DEVELOPMENT AND DESIGN
OF
VENIER SCARFING MACHINERY

by

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Date thesis is presented June 1962

Typed by Mrs. Virginia Warneke
# Development and Design of Veneer Scarfing Machinery

## Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synopsis</td>
<td>3</td>
</tr>
<tr>
<td>Introduction</td>
<td>5</td>
</tr>
<tr>
<td>Strength Investigation</td>
<td>9</td>
</tr>
<tr>
<td>Testing Machine</td>
<td>10</td>
</tr>
<tr>
<td>Cutter Studies</td>
<td>14</td>
</tr>
<tr>
<td>Preliminary Scarfing Machine</td>
<td>15</td>
</tr>
<tr>
<td>Scarfer for Full Size Sheets</td>
<td>17</td>
</tr>
<tr>
<td>Scarfed Veneer Press</td>
<td>18</td>
</tr>
<tr>
<td>Design of Production Scarfer</td>
<td>28</td>
</tr>
<tr>
<td>Material Characteristics</td>
<td>28</td>
</tr>
<tr>
<td>Scarf Design</td>
<td>35</td>
</tr>
<tr>
<td>Machine Weakness</td>
<td>38</td>
</tr>
<tr>
<td>Practical Design Considerations</td>
<td>40</td>
</tr>
<tr>
<td>Major Criteria</td>
<td>42</td>
</tr>
<tr>
<td>Scarfer Design</td>
<td>42</td>
</tr>
<tr>
<td>Veneer Joining Equipment</td>
<td>54</td>
</tr>
<tr>
<td>Transport System</td>
<td>58</td>
</tr>
<tr>
<td>Press</td>
<td>60</td>
</tr>
<tr>
<td>Press Infeed and Outfeed Tables</td>
<td>63</td>
</tr>
<tr>
<td>Cut-Off Saw</td>
<td>63</td>
</tr>
<tr>
<td>Operation</td>
<td>64</td>
</tr>
<tr>
<td>Illustrations</td>
<td>2</td>
</tr>
<tr>
<td>Bibliography</td>
<td>67</td>
</tr>
</tbody>
</table>
ILLUSTRATIONS

Fig. 1. Plain scarfed veneer joint
Fig. 2. Preliminary veneer scarifying machine
Fig. 3. Infeed of preliminary veneer scarfer
Fig. 4. Rear view of saw, scarifying cutter, and glue spreader
Fig. 5. Front view of saw, scarifying cutter and glue spreader
Fig. 6. Off-bearing preliminary veneer scarfer
Fig. 7. Feeding preliminary veneer scarfer
Fig. 8. Joining and processing machine
Fig. 9. Scarfed veneer press—front
Fig. 10. Scarfed veneer press—rear and cut-off saw
Fig. 11. Stapling sheets on infeed table
Fig. 12. Pushing stapled sheets to press
Fig. 13. Cut-off saw with cover removed—sheet ready to be cut
Fig. 14. Veneer sheet cut-off
Fig. 15. Completed veneer sheet cut-off
Fig. 16. Scarf joints and modifications
Fig. 17. Diagramatic plan of production veneer scarifying machine
Fig. 18. Elevations of veneer scarifying machine
Fig. 19. Sections of veneer scarifying machine
Fig. 20. \( \frac{1}{4} \)-scale section of veneer scarifying head
Fig. 21. Semi-automatic scarfed veneer joining and processing machine
Fig. 22. Infeed table with aligning stops
Fig. 23. Sections thru infeed table
Fig. 24. Operation diagrams of scarfed veneer joining and processing machine
Fig. 25. Section of scarfed veneer press
SYNOPSIS

In the manufacture of plywood, veneers are used which are rotary cut or sliced. The veneers show the grain of the wood which may be of esthetic and structural value, but also reveal various defects which were in the parent block, along with those of manufacture.

It is usual to cut the veneers into sheets and sort them according to appearance and strength requirements, to arrive at standardized grades of plywood. The use of the higher quality veneer sheets is readily accepted. The lower quality sheets are not as readily accepted, and may require modification of width or length of panel to be economically marketed.

This paper deals with a process of scarfing and end joining veneers, and the machinery developed for this processing. A scarfed splice is one in which the ends of the pieces to be joined are beveled, one with an over bevel and one with an under bevel and joined by gluing, Fig. 1. The process is particularly adapted to the end joining of lower grade veneers, but can be extended to higher grade veneers and other products such as hardboard.

Since practical means have been developed for the end joining of veneers by scarfing, the matter of utilization of the process is one of economics. Joining by scarfing does not increase the quality, and in fact, might decrease the quality of high grade veneers and adds to the cost of manufacture. On the other hand veneer scarfing
PLAIN SCARFED VENEER JOINT

Fig. 1
allows an orderly flow of low grade veneers thru a plant, taking advantage of premium prices for length, and avoiding other lengths which must be sold at a discount.

INTRODUCTION

In the manufacture of Douglas Fir Plywood, logs are cut into blocks or bolts from which the veneer is peeled on rotary lathes. The length of the block will be a few inches longer than the desired finished panel length to allow for shrinkage of the veneer in drying and for trimming of the panel to get sound square ends. The blocks are usually handled and stored in water prior to peeling.

Peeler blocks are graded into different grades in accordance with the quality of the log and its defects. The best blocks are #1 peelers, and #2 and #3 peelers having progressively more defects. Other grades are used such as "peelable mill", "peelable cull", "Peewee", etc.

