers could be taken from the individual machines and two of them set up to supply two machines completely and part of the veneer for a third gluing machine.

The last alternative method would reduce the cycle time in two ways. By edgegluing cores and clipping them to a standard width, sorting time would be eliminated, and the time to place a layer of cores could be reduced. For purposes of this study, a standard core width of 16 inches has been used as that width is handled easily, and fills the eight-foot panel with no waste. The next larger width, 24 inches, is in a range which would be more difficult to handle. After eliminating the time for sorting and changing the number of cores per layer, the cycle time was found as shown in Table 8.

Table 8

DEVELOPMENT OF CYCLE TIME
EIGHTH ALTERNATIVE METHOD

	Minutes
Present Method Cycle Time	0.4909
Subtract time for discarding bad cores	0.0382
	0.4527
Reduction due to change in number of cores per layer	0.0168
Total Cycle Time	0.4359
Add 40% Allowance	0.1744
Allowed Cycle Time	0.6103

As a means of more clearly illustrating the differences between the various alternatives, a tabulation will be made of the alternatives and their respective cycle times. This will show the differences between the alternatives on a time basis only. It is important that this fact be remembered, as some of the major changes have no effect upon the cycle times. The synthesized cycle times for the eight alternatives which were considered are shown in Table 9.

This comparison indicates that the effects of most of the alternate proposals are very nearly the same, with the exceptions of alternative number five, where the time increased, and the sixth alternative, where a much greater reduction in time was made than in any of the others. It would appear from this, then, that the sixth alternate proposal, the use of two core layers, would be by far the most advantageous. It must be remembered, however, that the advantage

Table 9

COMPARISON OF CYCLE TIMES FOR
EIGHT ALTERNATIVE METHODS

Alternative	Allowed Cycle Time (minutes)	% Change From Present Method
Present Method	0.6873	-------
1. Sheet slinger laying first core until core layer returns to position	0.6023	-12.4
2. Feeding cores first from one end and then from the other	0.6023	-12.4
3. Rotating as core layer and sheet slingers	0.6023	-12.4
4. Pre-sorting of cores	0.6338	-7.8
5. Core layer taking the place of one sheet slinger	0.7430	8.1
6. Use of two core layers	0.5300	-22.9
7. Prepositioning of sheets in rack over laying area	0.6023	-12.4
8. Edgegluing cores and clipping to standard width	0.6103	-11.2

is only one of time. Other important factors enter into an over-all comparison, and the effects of all of these factors must be considered before any final decision can be made. To make this over-all comparison, the various factors can be weighed on the basis of their effects on the cost of the operation and by this means a more valid decision can be made. In the final analysis, it is the cost involved that must be considered in determining the most advantageous alternative.

COST ANALYSIS

Analyses of the costs of alternative methods are commonly made in several different ways. Alternatives may be compared simply on the basis of the total cost of putting the plan into effect. This method does not, however, take into consideration the savings which may accrue as a result of putting the alternatives into use. Another method, then, is to consider the estimated annual savings as a return on the total investment, and compare the alternatives on the basis of their respective rate of return. Conversely, the comparison can also be made on the basis of the length of time needed for the estimated savings to repay the total investment.

These methods are not strictly applicable, however, to a comparison of the alternatives proposed in this study. Six out of the eight alternatives, for instance, require no investment in new machines or equipment. These six are concerned only with reductions in, or reassignment of, direct labor. The other two, as well as advocating changes in the use of direct labor, would require new machines and equipment. In order to obtain estimates of the costs involved in using such machinery, manufacturers of plywood and veneer machinery throughout the country were contacted and several quotations were received. From these quotations a representative estimate was developed for the costs involved in obtaining machinery for edgegluing and clipping cores. A list of the companies contacted is included in the appendix. No information was obtained, however, on any equipment resembling the rack proposed in the seventh alternative. Consequently, only a very rough estimate could be made by comparing with other somewhat similar pieces of equipment. In those cases where the cycle time was reduced, there would be a corresponding increase in production. This increased production is, quite naturally, an important consideration in making a final decision. Without a sales forecast or estimate, however, the final effect of changes in production cannot be determined.

The limitations which were previously imposed mean, then, that the comparison of alternatives must be modified to conform to these conditions. A modified cost reduction report will be included for each alternative, thus showing the effect of each one on the direct labor involved, as well as the additional costs for the last two alternatives. This will not, of course, provide a complete picture of some of the alternatives, so that other pertinent factors will be discussed whenever necessary to round out the study of that particular alternative. In making the calculations, an eight-hour day and a 21½-day month were used. Hourly rates used were those in effect at the time the study began; $2.03 per hour for the core feeder and core layer, and $1.88 per hour for the sheet slingers.

The savings possible from the use of the first alternative can be found quite easily. By having the sheet slinger lay the first core until the core layer returns to position, some of the idle time of this sheet slinger has been utilized, while nothing new has been added to the operation. The only change, then, is a reduction in cycle time for the operation as presently performed. The computation of the approximate savings for this proposal is shown in Figure 22 with approximate annual savings being $2000.

As was stated previously, the above estimate is based entirely on savings in direct labor, which is in turn based on the assumption that total annual production will remain the same as at present. It should be obvious, however, that whenever the time required to produce one unit is reduced the number of units which can be produced during a given period of time is increased. Providing that this increased production can be disposed of without creating new problems, the prospective increase in quantity is an important factor in the consideration of this alternative. A further reduction in unit costs may be realized when indirect and overhead costs which do not vary with production, are spread out over more units, thus reducing the amount applied to any one unit.

Another factor which should have a part in the evaluation of this alternative is that of possible effects on other operations. Shorter unit times and increased production for the glue spreading operation would mean that preceding operations would have to be speeded up to meet the material requirements of the glue spreaders with possible cost increases arising for these preceding operations. This same line of reasoning may also be applied to operations which follow the gluing operation in the overall process. These succeeding operations would require increased capacity to care for the greater number of panels being fabricated. This could be especially true of the press where there are definite limitations imposed upon both physical capacity and

COST - REDUCTION REPORT

DESCRIPTION OF ITEM INVOLVED

Dept.: Gluing — Date: 3/10/54

Operation: Gluing cores and panel layup — Product: Panels for press

Object Of Analysis: To determine possible savings from having one sheet slinger lay core until the core layer returned to position

COMPARISON

Present Method		Proposed Method	
Machine: Glue spreader		Machine: Glue spreader	
Tools:		Tools:	
Description: Core layer bends while veneer is carried over his head, then straightens and walks to position at opposite end of machine		Description: After placing a sheet of veneer one sheet slinger would lay core until the core layer had returned to position for work.	
Cost of Operations Involved	$ Per Panel	Cost of Operations Involved	$ Per Panel
Labor: 0.6873 minute per panel @ $7.82 per hour	0.0896	Labor: 0.6023 minute per panel @ $7.82 per hour	0.0785
Materials:		Materials:	
Misc.:		Misc.:	
Total of Above Items:	0.0896	Total of Above Items:	0.0785

ESTIMATE OF SAVING

Saving With Proposed Change: ($0.0896-0.0785) Equals $0.0111 Per Panel

Probable Yearly Requirements: 180,180 panels--present production

Estimated Savings Per Year (Based on 180,180 Per Year)--$2000

Figure 22

required processing time.

The additional considerations just pointed out could, in many cases, be more closely evaluated by further study of other operations. No matter how the evaluation was made, however, the final decision must be based on the consideration of all pertinent facts.

The savings possible from the use of the second alternative may be found in the same manner. The reduction in cycle time is the same as for the first alternative, and as no other changes have been made, the savings for the first two alternatives will be identical.

The calculation of the savings which would result from the use of the third alternative, however, must be made in a somewhat different manner. One of the disadvantages of having the core layer and sheet slingers rotate on their jobs was previously listed as being the probability of union demands for equal pay for all three of the men. Assuming that all three would be given the same rate that the core layer receives at present, the total annual cost for this method can be found, as shown in Figure 23. Considering, then, the increased labor cost and the reduced production time which would result from the third alternative's use, the total annual savings in labor cost would be approximately $1460.

The reduction in cycle time for this alternative means that such factors as increased production, lower overhead costs assigned per unit, and possible effects on other operations, as discussed previously, must be considered in an evaluation of this alternative.

An analysis of the costs involved in operating under the conditions proposed in the fourth alternative includes the same factors as in the

COST-REDUCTION REPORT

DESCRIPTION OF ITEM INVOLVED

Dept.: Gluing | Date: 3/10/54

Operation: Gluing cores and panel layup | Product: Panels for press

Object of Analysis: To determine possible savings from having the sheet slingers and core layer rotate on their jobs

COMPARISON

Present Method	Proposed Method
Machine: Glue spreader	Machine: Glue spreader
Tools:	Tools:
Description: Core layer bends while veneer is carried over his head, then straightens and walks to position at opposite end of machine	Description: After placing a sheet of veneer one sheet slinger would lay core while the other sheet slinger and the core layer handled the veneer. The three men would rotate after each layer of cores

Cost of Operations Involved	$ Per Panel	Cost of Operations Involved	$ Per Panel
Labor: 0.6873 minute per panel @ $7.82 per hour	0.0896	Labor: 0.6023 minute per panel @ $8.12 per hour	0.0815
Materials:		Materials:	
Misc.:		Misc.:	
Total of Above Items:	0.0896	Total of Above Items:	0.0815

ESTIMATE OF SAVING

Saving With Proposed Change: (0.0896-0.0815) Equals $0.0081 Per Panel

Probable Yearly Requirements: 180,180 panels--present production

Estimated Savings Per Year (Based on 180,180 Per Year)--$1460

Figure 23

first three, as well as the addition of another one. Pre-sorting the cores before they are brought to the core feeder decreases the cycle time, but is at least partially counteracted by the necessity for providing for sorting facilities somewhere else. If the sorting is done elsewhere, then one sorter should be able to supply more than one machine. This can be shown by using the synthetic data already developed. Taking the cycle time from which sorting time has been eliminated and dividing it by the time to inspect and sort one core, it is found that approximately 25 cores can be sorted during the time that one panel is being formed. As the average number of cores per panel is about 12.8, this means that one man, sorting full time, could supply two machines. In other words, one-half of his time should be charged to each machine in evaluating this proposal. Again using the present annual labor cost and deducting the savings due to decreased cycle time while adding the value of one-half the time of a sorter, the total annual difference in labor cost under the fourth alternative is estimated to be an increase of $515, as shown in Figure 24. In making this calculation, it was assumed that a core sorter would be paid at the same rate as the sheet slingers.

It is evident from the foregoing analysis that the success of this alternative would depend directly upon the number of pieces of core which were discarded per panel. This point can be well illustrated by the use of the following break-even point calculation to show when it would become advantageous to presort cores.

Let "x" = number of cores discarded per panel to break even

$$\frac{7.82}{60}(0.6338 + 0.0255x) = \frac{8.76}{60}(0.6338)$$
$$4.9563 + 0.1994x) = 5.5521$$
$$0.1994x = 0.5958$$
$$x = \underline{2.99} \text{ or } \underline{3} \text{ cores}$$

This calculation, then, determines how many cores must be discarded before the cost per panel becomes the same for both the present and proposed methods. From this the conclusion is reached that when less than three cores are discarded per panel, it is more advantageous to operate under the present system where the core feeder also does the sorting. If, however, the nuber discarded should rise above three per panel, then it would become more feasible to have the cores presorted before they reach the gluing operation.

In addition, a consideration of this alternative should include some attention to the additional space requirements for setting up a core sorting station.

Alternative number five presents a situation different from any yet considered. In this case, where the core layer replaces one sheet slinger, the analyst is confronted with an increase in the cycle time, elimination of one sheet slinger from the operation, and the necessity for "pairing up" the sheets of veneer before they are brought to the glue spreader.

The fifth alternative, then, has been evaluated with the following results. For purposes of determining the comparative value of "pairing up" the sheets of veneer, it has been assumed that one sheet of veneer can be handled in approximately the time that it takes to

COST-REDUCTION REPORT

DESCRIPTION OF ITEM INVOLVED

Dept.: Gluing Date: 3/10/54

Operation: Gluing cores and panel layup Product: Panels for press

Object of Analysis: To determine possible savings from having the cores sorted before they reach the gluing operation so that the core layer would not be required to sort.

COMPARISON

Present Method		Proposed Method	
Machine: Glue spreader		Machine: Glue spreader	
Tools:		Tools:	
Description: Core feeder inspects all cores and discards bad ones as he feeds them into the rolls on the machine		Description: Cores would all be inspected and defective ones removed before they were brought to the core feeder	
Cost of Operations Involved	$ Per Panel	Cost of Operations Involved	$ Per Panel
Labor: 0.6873 minute per panel @ $7.82 per hour	0.0896	Labor: 0.6338 minute per panel @ $8.76 per hour	0.0925
Materials:		Materials:	
Misc.:		Misc.:	
Total of Above Items:	0.0896	Total of Above Items:	0.0925

ESTIMATE OF SAVING

Saving With Proposed Change: (0.0925-0.0896) Equals $0.0029 (increase) Per Panel

Probable Yearly Requirements: 180,180 panels--present production

Estimated Savings Per Year (Based on 180,180 Per Year) -- $515 (increase)

Figure 24

place the top caul board in position. Using the increased cycle time and dividing by the time to handle one sheet of veneer in the "pairing up" operation, it becomes apparent that approximately eight sheets of veneer can be handled during the time required to form one panel. As there are three sheets of veneer used in each five-ply panel, this means that two men, devoting full time to "pairing up", could supply 37.5 per cent of the time of these two men should be applied to each machine while making this analysis. Men engaged in "pairing up" veneer will draw the same pay as sheet slingers. Considering the increases due to the increased cycle time and the "pairing up" operation and the decrease due to the elimination of one sheet slinger, there is an increase of approximately $250 in direct labor costs annually, as shown in Figure 25.

Additional space would also be required under this alternative for the "pairing up" operation. In this particular case, however, it is extremely probable that there would be more than ample space released when the veneer supply for the gluing operation was all placed in one pile, rather than several.

The use of two core layers, as proposed in the sixth alternative, again brings two conflicting factors under consideration. In this case, a sizeable reduction in cycle time is opposed by the addition of another core layer. Analysis and evaluation of these two factors resulted in an approximate saving of $470 in annual labor costs, as determined in Figure 26.

Here, again, as in other cases where the cycle time was reduced,

COST-REDUCTION REPORT

DESCRIPTION OF ITEM INVOLVED

Dept.: Gluing — Date: 3/10/54

Operation: Gluing cores and panel layup — Product: Panels for press

Object of Analysis: To determine possible savings from having veneer "paired up" so that one sheet slinger and the core layer could handle the placing of veneer

COMPARISON

Present Method	Proposed Method
Machine: Glue spreader	Machine: Glue spreader
Tools:	Tools:
Description: Sheet slingers select veneer from proper pile and carry it over the core layer's head into position on the machine bed	Description: Sheets of veneer are prepositioned on a single pile so that the core layer can turn around and assist the sheet slinger in positioning the veneer on the machine

Cost of Operations Involved	$Per Panel	Cost of Operations Involved	$ Per Panel
Labor: 0.6873 minute per panel @ $7.82 per hour	0.0896	Labor: 0.7430 minute per panel @ $7.35 per hour	0.0910
Materials:		Materials:	
Misc.		Misc.	
Total of Above Items	0.0896	Total of Above Items	0.0910

ESTIMATE OF SAVING

Saving With Proposed Change: (0.0910-0.0896) Equals $0.0014 (increase) Per Panel

Probable Yearly Requirements: 180,180 panels--present production

Estimated Savings Per Year (Based on 180,180 Per Year)--$252 (increase)

Figure 25

COST-REDUCTION REPORT

DESCRIPTION OF ITEM INVOLVED

Dept.: Gluing | Date: 3/10/54

Operation: Gluing cores and panel layup | Product: Panels for press

Object of Analysis: To determine possible savings from the use of two core layers.

COMPARISON

Present Method	Proposed Method
Machine: Glue spreader	Machine: Glue spreader
Tools:	Tools:
Description: Core layer places one layer of cores and then returns to starting point where the next layer is begun	Description: Two core layers would start from the middle and lay cores towards the ends of the veneer, returning to the center at start of each layer

Cost of Operations Involved	$ Per Panel	Cost of Operations Involved	$ Per Panel
Labor: 0.6873 minute per panel @ $7.82 per hour	0.0896	Labor: 0.5300 minute per panel @ $9.85 per hour	0.0870
Materials:		Materials:	
Misc.:		Misc.:	
Total of Above Items:	0.0896	Total of Above Items:	0.0870

ESTIMATE OF SAVING

Saving With Proposed Change: (0.0896-0.0870) Equals $0.0026 Per Panel

Probable Yearly Requirements: 180,180 panels--present production

Estimated Savings Per Year (Based on 180,180 Per Year)--$468

Figure 26

due consideration should be given to the possible increased production and related factors.

The seventh alternative proposal presents a situation which has not arisen in any of the proposals considered previously. In order to preposition the sheets of veneer in a rack over the laying area and feed them automatically, it is necessary that additional equipment be provided to carry on this work.

The cost of obtaining the necessary equipment should enter into any final evaluation, as well as the reduced cycle time, the elimination of both sheet slingers, and the necessity for "pairing up" the sheets of veneer. It would be extremely difficult to make an accurate estimate of the cost of the required equipment without having some preliminary designs for such equipment. Consequently, only a rough approximation has been made. The total cost was estimated to be $4000. To put this on an annual basis, comparable to the other items involved, the most commonly used depreciation method, the straight-line method, was used with an assumed write-off period of ten years to give an annual cost of $400. Annual cost of operation and maintenance is estimated to be approximately $200. Using these estimates, then, and considering the other factors previously mentioned, the estimated annual savings are found to be approximately $5654 in Figure 27. Further study of Figure 27 shows that the costs of putting this proposal into effect might go much higher than the estimate and the alternative would still be highly advantageous. If the costs were ten times as great it would still be a desirable change.

COST-REDUCTION REPORT

DESCRIPTION OF ITEM INVOLVED

Dept.: Gluing — Date: 3/10/54

Operation: Gluing cores and panel layup — Product: Panels for press

Object of Analysis: To determine possible savings from the use of a rack to hold veneer over the work area and feed it as needed

COMPARISON

Present Method	Proposed Method
Machine: Glue Spreader	Machine: Glue spreader
Tools:	Tools:
Description: After each layer of cores is completed the two sheet slingers place the next sheet of veneer in position	Description: Sheets of veneer would be prepositioned in a rack over the laying area and allowed to fall into position as needed

Cost of Operations Involved	$ Per Panel	Cost of Operations Involved	$ Per Panel
Labor: 0.6873 minute per panel @ $7.82 per hour	0.0896	Labor: 0.6023 minute per panel @ $5.47 per hour	0.0549
Materials:		Materials:	
Misc.:		Misc.: Operation and maintenance of feeding rack	0.0011
Total of Above Items:	0.0896	Total of Above Items:	0.0560

ESTIMATE OF SAVING

Saving With Proposed Change: (0.0896-0.0560) Equals 0.0336 Per Panel

Probable Yearly Requirements: 180,180 panels--present production

Estimated Savings Per Year (Based on 180,180 Per Year--$6054

Less Annual Cost of Change 400

NET ANNUAL SAVINGS $5654

ESTIMATED COST OF CHANGE

Total Cost of Change--$4000

Annual Cost of Change 400

New Method Would Pay For Itself In One Month

Figure 27

Looking at the problem from this viewpoint serves to better point out the importance of the seventh alternative proposal.

In addition to the cost of new equipment consideration should again be given to the possible benefits to be derived from increased production and associated factors.

The application of the last alternative would again result in the emergence of factors which must be studied in greater detail than were the first six alternatives.

In addition to the direct labor costs of performing the gluing operation, the additional costs of obtaining and installing the edge-gluing and clipping machines, furnishing the additional labor required, and operating and maintaining the new machinery. Information received on edgegluing and clipping equipment indicates that an electronic edge gluer and a veneer clipper would cost at least $30,000 to install. Such an installation would require two men who would probably draw about the same pay as the core feeder. Using the average speed of the edgegluer as a basis it should be possible for one such machine to supply approximately two and one-third gluing machines so that costs can be apportioned on that basis. The annual cost of change will again be figured on a straight-line basis using a write-off period of ten years. These factors, then, together with the decreased cycle time, would result in a approximate annual increase of $2838, as shown in Figure 28.

As was previously mentioned, the effects of possible increased production should also be considered here.

COST-REDUCTION REPORT

DESCRIPTION OF ITEM INVOLVED

Dept.: Gluing — Date: 3/10/54

Operation: Gluing cores and panel layup — Product: Panels for press

Object of Analysis: To determine possible savings from egegluing

COMPARISON

Present Method		Proposed Method	
Machine: Glue spreader		Machine: Glue spreader	
Tools:		Tools:	
Description: Cores of various widths are sorted and fed into the gluing machine in random order		Description: Cores would be inspected and good ones edgeglued and clipped to a standard width	
Cost of Operations Involved	$ Per Panel	Cost of Operations Involved	$ Per Panel
Labor: 0.6873 minute per panel @ $7.82 per hour	0.0896	Labor: 0.6103 minute per panel @ $7.82 per hour	0.0795
Materials:		Materials:	
Misc.:		Misc.: Operation and maintenance of new equipment	0.0187
Total of Above Items:	0.0896	Total of Above Items	0.0982

ESTIMATE OF SAVING

Saving With Proposed Change: (0.0896-0.0982) Equals $0.0086 Increase Per Panel

Probable Yearly Requirements: 180,180 panels--present production

Estimated Savings Per Year (Based on 180,180 Per Year)--(Increase) $1550

ESTIMATED COST OF CHANGE			
Total Cost of Change	$30,000	Less Proportionate Share of Annual Cost of Change	$1288
Annual Cost of Change	$ 3,000	NET ANNUAL SAVINGS (Increase)	$2838
Proportionate Share	$ 1,288	New Method Would <u>Not</u> Pay For Itself.	

Figure 28

In order that the results of this analysis can be compared more easily, the values found have been tabulated in Table 10. Such a tabulation of the values obtained provides a good picture of the relative values of the proposed alternatives.

Table 10

SUMMARY OF ESTIMATED ANNUAL SAVINGS
PLYWOOD GLUING OPERATION

Alternative	Annual Savings
1. Sheet slinger laying first core until core layer returns to position	$2000
2. Feeding cores first from one end and then from the other	$2000
3. Rotating as core layer and sheet slingers	$1460
4. Pre-sorting of cores	-515
5. Core layer taking the place of one slinger	-252
6. Use of two core layers	468
7. Prepositioning of sheets of veneer in rack over laying area	5654
8. Edgegluing cores and clipping to standard width	-2838

Note: Negative figures represent increases in costs

CONCLUSION

The purpose of this study has, in reality, been twofold. From the general standpoint, it was felt desirable to apply several methods and time study techniques to a basic operation in the plywood manufacturing process and obtain an indication of their value for future use in the industry. Such things as material flow charts, multi-man activity charts, micromotion study, synthetic data, and cost analysis procedures are all valuable aids when properly applied in other industries and very probably will prove of value in the wood products industries as well. More specifically, the study has been made to evaluate eight different proposals for revising the present glue spreading operation to determine which one, or ones, might be used to advantage.