Veneers are also graded in accordance with their quality. The best veneers are grade "A", those sheets with more and more defects being graded "B", "C", and "D". It does not follow, however, that all of the veneer peeled from a No. 1 peeler block will be grade "A", nor that all the veneer peeled from a No. 3 peeler block will be grade "C", or "D". The following table indicates typical veneer recovery in a Northwest Oregon plywood plant:
Veneer Grade In Percent

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 Peeler</td>
<td>37</td>
<td>10</td>
<td>22</td>
<td>31</td>
</tr>
<tr>
<td>#2 Peeler</td>
<td>25</td>
<td>9</td>
<td>24</td>
<td>42</td>
</tr>
<tr>
<td>#3 Peeler</td>
<td>16</td>
<td>8</td>
<td>27</td>
<td>49</td>
</tr>
<tr>
<td>Paewee Peeler</td>
<td>8</td>
<td>7</td>
<td>32</td>
<td>53</td>
</tr>
</tbody>
</table>

Note particularly the large amounts of "C" and "D" veneers which develop in a typical operation.

The higher grade veneers are used for "faces" or the outside of a plywood panel. If both sides of the panel have equal quality veneers the panel has two faces. If one side is of higher quality, the lower quality side is usually referred to as the "back". A three ply panel might have two faces, or a face and a back with one layer of crossbanding or "core" between. A typical five ply panel may consist of a "face", a layer of crossbanding, a center, another layer of crossbanding, and a "back". A seven ply panel would have three crossbandings and two centers between the face and back.

While crossbanding, centers, and backs may be of lower quality, they do have specific requirements in the various grades. Plywood was originally made in "appearance" grades, but to better utilize the material, and due to the great abundance of lower grade veneers, the industry has developed "utility" grades, the principle one being called "sheathing". These panels are made entirely of low grade veneers.

Plywood plants making a single size panel such as 4 x 8 feet make up the excess low grade veneers into sheathing of the same size. Some plants, however, specialize in making high quality panels in sizes to suit customer requirements. Since the blocks must be cut...
to obtain the high grade veneers for these panels, and since there also develops a great amount of low grade veneer, these plants find themselves with an excess of odd-length, low grade veneer. This excess low grade veneer may be used in several ways:

1. They may be made up into odd length panels in the hope of finding an order to match them in grade and size, or failing to find an order they may be discounted to a price at which some customer will take them. This may involve long storage or uneconomic discounting.

2. The veneers may be cut to the next shorter marketable length. This may involve considerable loss of area, and in the case of short veneer it may have to be cut to be used in crossbanding.

3. Veneers may be stored until orders are available to make them up into panels suitable to their length. This practice has been widely used, but has several disadvantages. Stored veneers take up space, prevent an orderly flow of materials thru the plant, and tie up capital. Veneers also deteriorate with time and are damaged in repeated handling.

4. Odd length veneers may be spliced by scarfing to be recut into readily marketable lengths. Moreover, since some panel lengths bring a premium price, these lengths are available regardless of the initial stock length. Lengths longer than can be cut on the veneer lathes are available if desired.

DEVELOPMENT OF USE

An attempt to evaluate the economics of the various solutions
suggested is complex. The quantities of material involved varies with
the market demand. An odd length today may be a premium order tomor-
row. Assuming that veneers could be joined satisfactorily by
scarfing, and recut to a more desirable length, the process would
consume manpower and expense, without increasing the value of the
finished product. For example, 88 inch veneers scarfed and joined
endlessly and recut to 124 inches is no more valuable than veneers
of equal quality cut from 124 inch blocks.

The various disposal ideas were considered and discussed over a
period of several months between Mr. A. E. Anderson, then Vice-Presi-
dent and Plant Manager, Cascades Plywood, Lebanon, Oregon, and the
author. The idea of scarfing was introduced early in the discussions
by Mr. Anderson. Several inspections of our plant were made to deter-
mine the quantities of materials involved in our operation, and if
these quantities justified the required process machinery.

At the same time the author investigated the current practice
in scarfing lumber and made actual tests to determine if suitable
machinery could be developed for scarfing veneers.

Having determined that a practical process could be developed
for scarfing, joining, and recutting veneers to more desirable length,
and that a significant quantity of material was available which could
be profitably handled by this process, such equipment was built and
put into use. The original production schedule called for two hours
per day, but after a few weeks this was increased to four hours, then
six, eight, and ten hours per day, then to two shifts, and for several
years the equipment operated on three shift basis.

PRELIMINARY STUDIES — STRENGTH INVESTIGATION

The practice of making longer lengths by scarfing and gluing is quite common in lumber, particularly in glued-laminated beam and truss construction. Many other items are also extended by this method, such as venetian blind slats, furniture parts and just plain 2 x 4's. Also in the case of lumber, numerous variations are used such as finger joint, serrated scarf, square tooth scarf, Onsrud joint, etc. These variations are used mostly to reduce the length of the joint and thus save material. Tests by the Forest Products Laboratory and others indicate, however, that none of these are as efficient from a strength standpoint as the plain scarf. In the scarfing of veneers, due to their thin nature a plain scarf is not particularly wasteful of material.

A preliminary set of tests were made on one inch wide by six inch long strips of 1/8 inch thick veneer scarfed as follows: 1 to 12, 1 1/4 to 12, 1 1/2 to 12, 2 to 12 and 3 to 12. Ten pairs were made for each scarf angle except for 60 pairs with 1 1/2 to 12 slope. Ten pieces were also cut from the same stock, but 10 inches long for control samples.