The methods and time study techniques previously mentioned were found to apply to the plywood making process equally as well as to other industries where they have been used. The flow chart of materials passing through the plant served to illustrate the overall process as well as pointing out the importance of the gluing operation as it controlled both preceding and succeeding operations. On a more limited basis the multi-man chart pointed out very realistically the weak spots in the present operation and focused attention upon needed changes. The micromotion study procedure itself served to familiarize the analyst with the operation to a greater degree than is usually possible in the more casual types of studies. With the basic micromotion study accomplished the development of synthetic data allowed the synthesis of times for the various proposed methods, thus providing the basis for the final step, the evaluation of the alternatives from a money cost standpoint. It is quite apparent that all of these techniques have been valuable parts of the study. Each has been an integral part, without which the others would have been only partially complete.

The study of the various alternatives has served to illustrate various methods of analysis which can be used, as well as establishing the superiority of some of the proposed alternatives over others. The alternatives have been regrouped in Table 11 and listed in order of magnitude of estimated savings.

Table 11

TABULATION OF ALTERNATIVES
IN ORDER OF ESTIMATED SAVINGS

Alternative	Annual Savings
Prepositioning of sheets of veneer in rack over laying area	$5654
Sheet slinger laying first core until core layer returns to position	2000
Feeding cores first from one end and then from the other	2000
Rotating as core layer and sheet slingers	1460
Use of two core layers	468
Core layer taking the place of one slinger	252 (incr.)
Pre-sorting of cores	515 (incr.)
Edgegluing cores and clipping to standard width	2838 (incr.)

It should be noted that where one alternative is under consideration, it does not necessarily eliminate all of the other alternatives. In other words, it should be possible to have combinations of the proposed alternatives and realize even greater savings than for the individual proposals.

RECOMMENDATIONS

As a result of the study some concrete recommendations can be made with regard to future action on the material covered. First, it is recommended that the following four proposals for changes in the glue spreading operation be seriously considered for actual application:

1. Sheet slinger laying first core until core layer returns to position
2. Feeding cores first from one end and then from the other
3. Rotating as core layer and sheet slingers
4. Use of two core layers.

Naturally, not all can be used at once but where it is practical as many as possible should be used to give the greatest savings. Secondly, because of the substantial savings in direct labor which could be recognized from the seventh alternative, it is further recommended that consideration be given to the development of a rack for feeding the sheets of veneer. Great savings in labor could result from such a change and would make it well worthwhile to invest in the development of such a device.

This study has shown that substantial savings can be made in the gluing operation; only by actually putting the proposals into practice can the true results be known.

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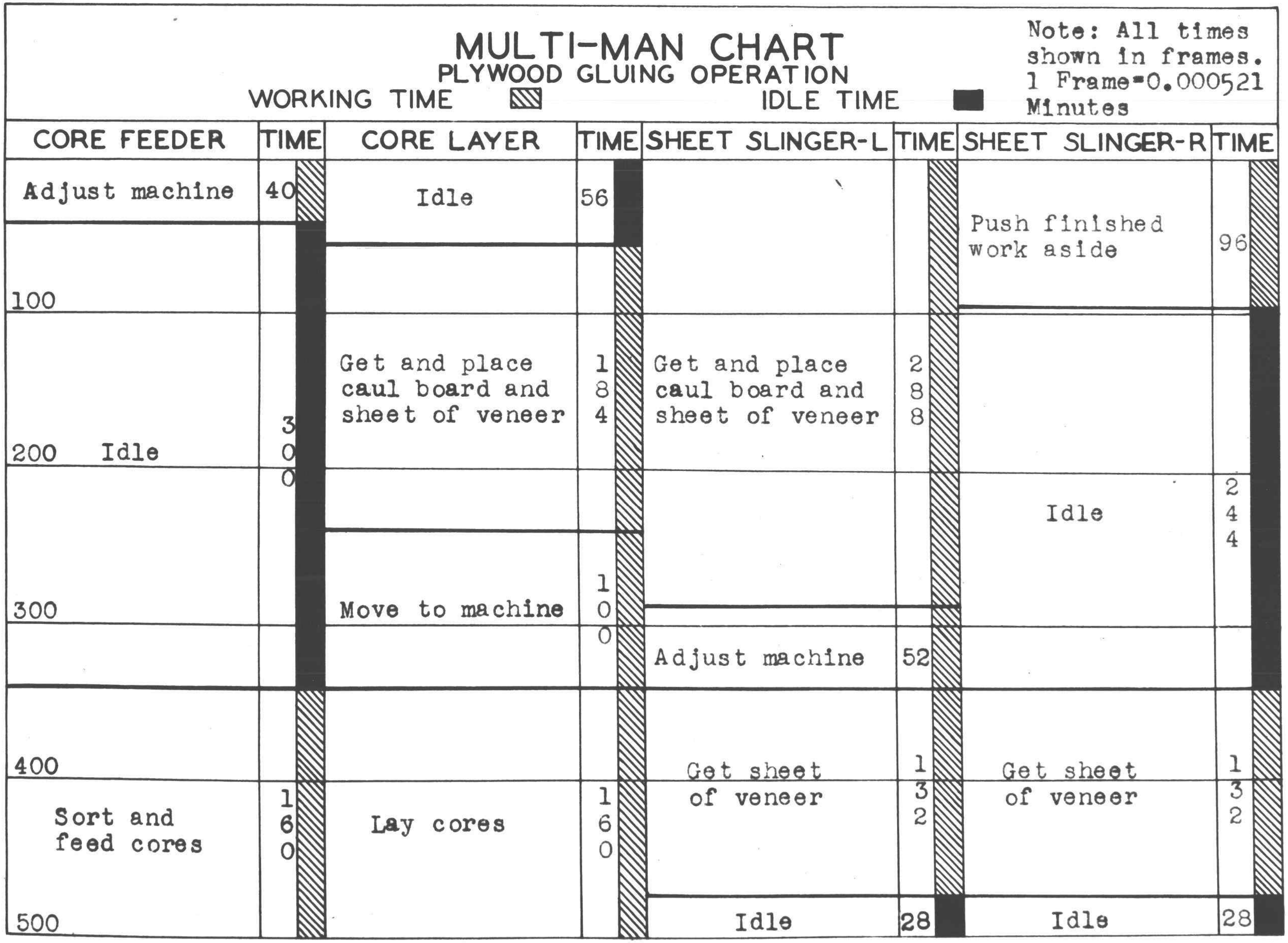
APPENDIX


MULTI-MAN CHART
PLYWOOD GLUING OPERATION
WORKING TIME
IDLE TIME
Note: All times shown in frames. 1 Frame=0.000521 Minutes
CORE FEEDER
TIME
CORE LAYER
TIME
SHEET SLINGER-L
TIME
SHEET SLINGER-R
TIME
Adjust machine
40
Idle
300
Sort and feed cores
160
Idle
56
Get and place caul board and sheet of veneer
184
Move to machine
100
Lay cores
160
Get and place caul board and sheet of veneer
288
Adjust machine
52
Get sheet of veneer
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Idle
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Idle
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Get sheet of veneer
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Idle
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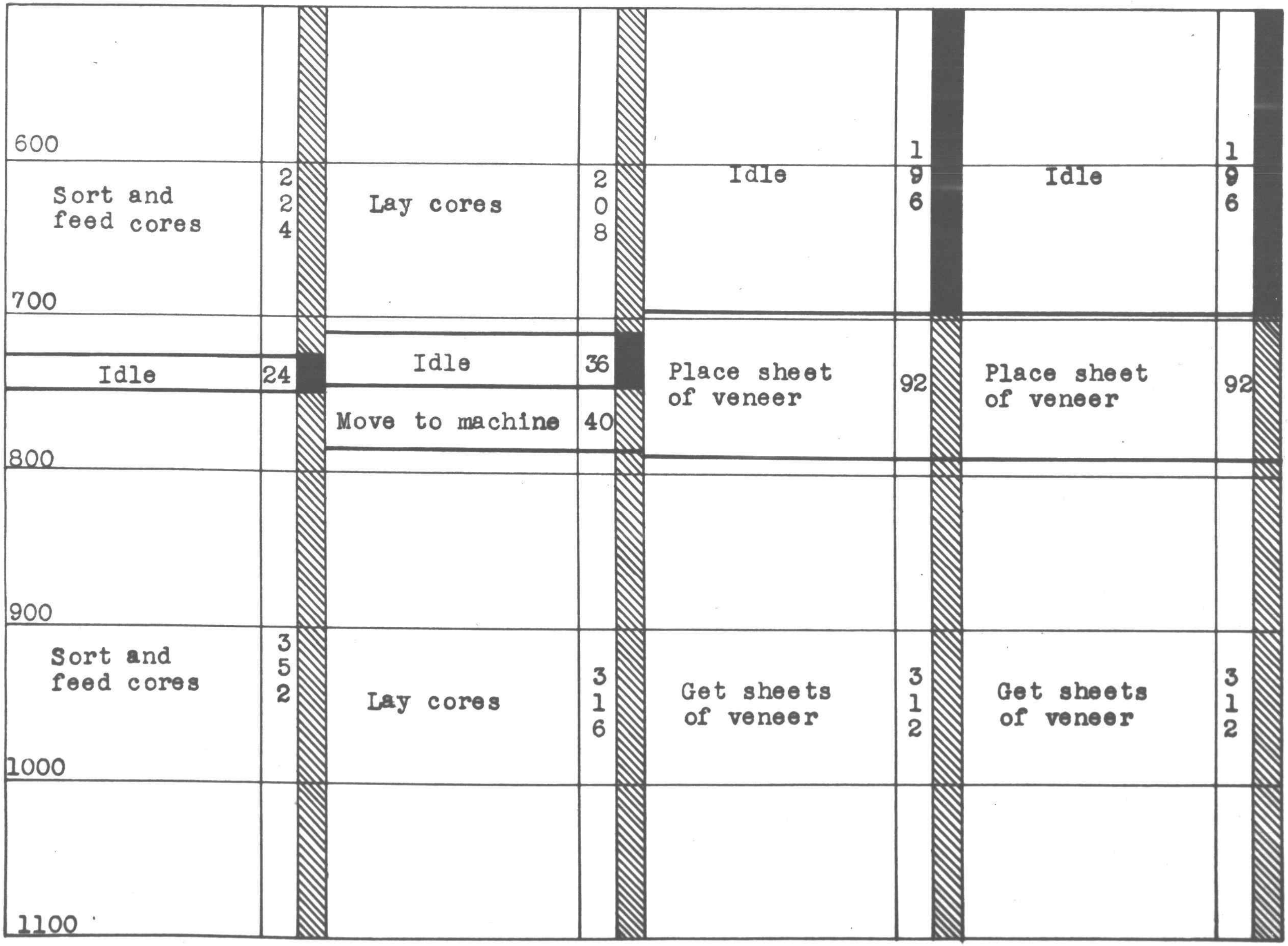
300
400
500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352
Lay cores
208
Idle
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40
Lay cores
316
Idle
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Get sheets of veneer
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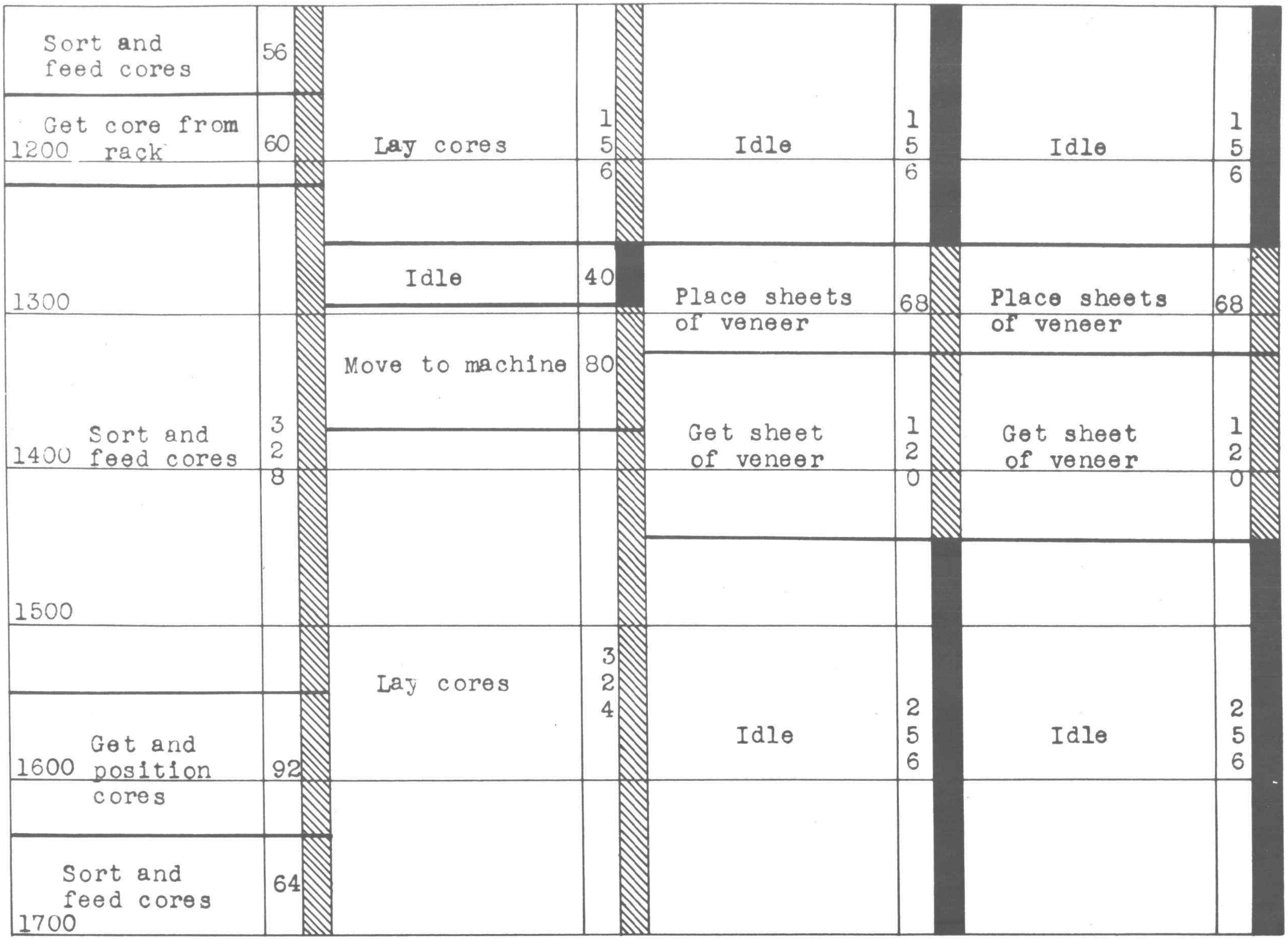
Idle
196
Place sheet of veneer
92
Get sheets of veneer