These strips were sprayed on the scarfed surfaces with a Urea glue which was compounded for patch setting. The strips were allowed to dry for an hour and were then put together and joined between the hot platens of a patch setter machine at 500° F for 5 seconds.

The first set of tests did not reveal consistent results for
several reasons: First of all, it was difficult to hold the two dry scarf faces in proper position one above the other. This resulted in miss-matching, insufficient lap or excessive overlapping. The test samples were all broken by hand and observed for strength in comparison with the control samples and for bond by the amount of wood grain pulled. A few excellent bonds were made at all scarf angles.

Next, a set of ten samples with $1\frac{1}{2}$ to 12 slope were made up using a Resorcinol resin glue which was compounded for joining scarfed panels. This glue was applied with a brush and the pieces joined immediately. Since the glue was of a thick consistency it held the pieces in proper relationship for curing in the hot platen patch setter. It was also observed that any excess of overlapping which thickened the joint made the joint stiffer than the remainder of the strip with the result that the sample would break outside of the scarf area. This set of tests was consistently much stronger than the previous sets, with a greater amount of torn grain when the sample was broken near the scarf. The actual improvement was probably as much in technique as in the glue used.

With a few days of testing with improvement of techniques, as well as several glues specifically compounded for this application, the quality and consistency of the joints were greatly improved in bond and strength.

**TESTING MACHINE**

As samples of scarfed joints began to be made it seemed desirable
to have a quantitative test. Manual destruction and the observation "torn grain 60%" gave some preliminary information, but manual testing is an inadequate means of comparative testing. The manual destruction suggested that a bending test would be desirable, could give comparative test results, would be an actual stress test, and could be rapidly performed.

A testing device was accordingly made which consisted of a 16 inch square of 1 inch plywood with the corners rounded, with radii of 18, 16, 14, and 12 inches. A sample to be tested was simply bent around the various corners of this board, starting with the 18 inch radius, and working down toward the 12 inch radius.

This simple testing device is designed on the principle of a beam in simple flexure, the following assumptions being made:

1. Shear is neglected as being of minor effect.
2. The modulus of elasticity is the same in tension and compression.
3. The proportional limit is not exceeded.

With these assumptions (which are not quite, but nearly true), bending the strip around the curve will cause an equal elongation of the outer surface and contraction of the inner surface, the moment will be uniform around the curve, and the neutral axis will be the center of the strip—one half thickness from either face, (t/2).

Unit deformation, therefore, becomes

\[ d = \frac{t/2}{R} \]
in which:  

\[ d \text{ is deformation} \]

\[ t \text{ is thickness in inches} \]

\[ R \text{ is radius in inches} \]

By definition the elastic law is

\[ d = \frac{S}{E} \]

in which \( S \) is stress in extreme fiber in pounds

\( E \) is Modulus of Elasticity

Combining these two equations:

\[ \frac{t}{2} = \frac{S}{E} \]

\[ S = \frac{E \cdot t/2}{R} \]

Therefore, with strips 1/8 inch thick and with a modulus of elasticity, \( E = 1,600,000 \)

<table>
<thead>
<tr>
<th>( R )</th>
<th>( S )</th>
<th>( S/4 )</th>
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<tr>
<td>18</td>
<td>5,550</td>
<td>1,389</td>
</tr>
<tr>
<td>16</td>
<td>6,250</td>
<td>1,562</td>
</tr>
<tr>
<td>14</td>
<td>7,100</td>
<td>1,775</td>
</tr>
<tr>
<td>12</td>
<td>8,300</td>
<td>2,075</td>
</tr>
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The column of \( S/4 \) represents a factor of safety of four as suggested by DPPA, and thus is a recommended working stress.

The required working stresses for C and D veneers are: (1, p.11)

- For extreme fiber in bending \( 1,875 \)
- Tension in face grain \( 1,875 \)
- Compression in face grain \( 1,375 \)

On the testing device samples breaking on the 18 inch, 16 inch or 14 inch radii would be substandard, while those breaking on the 12 inch radius would be acceptable. Those samples not breaking on the 12 inch radius would be superior.
In stressing wood the time or duration of the test is an important consideration. For the purpose of rapid evaluation, our tests were retained for approximately three seconds, the sample being bent one way and then the other around successive corners of the testing device starting with the larger radius and working toward the smaller until failure, or the sample had passed the 12 inch radius test.

The following actual test results were obtained on a set of eight strips 1/8 inch thick with 1 1/8 to 12 scarf, using a glue compounded for this application:

One broke on 14 inch radius—most of spring wood pulled.
One broke about one inch from scarf on 12 inch R.
One cracked on opposite side from tip of scarf on 12 inch R.
One cracked about one inch from scarf on 12 inch R on reversal.

Four withstood 12 inch radius bend in both directions.

Solid control strips tested as follows:

One broke on 12 inch radius.
Two broke on 12 inch radius (one on reversal).
Five withstood 12 inch bend both directions.

This test is quite typical of results that could be obtained using C and D grade veneers with little selection except elimination of knots and knot holes. It is quite easy to select strips which will pass the 12 inch bend test 100 percent, and will approach 100 percent when scarf ed and glued. With the slight excessive overlap which was found desirable in the joint, the joint is stiffer than the remainder of the strip. The stiffer joint contributes to breaks at the end of
the scarf or outside of the scarf area.

After a few days use of the testing device the tests on the 18 inch radius and 16 inch radius were discontinued. The only significant tests were:

1. Failure on 14 inch radius test — substandard.
2. Passing 14 inch radius test — standard.
3. Passing 12 inch radius test — superior.

These tests proved the efficiency of the scarfed joint and its adequacy for the service requirements of C and D grade veneers.

Glues were compounded by our Standards and Quality Control Departments under the direction of Mr. Hugh Wilcox. This department also conducted soak tests, boil tests, shear tests, bond tests, etc. to establish the suitability of the scarfed joints to panel construction.

CUTTER STUDIES

In reviewing the various cutters that might be used for scarfing veneer, one of the types which seemed reasonable was the milling cutter. A 45° spiral milling cutter held at 45° angle to the end of a sheet of veneer and rotated would simulate a knife drawn from a point on the veneer toward the end of the sheet. With the milling cutter revolving rapidly and the end of the veneer sheet drawn under it at an angle of 45° and at a comparatively slow speed, the successive cuts of the cutter blades would be toward the end of the veneer. Furthermore, with the cutter mounted on a slope of 1 1/8 to 12 and the veneer sheet drawn along a flat backing bar the end of the
veneer would be sharpened, or scarfed, on that slope.

The first attempt to prove the feasibility of such a cutter was made July 18, 1952, using a small milling cutter mounted on a mandrel in an electric drill motor. The drill motor was clamped to a table inclined at an angle of about 2 in 12 and veneer sheets were drawn under the cutter at various horizontal angles. The veneer sheets were nailed between 1 x 6 boards to hold them, with the top board stepped back leaving the end to be scarfed exposed. It was observed that the end pull was quite strong and that considerable thrust was required to push the veneer through the cut. The veneer stock was selected for straight, soft, fine grain. The results were quite good.

PRELIMINARY SCARFING MACHINE

Next, a three inch diameter spiral milling cutter was mounted on a suitable mandrel which could be bolted to a 1 1/2 to 12 incline, adjacent to a suitable track with a carriage for carrying the veneer. The cutter was mounted over a brass backing bar over which the veneer projected from the carriage. Again the carriage consisted of two 1 x 6 boards two feet long, hinged together so they could be opened up to insert the veneer to be scarfed, and with teeth at two inch spacing top and bottom on the side next to the cutter. The teeth consisted of the points of shingle nails projecting 1/8 inch. The boards were clamped and held by hand while they were pushed past the scarifying cutter.

The cutter was rotated at 600, 1000, 1750, and 3000 revolutions
per minute, and at angles of $90^\circ$, $70^\circ$, $60^\circ$, $50^\circ$, $45^\circ$, $40^\circ$ and $35^\circ$ to the scarf edge.

At all speeds more damage is done at angles approaching $90^\circ$ to the veneer edge. At $90^\circ$ the veneer is picked up and completely dis-integrated. An angle of $70^\circ$ results in many damaged corners and damage may be continuous from knots, splits, or cross grain. An angle of $60^\circ$ largely eliminates the above damage. At angles below $45^\circ$ it was much harder to make a straight scarf. The edge tended to curve up to a feather edge, the $45^\circ$ to $50^\circ$ range seemed to give the most desirable cut. In this range:

Knots and cross grain — less damage at high speed.

Wavy stock — less damage at low speed — high speed scalps the top of ridges.

Pulled grain — about the same at all speeds.

Torn grain — less at moderate speed.

Soft wood, spring growth — eaten out worse at high speed.

Hard wood, summer growth — smoother cut at moderate speed.

End pull — greater at low speed.

Splits — not serious if securely held on both sides of split.

Tests were also run with two kinds of end mills of small diameter and at speeds up to 25,000 R.P.M. In general much greater care was required to keep the stock against the backing bar than with the spiral milling cutter. Any high spot would be planed off and the area near knots, and cross grain were usually completely torn out. A grinding wheel was used in place of the milling cutter and gave very good scarfs but a sufficiently open grained stone was not available.
In any event the pores of the stone soon filled with resin and wood fiber in which condition it burned the veneer.

These tests continued over a period of several months, during which time several three ply panels were made up and tested by our Quality Control Department.

**SCARPER FOR FULL SIZE SHEETS**

After it was substantiated that a satisfactory scarf, splice and panel could be made, the first production scarfing machine was designed and constructed. This machine consisted of a light structural frame carrying two inclined feed chains with pusher lugs, Fig. 2 to 7. The chains carried the stock past the cutoff saw, scarfing cutter and glue spreader and out of the machine where it was turned over and laid down by the off bearer.

After some preliminary operation by the author this machine was put in production on a two hour per day basis. As it proved its proficiency the time was gradually increased to three shift operation. After a period of three shift operation a further increase of production was needed, so a completely new double end scarfing machine was designed.