312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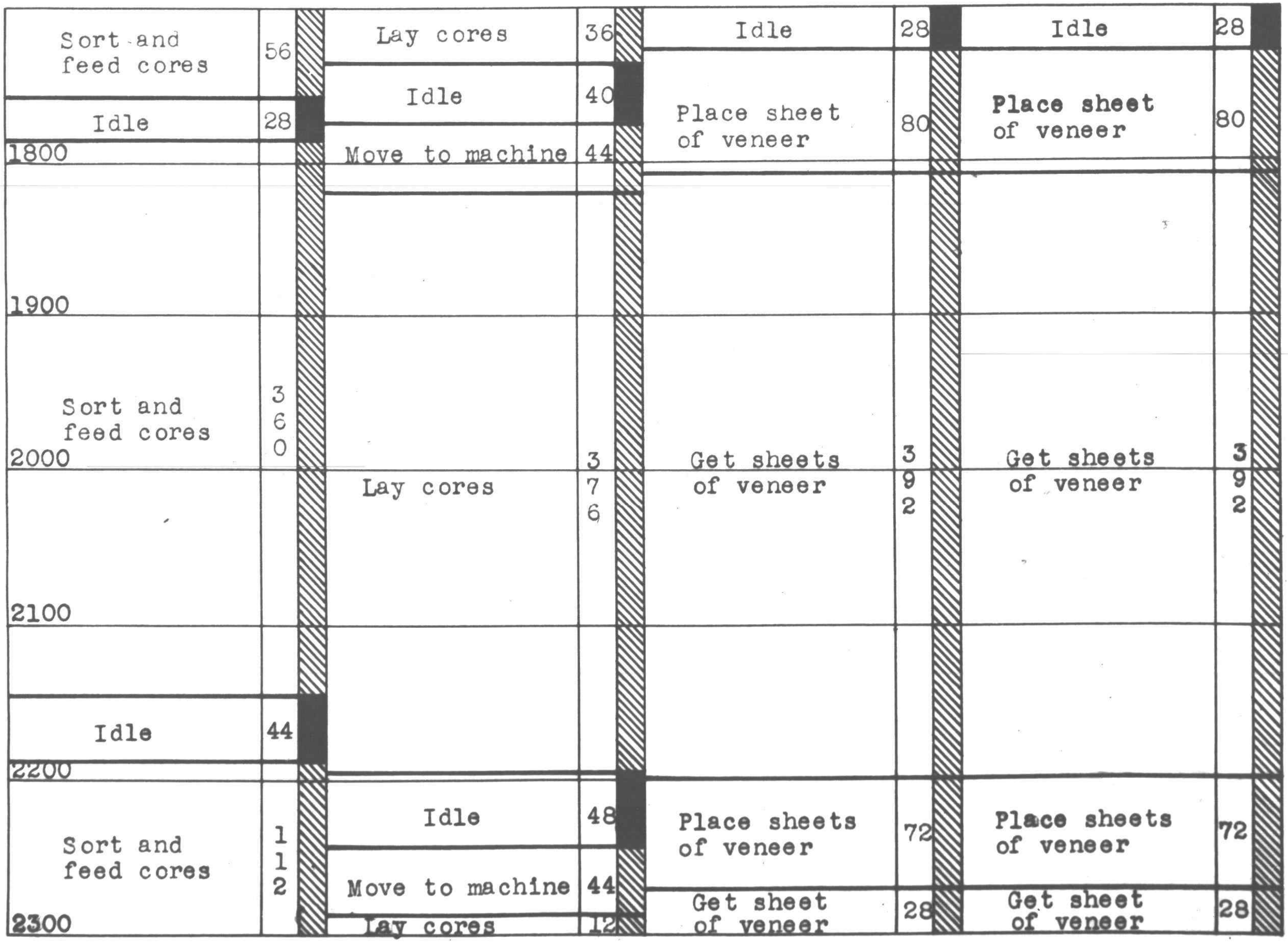
Get core from rack 60
1200
Lay cores 156
Idle 156
Idle 156
Idle 40
1300
Place sheets of veneer 68
Place sheets of veneer 68
Move to machine 80
Sort and feed cores 328
1400
Get sheet of veneer 120
Get sheet of veneer 120
1500
Lay cores 324
Idle 256
Idle 256
Get and position cores 92
1600
Sort and feed cores 64
1700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Idle
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1900
Sort and feed cores
360
2000
2100
Idle
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2200
Sort and feed cores
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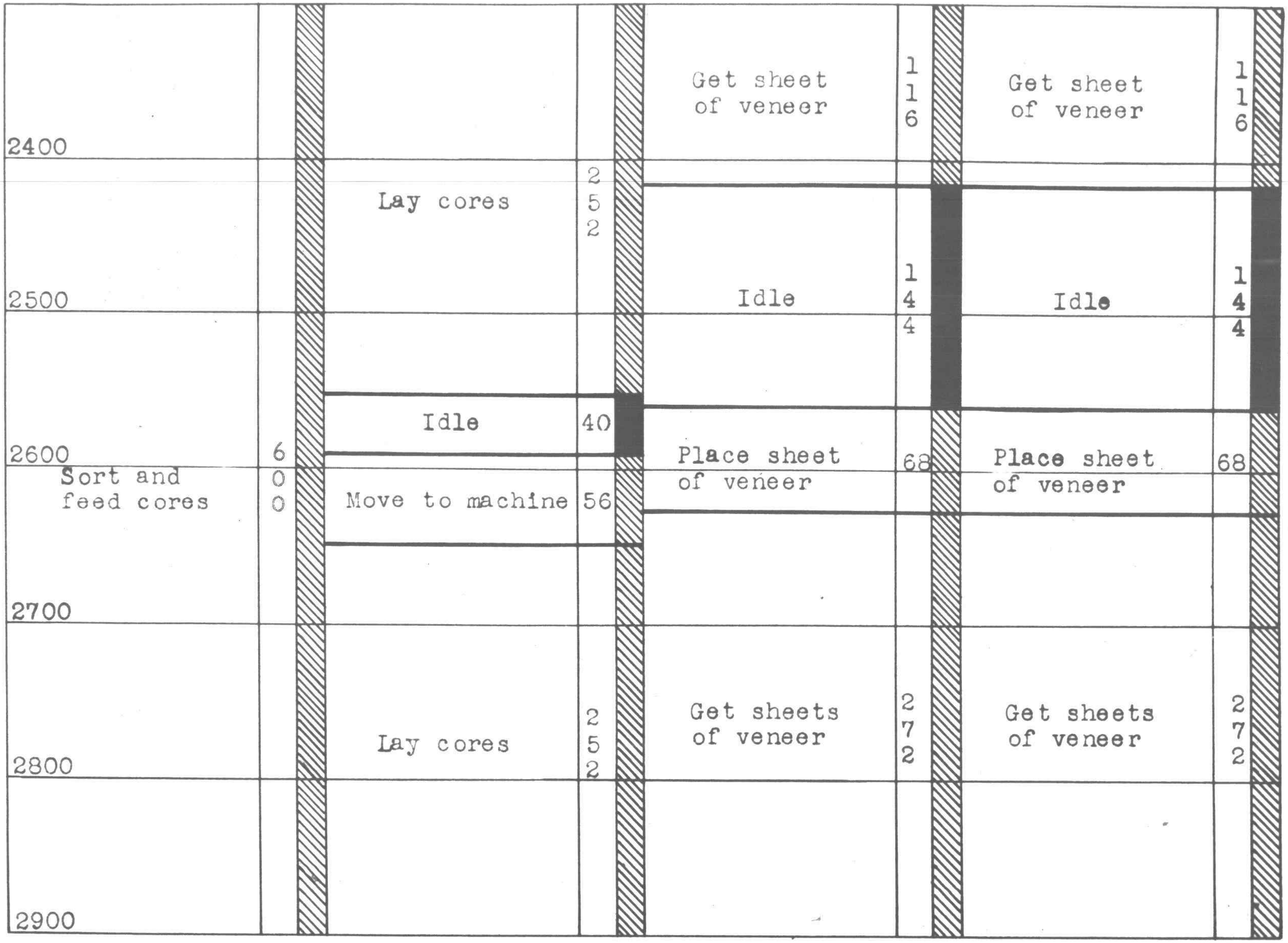
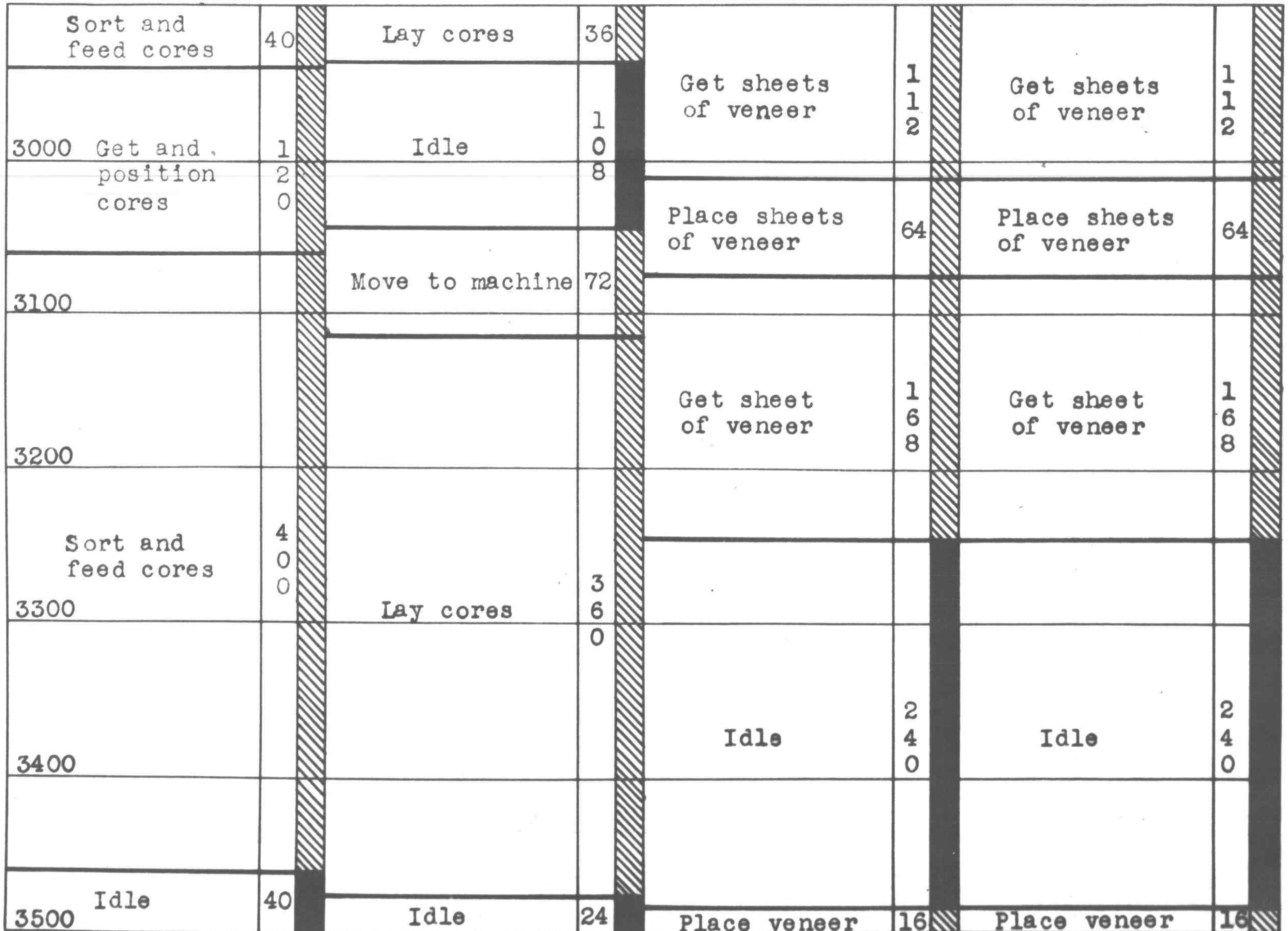
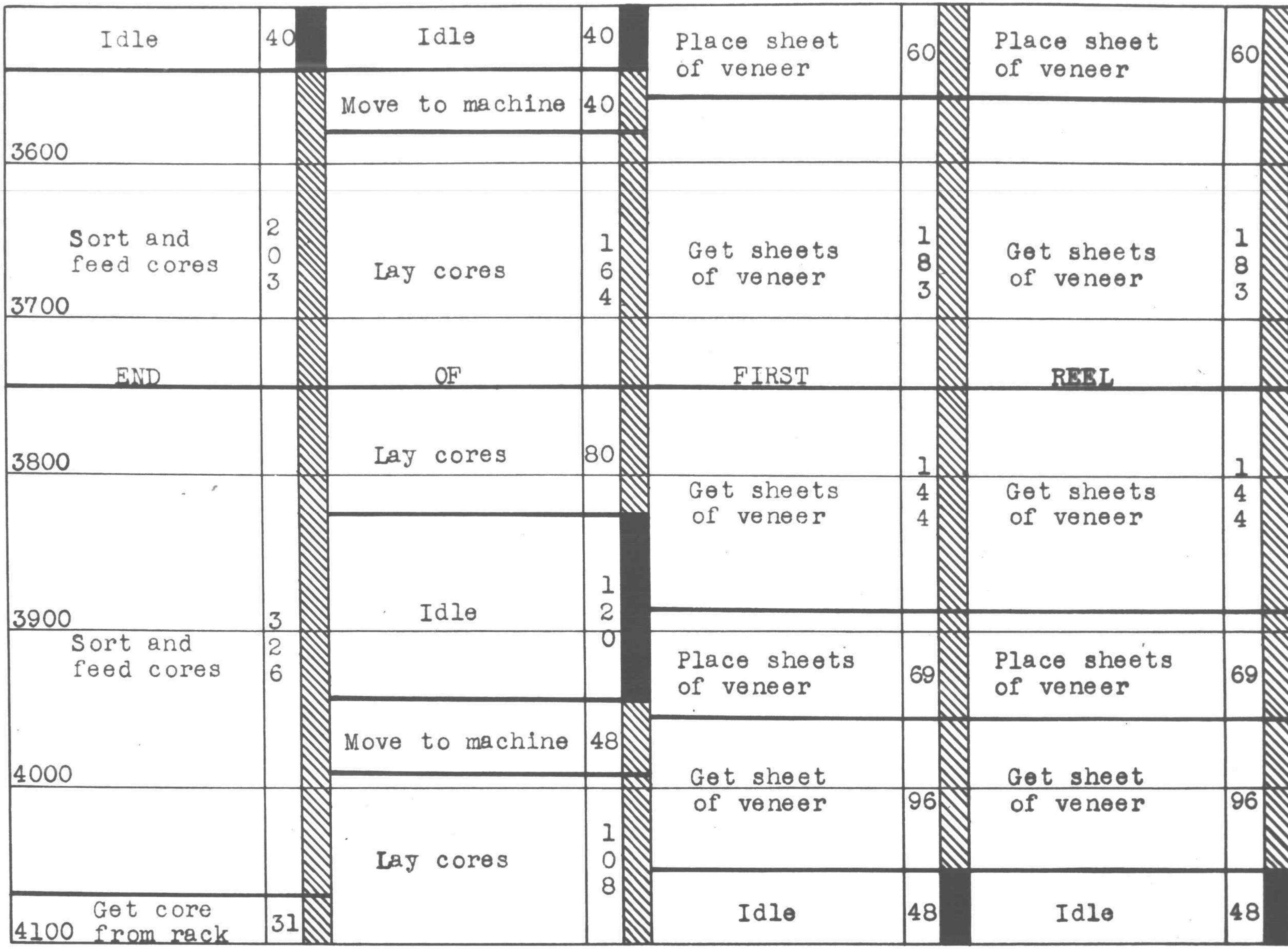
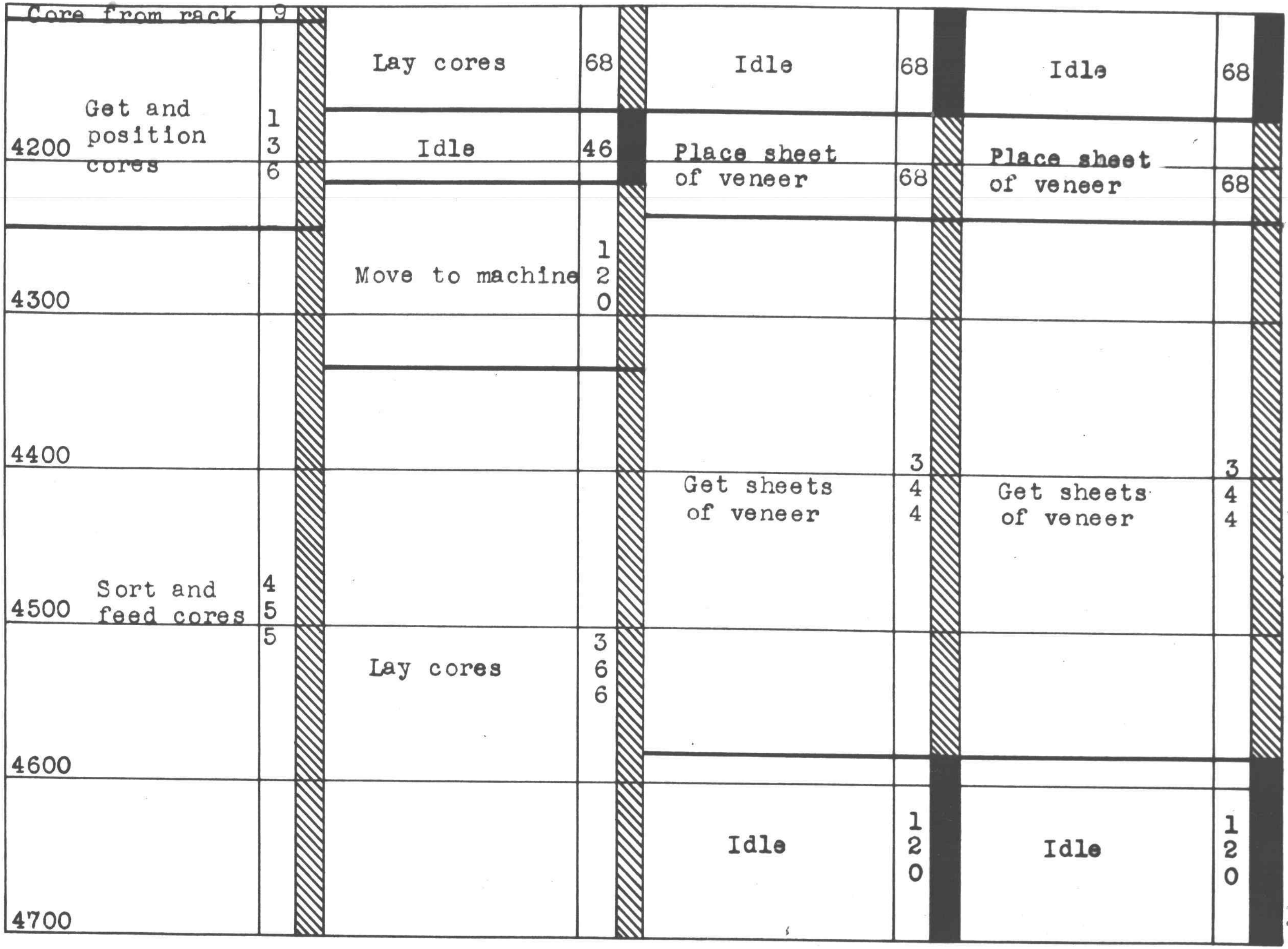
Lay cores
36
Idle
40
Move to machine
44
Lay cores
376
Idle
48
Move to machine
44
Lay cores
12
Idle
28
Place sheet of veneer
80
Get sheets of veneer
392
Place sheets of veneer
72
Get sheet of veneer
28
Idle
28
Place sheet of veneer
80
Get sheets of veneer
392
Place sheets of veneer
72
Get sheet of veneer
28

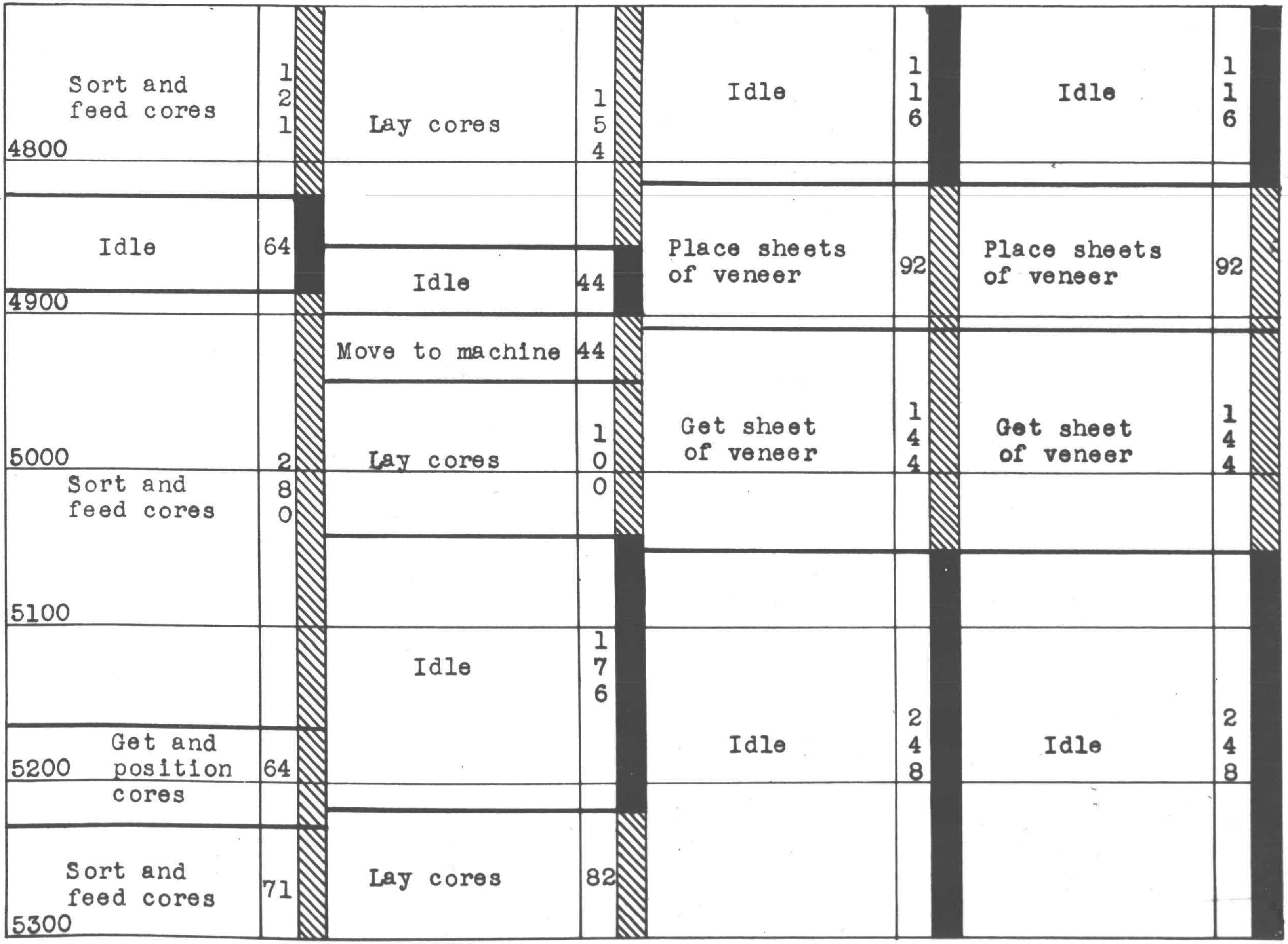


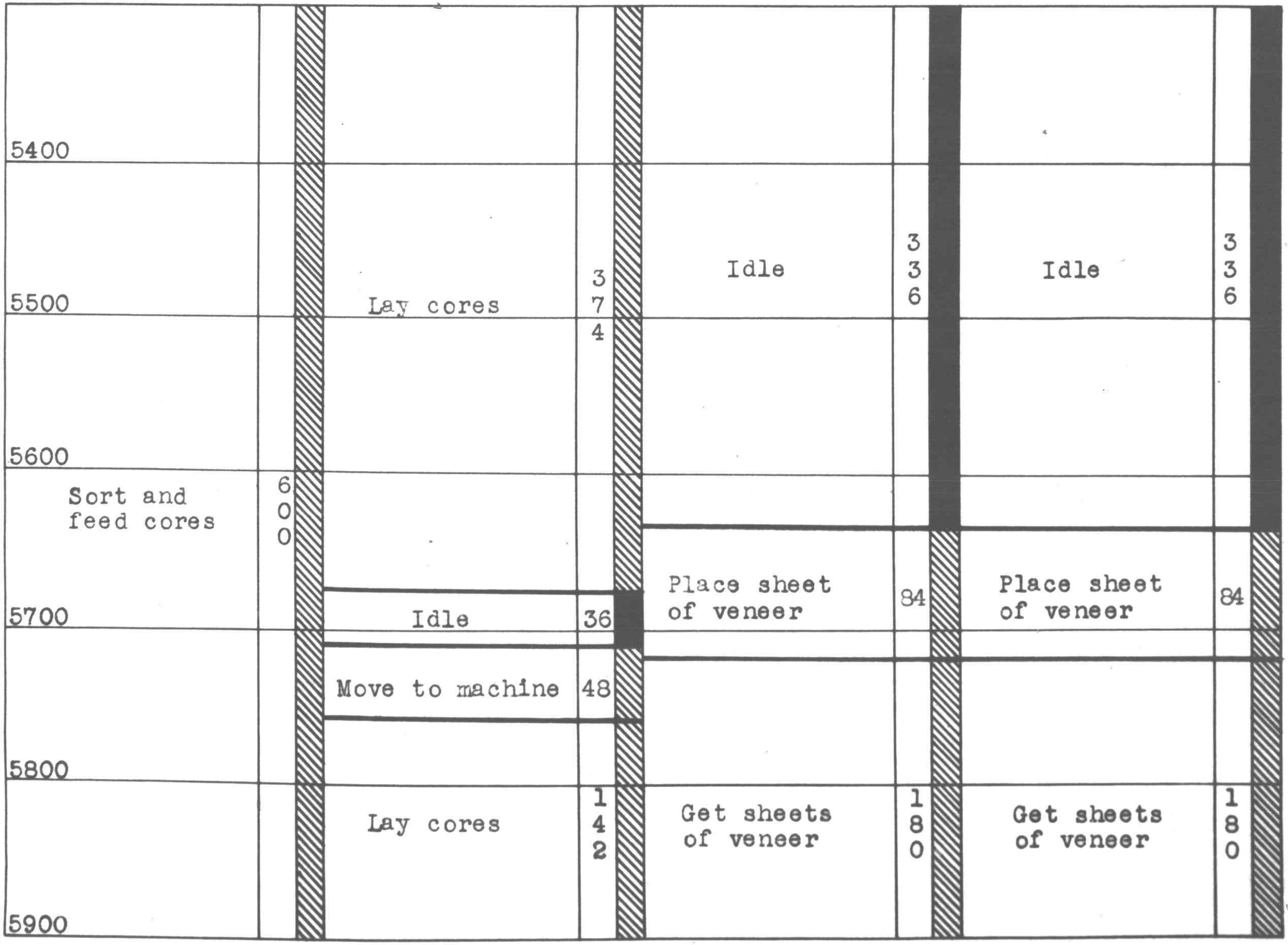
2400
2500
2600
2700
2800
2900
Sort and feed cores
600
Lay cores
252
Idle
40
Move to machine
56
Lay cores
252
Get sheet of veneer
116
Idle
144
Place sheet of veneer
68
Get sheets of veneer
272
Get sheet of veneer
116
Idle
144
Place sheet of veneer
68
Get sheets of veneer
272


Sort and feed cores 40
Get and position cores 120
Idle 40
3000
3100
3200
3300
3400
3500
Sort and feed cores 400
Lay cores 36
Idle 108
Move to machine 72
Lay cores 360
Idle 24
Get sheets of veneer 112
Place sheets of veneer 64
Get sheet of veneer 168
Idle 240
Place veneer 16
Get sheets of veneer 112
Place sheets of veneer 64
Get sheet of veneer 168
Idle 240
Place veneer 16