**SCARFED VENEER PRESS**

While it was possible to test samples and small pieces of scarfed veneer in patch setters and other available equipment, full sized sheets required a press which could press the full width at one time. Therefore, concurrently with the building of the first production
Fig. 5
scarf for a full sized press was built, Figs. 8, 9, & 10. The press proper consisted of top and bottom bolster of 12" x 12" wide flange beams connected by channels at each side. The channels made four corner posts which extended for legs. Laying on the top of the lower bolster were two 3½" fire hoses in flattened condition. On top of the hoses rested a ½" x 12" wide plate and above the plate was welded an 8" x 8" wide flange beam. By inflating the hoses with air the plate carrying the 8 WF beam (the moving platen) was raised toward the upper bolster. On the moving platen and beneath the upper bolster were mounted hot plates which engaged the scarfed joint for joining them. Each hot plate was 3" wide by 66" long. In the open position of the press the hot plates were about ½" apart. Each plate was heated by two 2000 watt electric heating elements and each was individually thermostatically controlled, Fig. 10. The usual range was 400 to 550° with the top element held 50° cooler than the bottom element.

In operation the hoses were inflated with air at 60 to 80 pounds per square inch, which corresponded to 180 to 225 pounds per square inch on the stock. The pressure was timed with an electronic timer which automatically exhausted the air to open the press in about 4 seconds.

The scarfed joints were placed in juxta-position by hand and were stapled near the edges with copper staples to hold alignment for inserting the sheets into the press, Fig. 11 and 12. Immediately at the rear of the press was a traveling saw which could be activated to recut the sheets to the desired length. Fig. 13 shows the saw
with cover removed, while Fig. 10 shows a sheet ready to be cut. Fig. 14 shows a cut being made and Fig. 15 shows the sheet cut off. It will be seen that this machine required two staplers and one operator of the press and saw units. The "operator" also fed the sheets along a fence thru powered rolls, and past an edge trimming saw after which they were automatically stacked, Fig. 8.

To increase the efficiency of pressing the scarfed joints, to eliminate the staples in the edges, and to reduce the man power requirements, a semi-automatic machine was developed which will be described in greater detail later.

DESIGN OF PRODUCTION SCARFER

MATERIAL CHARACTERISTICS

It would be well to consider some specific characteristics of the veneer to be processed. The veneers come from blocks that have been stored in the water for some period of time. The ends of the block soak up more water than is transmitted to the interior. Therefore, when the block is peeled, the ends still have more moisture. When the veneers are dried rather rapidly (in five to ten minutes) in the kiln, a great deal of shrinkage occurs, but due to the unequal distribution of moisture the ends are left distorted or wavy. In order to make a satisfactory scarf, therefore, the wavy ends must be "ironed out" or held flat during the scarfing process.

Another characteristic is the difference in texture of the soft spring growth, and dense, hard, summer growth, especially in the
coarser growth usually found in the lower grade products to be processed.

Another characteristic common to the low grade product was knots and the cross-grained areas near them, Figs. 8, 9, 13 and 14. This type of wood does not lend itself to low or moderate cutter speed. In fact, only high speed cutters of proper tooth shape and at light feed rates can "cut" this type of material cleanly.

Wood is a resilient material, and experience has shown that enough pressure to assure good, intimate contact is important in making glued joints. Excessive pressure, especially when accompanied by heat, will permanently crush the wood. The pressures usually considered good practice for Douglas fir are in the range of 100 to 225 pounds per square inch (3, p. 47-48; 4, p.4; 5, p.7; 6, p.10). The press for joining scarfed veneers was designed to be on the high side of this range.

As the scarfed joint developed for Douglas fir is a slightly overlapped joint, this assures that full pressure is exerted on the joint for good glue bond in the joining press. With the joint slightly thicker than the sheet thickness, the joint will be under considerably greater unit pressure than design pressure, since it is computed for a three inch width. The higher unit pressure, with the heat of the platen, will crush the joint until the platen is in contact for its entire width. This is not a cure-all for carelessly assembled joints, but is a practical way of obtaining good glue bonded joints when accurately assembled.

Wood is a humid atmosphere, contains a water percentage even
when it has just come from the veneer dryers. When this wood is subjected to the hot platens of the joining press the moisture content is accompanied by shrinkage which causes small checks or splits near the edges of the platen (2, p. 30-34). These checks are allowable in low grade veneers but would be considered defects in high grade veneers.

**SCARF DESIGN**

Figure 16 shows the scarfed joint as it has been developed. For plywood a plain scarf joint is used with modifications. The diagram, Fig. 16 (A), would indicate that the over and under bevels are both made to a feather edge, and joined exactly with a full lap. Fig. 16 (B) shows the actual scarf made by the first production machinery. Fig. 16 (C) indicates the modified joint as developed before pressing for the later machine. It will be noted that the scarfed sheets are not beveled to a feather edge, it being desirable to have a definite "end" on the sheets for purposes of aligning the lap. In the aligning, or registering of the ends they are actually pushed against stops at the infeed table of the joining press. Feather edges are not practical for exerting pressure against stops.

Fig. 16 (B) and 16 (C) also show that the sheets are lapped more than the full lap—the thickness is more than the sheet thickness. This over-full lap is called "overlapping scarf joint". The narrower and thicker joint area is subjected to higher unit pressure in the press, which is above the crushing strength of Douglas fir, especially in the presence of heat. The joint is therefore, crushed until
(A). Plain Scarf Joint

(B). Overlapping Scarf 4 x Full Before Pressing

(C). Modified Scarf 4 x Full Before Pressing

(D). Typical Scarf - Hardboard 4 x Full

Fig. 16
it is the thickness of the veneer sheet, at which point the pressure is distributed over the entire platen area, with consequent reduction of unit pressure below the crushing range.

With proper positioning of the lap, with slight excess preliminary thickness, and control of pressure, temperature, and time, the finished joint will be the same thickness as the veneer being joined. The joint will be slightly stiffer and more dense than the veneer from which it is made, and with available glues the joint approaches 100 percent efficiency. The fact that the ends are not scarfed to a feather edge, but given a quite definite thickness, is hardly discernable on finished joints in soft stock. On hard stock the square end appears as a "thumbnail" groove across the sheet, which is not objectionable in the grade. When these joined sheets are made into panels and sanded the joints give the appearance of feather edge joints.

Up to this point the scarfing of veneers only had been considered. Our operations do, however, also include a hardboard plant. A very useful combination panel can be made with plywood interior and hardboard faces. Since our production size of hardboard is limited to about 50 inches by 100 inches, the limiting size of such panels was 48 inches by 96 inches. By joining the hardboard by scarfing and recutting, any length would be available. The veneer scarfer should, therefore, also be capable of scarfing hardboard.

A hardboard scarf differs from a veneer scarf in several particulars. "Feather edges" are undesirable from an appearance standpoint, and are impractical. Any excess of overlap results in a
thick undesirable joint. Insufficient lap results in a weak, ineffective glue joint. A variation between a plain scarf and shiplap joint has been developed which gives quite satisfactory results. Fig. 16 (D) is a diagram of a typical scarfed joint for hardboard. Hardboard, having been formed at a pressure of 800 to 1000 pounds per square inch, is not compressible in the scarfed veneer press. Excess thickness cannot be allowed and compensated for as in the case of veneers. Feather edges are brittle and not suitable for pressure on the registering stops at the press infeed. Square cut ends can be concealed or made less conspicuous in a shiplap joint, or in the joint shown which is a practical modification from the shiplap joint. Since the hardboard sheets are comparatively flat, in contrast to the wavy nature of many veneer sheets, the square cut of the under beveled sheet end can be pushed in contact with the shoulder cut at the end of the over bevel sheet. The joint design in Fig. 16 (D) is used to make sheets for overlaying on plywood panels.

The glue used for joining the scarfed joints is a urea resin fortified with melamine resin (5, p. 13-15). This glue is applied as a liquid and normally allowed to dry at room temperature. Assembly time can, however, be from within a few minutes up to several days with satisfactory results.

MACHINE WEAKNESSES

The action of the milling type cutter at moderate speeds naturally pressed the veneer firmly against the backing bar, and was
an aid in flattening wavy ends of the veneer. This action was a characteristic which led to the early adoption of the spiral milling cutter. In practice the cutter alone was not sufficient to flatten out the sheet ends, so additional hold-down means, both shoe type and rolling types, were tried. Rolling type hold-downs could not be mounted close enough to be effective. The shoe type was difficult to build, and when fitted close enough to be effective, with the end actually part way under the cutter, would, with the slightest additional lift, as from a splinter on top of the veneer, be caught by the cutter and destroyed.

Other deficiencies of the milling cutter have been indicated, such as scalping out the soft wood at high speed, and tearing cross grain and knots at low speed. It was also stated that considerable force is required to push the wood past the cutter. This resulted in breaking the trailing corner off of the veneer sheets where the thrust was greater than the strength of the wood. This difficulty increased rapidly as the cutter began to dull. A slightly dull cutter would also separate the grain by crushing the soft summer growth beneath the hard summer growth. After the cutter had passed, the hard growth would spring back leaving a separation between it and the crushed soft wood beneath.

Another variation from a true scarf was caused by wear of the backing bar. As this tended to wear most at the end of the veneer it presented a convex surface to the veneer. With the cutter forcing the stock against this convex surface the actual cut when referred to the veneer was concave. Concave surfaces, of course,
made a poor joint.

Since only one end of a sheet of veneer was scarfed at a time, the two ends were seldom parallel. When the sheets were joined this resulted in an angle along the side. In some cases this might be sufficient to leave a void when made into a panel and sized.

Another deficiency was in the stapling of sheet ends for joining. Stapling had to be done by a person at each side, Fig. 13, who judged by eye the proper overlapping of sheets. It was difficult to obtain identical results from the two persons. It was also difficult to prevent some movement as the staples had to be in thin material of the scarf, and the sheets were transported a full length after stapling, Fig. 14. (The succeeding joint was stapled while the preceding one was in the press).

PRACTICAL DESIGN CONSIDERATIONS -- SCARFER

A general form of machine similar to a double end tenoner seemed a practical approach to double end scarfing of veneer sheets. The multiple processing often performed on a double end tenoner is required. First, each end had to be trimmed to true up irregularities or out-of-square sheets. Second, they had to be scarfed, one end with an over bevel, and one with an under bevel, and third, they should have glue applied to the scarfed surfaces.

The top and bottom gripping chains of the double end tenoner seemed desirable. With the heavy thrust of the cutter opposing the feed it was found necessary to drive the top chain as well as the bottom one. This is not usual in the double end tenoner. It was
also found necessary to drive the chains with pusher lugs on the infeed section at slightly less speed than the gripping chains. The gripping chains flattened out the wavy sheet starting from the front, causing a slight backward relative movement of the trailing edge, Fig. 5. With lugs traveling at the same speed as the gripping chains they were pushed into the sheet enough to damage the edge.