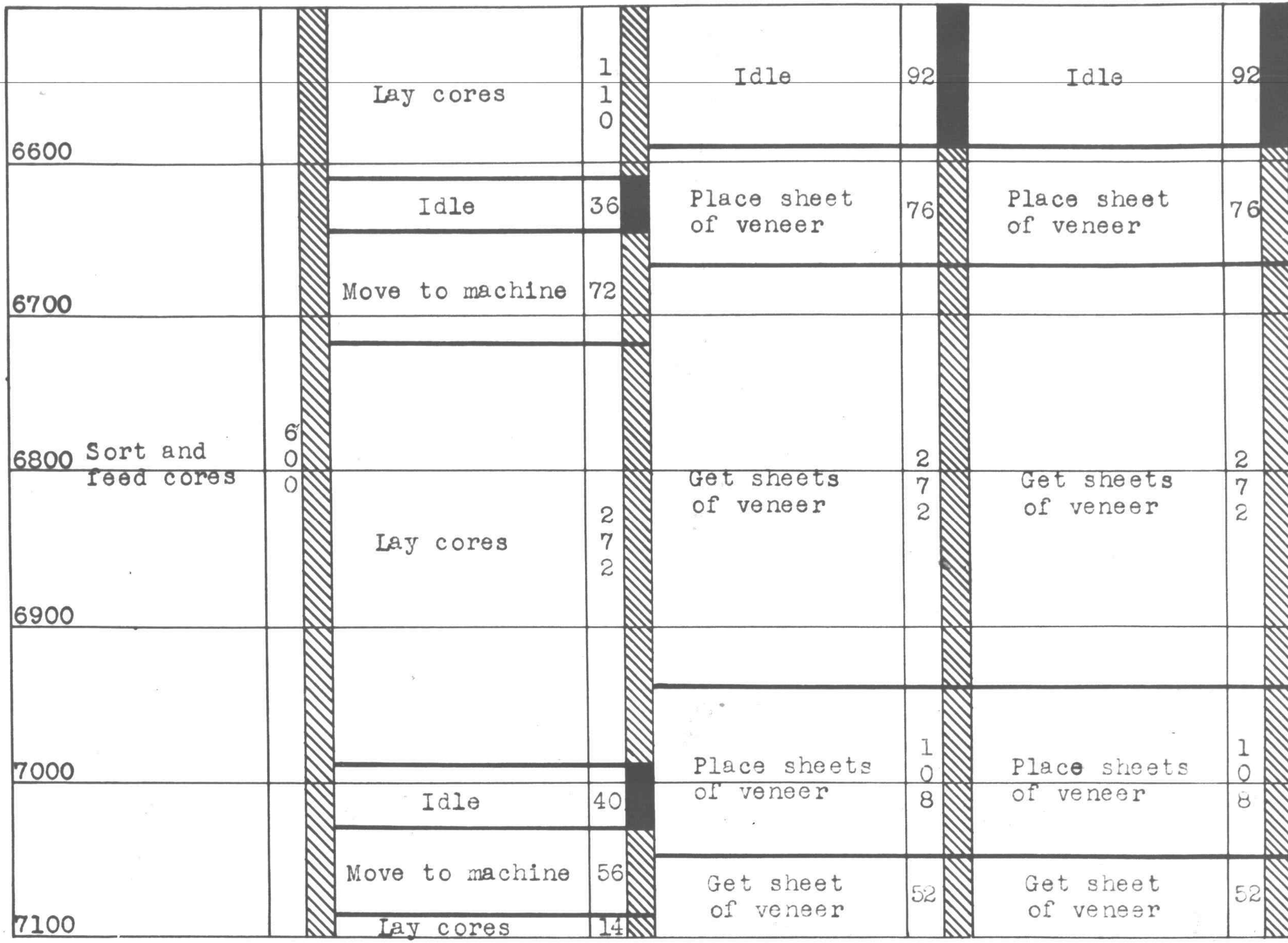

Idle
40
Sort and feed cores
203
END
3600
3700
3800
3900
Sort and feed cores
326
4000
Get core from rack
4100
31
Idle
40
Move to machine
40
Lay cores
164
OF
Lay cores
80
Idle
120
Move to machine
48
Lay cores
108
Place sheet of veneer
60
Get sheets of veneer
183
FIRST
Get sheets of veneer
144
Place sheets of veneer
69
Get sheet of veneer
96
Idle
48
Place sheet of veneer
60
Get sheets of veneer
183
REEL
Get sheets of veneer
144
Place sheets of veneer
69
Get sheet of veneer
96
Idle
48


Core from rack
9
Get and position cores
136
Sort and feed cores
455
Lay cores
68
Idle
46
Move to machine
120
Lay cores
366
Idle
68
Place sheet of veneer
68
Get sheets of veneer
344
Idle
120
Idle
68
Place sheet of veneer
68
Get sheets of veneer
344
Idle
120
4200
4300
4400
4500
4600
4700

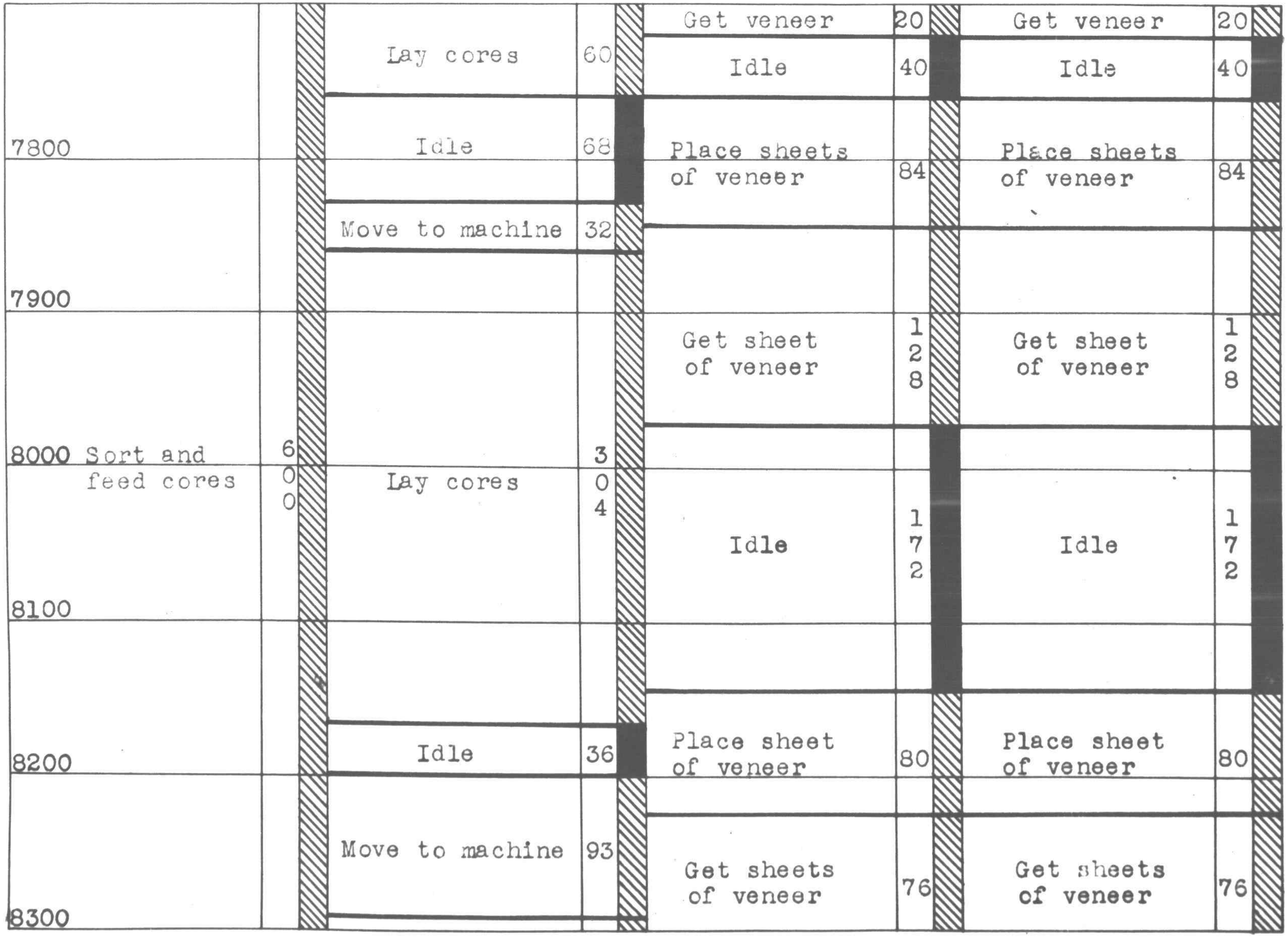

Sort and feed cores
121
4800
Idle
64
4900
5000
Sort and feed cores
280
5100
5200
Get and position cores
64
Sort and feed cores
71
5300
Lay cores
154
Idle
44
Move to machine
44
Lay cores
100
Idle
176
Lay cores
82
Idle
116
Place sheets of veneer
92
Get sheet of veneer
144
Idle
248
Idle
116
Place sheets of veneer
92
Get sheet of veneer
144
Idle
248

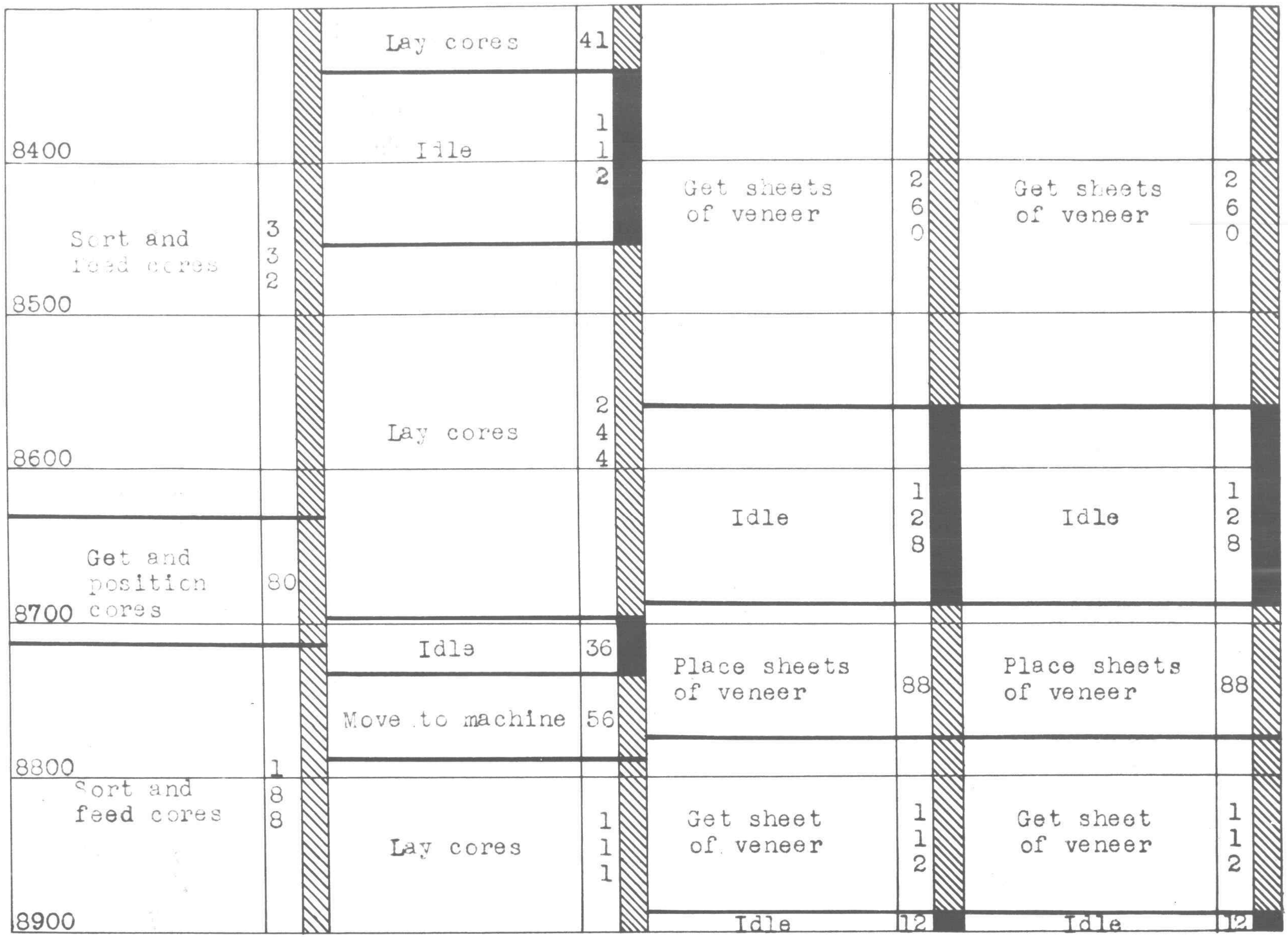

5400
5500
5600
5700
5800
5900
Sort and feed cores
600
Lay cores
374
Idle
36
Move to machine
48
Lay cores
142
Idle
336
Place sheet of veneer
84
Get sheets of veneer
180
Idle
336
Place sheet of veneer
84
Get sheets of veneer
180

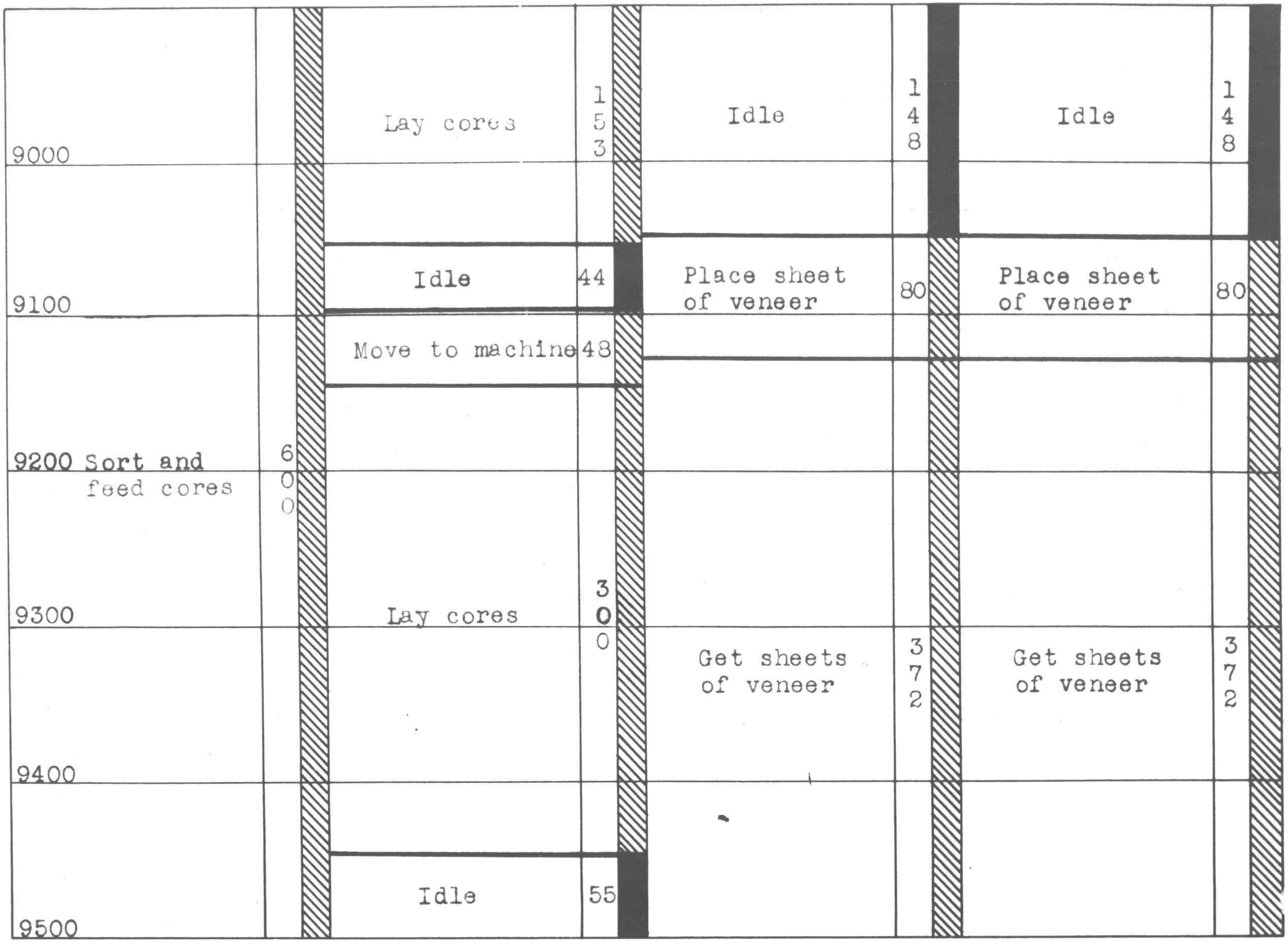

6000
6100
6200
6300
6400
6500
Sort and feed cores
343
Get and position cores
112
Sort and feed cores
145
Lay cores
206
Idle
46
Move to machine
82
Lay cores
266
Get sheets of veneer
188
Place sheets of veneer
88
Get sheet of veneer
168
Idle
156
Get sheets of veneer
188
Place sheets of veneer
88
Get sheet of veneer
168
Idle
156


6600
6700
6800
6900
7000
7100
Sort and feed cores
600
Lay cores
110
Idle
36
Move to machine
72
Lay cores
272
Idle
40
Move to machine
56
Lay cores
14
Idle
92
Place sheet of veneer
76
Get sheets of veneer
272
Place sheets of veneer
108
Get sheet of veneer
52
Idle
92
Place sheet of veneer
76
Get sheets of veneer
272
Place sheets of veneer
108
Get sheet of veneer
52

Time	Operation		Operation		Operation		Operation	
					Get sheet of veneer	124	Get sheet of veneer	124
7200	Sort and feed cores	223	Lay cores	254				
					Idle	112	Idle	112
7300								
	Idle	32						
			Idle	40	Place sheet of veneer	72	Place sheet of veneer	72
7400			Move to machine	44				
7500	Sort and feed cores	301	Lay cores	218	Get sheets of veneer	248	Get sheets of veneer	248
7600								
	END		OF		SECOND		REEL	
7700	Sort and feed cores	44	Lay cores	44	Get sheets of veneer	44	Get sheets of veneer	44


7800
7900
8000 Sort and feed cores 600
8100
8200
8300
Lay cores 60
Idle 68
Move to machine 32
Lay cores 304
Idle 36
Move to machine 93
Get veneer 20
Idle 40
Place sheets of veneer 84
Get sheet of veneer 128
Idle 172
Place sheet of veneer 80
Get sheets of veneer 76
Get veneer 20
Idle 40
Place sheets of veneer 84
Get sheet of veneer 128
Idle 172
Place sheet of veneer 80
Get sheets of veneer 76


8400
8500
8600
8700
8800
8900
Sort and feed cores
332
Get and position cores
80
Sort and feed cores
188
Lay cores
41
Idle
112
Lay cores
244
Idle
36
Move to machine
56
Lay cores
111
Get sheets of veneer
260
Idle
128
Place sheets of veneer
88
Get sheet of veneer
112
Idle
12
Get sheets of veneer
260
Idle
128
Place sheets of veneer
88
Get sheet of veneer
112
Idle
12


9000
9100
9200
9300
9400
9500
Sort and feed cores
600
Lay cores
153
Idle
44
Move to machine
48
Lay cores
300
Idle
55
Idle
148
Place sheet of veneer
80
Get sheets of veneer
372
Idle
148
Place sheet of veneer
80
Get sheets of veneer
372

					Get veneer	12	Get veneer	12
9600	Get and position cores	104			Place sheets of veneer	80	Place sheets of veneer	80
9700			Idle	328	Get top sheet	136	Get top sheet	136
9800	Adjust machine	220			Push away	100	Push away	100
9900								
10000								
10100								

Note: All times are shown in frames.

BASIC DATA USED TO CALCULATE ELEMENTAL TIMES

Element No. 3 - Move to machine.

Observation	Time(frames)	Observation	Time(frames)
1	100	11	44
2	40	12	48
3	80	13	82
4	44	14	72
5	44	15	56
6	56	16	44
7	72	17	32
8	40	18	93
9	48	19	56
10	120	20	48

Average is 60.95 frames or 0.0317 minutes

Element No. 4 - Lay cores

Observ.	Time-frames	Observ.	Time-frames	Observ.	Time-frames
1	36	35	38	69	36
2	48	36	44	70	40
3	34	37	36	71	46
4	38	38	34	72	46
5	36	39	36	73	34
6	38	40	34	74	48
7	50	41	40	75	36
8	32	42	36	76	40
9	44	43	38	77	42
10	40	44	36	78	40
11	32	45	34	79	38
12	56*	46	34	80	36
13	34	47	40	81	46
14	36	48	34	82	34
15	40	49	40	83	34
16	34*	50	64*	84	38
17	38	51	34	85	40
18	38	52	40	86	38
19	36	53	38	87	40
20	38	54	40	88	56
21	40	55	56	89	40
22	46	56	44	90	50
23	38	57	48	91	42
24	32	58	50	92	40
25	32	59	64*	93	42
26	56*	60	42	94	38
27	36	61	44	95	36
28	40	62	48	96	38
29	36	63	72*	97	64
30	44	64	44	98	44
31	38	65	92*	99	56
32	36	66	46	100	46
33	36	67	48		
34	40	68	42		

*Not used - delayed by core feeder
Average is 40.26 frames or 0.0210 minutes.

Element No. 5 - Discard bad cores.

Under 12 inches in width

Observation	Time(frames)
1	30
2	32
3	24
4	28
5	42
6	26
7	40
8	28
9	36

Over 12 inches in width

Observation	Time(frames)
1	32
2	30
3	58
4	48
5	32
6	44
7	28
8	39

Under 12 inches in width - Average is 31.77 frames or 0.0160 min.

Over 12 inches in width - Average is 38.88 frames or 0.0203 min.

Element No. 6 - Place sheet of veneer in position.

Observation	Time(frames)
1	94
2	84
3	88
4	96
5	112
6	84
7	76
8	96
9	88
10	76

Observation	Time(frames)
11	84
12	108
13	84
14	88
15	84
16	100
17	90
18	92
19	84

Average is 89.89 frames or 0.0468 minutes.

DEVELOPMENT OF ELEMENT TIMES USING METHODS-TIME MEASUREMENT DATA

Element No. 1 - Get and place bottom caul board and first sheet of veneer.

Reach 12 inches	R12E	11.8 TMU
Turn body	TBII	37.2
Walk 10 feet	W10'	53.0
Bend	B	29.0
Grasp sheet of veneer	Glb	3.5
Arise from bend	AB	31.9
Move sheet of veneer 30 inches	M30B5#	24.3
Move sheet of veneer 30 inches	M30B5#	24.3
Bend	B	29.0
Release veneer	RL1	1.7
Grasp veneer and caul board	Glb	3.5
Arise from bend	AB	31.9
Move veneer and caul board 30 inches	M30B15#	25.5
Move veneer and caul board 30 inches	M30B15#	25.5
Total		332.8 TMU
	or	0.1997 min.

Element No. 2 - Adjust machine.

Reach 28 inches	R28A	16.7 TMU
Grasp handle on machine	Gla	1.7
Turn handle 90 degrees	T90S	5.4
Apply pressure	AP	16.2
Release handle	RL1	1.7
Total		41.7 TMU
	or	0.025 min.

Element No. 7 - Get and place top caul board.

Turn body 90 degrees	TBI	18.6 TMU
Bend	B	29.0
Grasp caul board	G1b	3.5
Arise from bend	AB	31.9
Move caul board 30 inches against stop	M30A20#	29.3
Total		112.3 TMU

or 0.0674 min.

Element No. 8 - Push bundle aside.

Release caul board	RL1	1.7 TMU
Grasp bundle	G5	0
Turn body 45 degrees	TBI	18.6
Move 18 inches	M18B5#	17.0
Move bundle 30 inches	M30B25#	27.0
Move bundle 24 inches	M24B25#	22.9
Total		87.2 TMU

or 0.0523 min.

LIST OF COMPANIES CONTACTED
FOR INFORMATION ON PLYWOOD MACHINERY

American Manufacturing Company
Tacoma, Washington

Capital Machine Company
Indianapolis, Indiana

The Coe Manufacturing Company
Painesville, Ohio

The G. M. Diehl Machine Works, Inc.*
Wabash, Indiana

Lamb-Grays Harbor Company, Inc.
Hoquiam, Washington

Mann-Russell Electronics*
Tacoma, Washington

Merritt-Solem Division
Solem Machine Company
Lockport, New York

* Quotations Received