The production rate of the scarfing machine depends on the speed of the feed chains, and the spacing between sheets. The spacing between sheets is determined by the spacing of lugs on the infeed chains. The first production scarfer was made to take 62 inch wide sheets, Fig. 9. The production on the machine averaged 80 to 85 percent, 50 inch wide stock and less than 5 percent, 62 inch wide stock. The greater lug spacing, therefore, effectively reduced the production rate on the major production item. It was further observed that 62 inch wide stock was beyond the capacity of the average operator to handle conveniently. He could not fill each space on the feed chains, and splits and other damage from handling increase. It was therefore determined that the lugs of the feed chains should be spaced for the major production size, and that wider stock would be produced by processing narrow stock (e.g., 32 inch wide) to be subsequently edge-joined on a tape machine.

The original scarfer was made with a single-feed speed. There is a great difference between the feed speeds that will give a satisfactory scarf on different batches of stock. Fine soft grain wood with little defect can be scarfed at much higher feed rates than coarse hard grain wood, with numerous knots, cross grain, and other
defects. A variable speed drive could be used to advantage to maintain the greatest production rate. As the cutter begins to dull, a satisfactory scarf can still be obtained at reduced speed until a sharp cutter can be installed.

**MAJOR CRITERIA**

In designing a production scarf er it was assumed that the machine should:

1. Effectively flatten the ends of veneer sheets during scarfing.
2. Make a uniform scarf on soft and hard wood, with minimum variation.
3. Cause a minimum of damage at splits, knots, and cross grain.
4. Process both ends of a veneer sheet at the same time.
5. Have the general form of a double end tenoner, with required variations.
6. Be designed to process nominal 48 inch wide stock.
7. Have variable feed speed.
8. Scarf both veneers and hardboard.
9. Be easily adjusted, with minimum adjustment for thickness.
10. Be easily cleared from jam-ups, etc.
11. Arranged for waste removal by blow pipe system.

**SCARFER DESIGN**

A diagram of the general assembly of the scarfing machine is shown in Fig. 17, 18 and 19. The legs were made of 5 x 5 inch wide
flange beams. The cross girts which supported the stationary side and movable side are 8 x 6\(\frac{1}{2}\) inch wide flange beams. The main lower chain carrying beams are 8 x 8 inch wide flange beams and the upper chain carrying beams are 4 x 4 inch wide flange beams. The upper chain carriers are hinge mounted so they can be quickly raised clear in case of jam-up. They are also spring loaded so no adjustment is required for different thickness of stock. The hinge points are nearly on the level of the veneer and as far away as practical to minimize the arc effect on the alignment of the chain with the stock for different thicknesses. The movable side of the machine can be adjusted for stock lengths from less than four feet to over eleven feet, the adjustment being power operated.

The wide flange beams used in the transport system were selected to facilitate carrying the chains and mounting the bearings for the various shafts. Ball bearing pillow blocks and flanged bearings were used throughout. The infeed chains consisted of 122 links of one inch pitch roller chain, with two pusher lugs spaced at fifty-six inches, and run on 16 tooth sprockets. The chains run in "chain-races" which have sides higher than the chain height so only the pusher lugs will transport the veneer sheets.

The lower tractor chain is an extended pitch roller chain of one and one-half inch pitch with large rollers and with a single wing attachment on each link. The chain is standard Link Belt 1265 except the wing attachments are assembled with two on the right side and two on the left side and the wings are assembled toward the center of the chain. The tractor chain runs on 11 tooth sprockets, and the tail
sprocket is mounted on the head shaft of the infeed chain and drives it. It will be noted that eleven teeth on the tractor chain at one and one-half inches advances the chain sixteen and one-half inches per revolution of the sprocket, while the one inch pitch infeed chain on a sixteen tooth sprocket advances sixteen inches. The tractor chain extends above its chain-liner, to transport the veneer. The infeed chain runs on one side of the web of the 8 x 8 inch wide flange beam, and the tractor chain runs on the other side. The chain and sprockets run thru slots in the flanges of the beam with the pillow block bearings being mounted on the under side of the flange outside of the slots.

The top tractor chain is Link Belt 1260, which is an extended pitch roller chain of one and one-half inch pitch with standard size rollers. Alternate links of this chain have 3/16 x 1 x 2 7/8 inch long sections of flat bar welded to the links on which are mounted 1 x 1 x 2 7/8 inch rubber blocks. The rubber blocks give resilience to the tractor chain, and does not mark the stock. The top tractor chain is power driven in syncronism with the bottom tractor chain.

As the veneer sheet enters the tractor chain the ends pass by trim saws to true and square cut both ends. Originally a two winged hogging head, one inch wide, was mounted between each saw and motor on the saw arbor to reduce the end trim to suitable size for disposal by the blow pipe system. The hogging heads, however, created too much fan action or windage, which tended to throw waste out of the control of the blow pipe systems. The hogging heads were removed and curved stationary shoes were mounted from the machine.
frame to direct the trim into the blow pipes. The curve of these shoes is sharp enough to cause frequent breaks in the trim. This has operated quite satisfactorily.

The deficiencies of the spiral milling cutter led to a review of cutters which might be used for scarfing, and which might overcome the problems encountered with this cutter. A head arrangement was envisioned consisting of three concentric rings. The outer ring would be a hold down to flatten out the wavy edge, the center ring would be a narrow shall end mill with suitable teeth and revolving at high speed, and the inside ring would be another hold down to hold the veneer flat inside of the cutter. The outside ring always remains flat above the bracing bar. The shell mill cutter and the inside ring are sloped on the scarf angle. The shell mill was also inclined slightly at right angles to the scarf to provide "heel" relief for the teeth returning across the scarf.

In the original design the outside rings were actually rings with eased infeed edges, backed by ball bearing thrust bearings and power driven.

Experience proved that it was not necessary to drive the outside rings and thus removed a great complication of the system. In fact, a sector of a ring, or a shoe with a sector cut out to fit around the cutter worked quite satisfactorily.

The original cutters were made 5 inches in diameter, the size being largely influenced by the outside rings. The cutters had 12 carbide teeth and were driven at 7200 revolutions per minute by timing belts from 5 horsepower 3600 RPM motors. Some of the one
inch wide belts ran for more than a year of two shift operation. The cutters were carried in ball bearing quills with oil mist lubrication. Standard ball bearings were used with brass or phenolic cages. In several years operation only two bearings failed, and in both instances the oil mist line had been broken.

The 5 inch cutters and hold down systems, as designed, operated quite satisfactorily, but the arrangement of adjustments were quite awkward, since the motors were mounted on separate stationary plates. In this design there was only slight adjustment of the scarf angle, and an up and down adjustment of the cutter possible.

With the possibility of reducing the outside hold-down to a shoe, and desiring a more flexible range of adjustment, a new direct drive scarfer head was designed. This cutter was made 11 1/8 inch in diameter, which corresponds to a cutter speed in excess of 10,000 feet per minute when direct driven by a two-pole motor with 60 cycles alternating current. At this surface speed of the cutter, individual fibers of wood are cut off and a smoother cut is possible than at lower speeds. There is much less damage at cross grain, knots and splits in the veneer. The force required to push the wood into the cutter is also lessened so splits at the trailing edge of sheets is reduced. The tooth shape was designed for a carbide cutter cutting wood, with a sharp hook to the inside of the cutter, and 8 degree heel relief. The tooth shape is also satisfactory for scarfing or shiplapping hardboard.

A 1/4 inch scale section of this cutter is shown in Fig. 20, with its mount and adjusting means. The outside "ring" is reduced
to a shoe with circular cut-out for the cutter. This shoe is supported by side plates in which the head is also pivoted. The shoe is not adjustable, but is spring loaded with two die springs (D3) at each end. The die springs were selected so the tension is sufficient for flattening one-tenth inch veneer, and three sixteenths inch veneer, the spring rate giving the proper tension due to increased compression. No adjustment of the shoe is required when changing thickness of veneer.

The cutter head with its driving motor, and the inside hold-down are mounted on a carriage with "V" ways so they may be adjusted in and out by hand wheel. The carriage is pivot-mounted between side plates with a vertical screw for adjusting the scarf angle. The angle and in-and-out movement move the cutter and inside hold-down as a unit.

The cutter head with its drive motor are mounted on a vertical carriage with V-ways which are pivot mounted to vertical channels on the horizontal carriages. The pivot points are nearly in line with the cutter, and are used for adjusting heel relief of the cutter. The pivot plate is held near the top by countersunk bolts extending thru slots in the channel which allows about two degrees of rotation for heel relief. The actual heel relief is quite small, being perhaps, one-fourth degree.

The vertical carriage is mounted in "V" ways for vertical adjustment of the cutter, and for raising the head for changing cutters.

The inside hold-down is a "toadstool" or "umbrella" shape with
the stem extending through bronze bushings in a tube pressed into the horizontal carriage. The stem is designed as a suction pipe to be connected with the blow pipe system for removal of sawdust. On the bottom of the stem, a collar is fitted which has spring pockets with die springs pressing on a ball bearing thrust bearing to exert a downward thrust on the veneer at the rim of the toadstool. Since the inside hold-down operates on the scarf surface, and this surface is little affected by thickness of veneer, or hardboard, no adjustment for thickness is required.

The entire scarfing assembly is quite easily set to precise scarf requirements and requires very little adjustment. No adjustment need be made in scarfing one-tenth, one-eighth and three-sixteenth veneers. Due to a stop cut in hardboard scarfing the over cutting head must be adjusted for each thickness, but not the under cutting head.

Glue is applied to both the over and the under scarf bevel. The glue is applied by glue rolls which are power driven, but not exactly in synchronism with the sheet speed. In order to control the glue film thickness, doctor rolls are fitted on the glue rolls. The doctor rolls are urged toward the spreader roll by spring pressure, but are prevented from touching it by a stop and adjusting screws. With this arrangement a grain of sawdust, or splinter can pass between the rolls, opening them momentarily without damage, closing the rolls again to the setting of the stop screw. The surface speed of the doctor roll is one-fourth to one-eighth of the applicator speed, and the applicator roll is grooved or knurled, both factors aiding to keep
the metered glue film on the applicator until applied to the scarf-
ed surface. On the under bevel the bottom rim of the applicator
roll runs in a pan of glue from which it picks up an excess, to be
metered by the doctor roll, and applied to the scarf. For the over
bevel the glue is picked up by the rim of a disk, attached to the
applicator roll. This disk lifts the glue to a scraper angle, which
conveys the glue to the groove between the doctor and applicator
roll. Excess glue drains back to the glue pan.

An attempt was made to stack the processed sheets as they were
discharged from the scarfing machine. Arms were made to travel out
with the sheet at the same speed as the sheet, to carry it out over
a pallet for stacking. After the sheet was clear of the machine the
arms retracted rapidly to drop the sheet on the pallet.

The operation of this system was quite erratic. Some of the
sheets would be pulled back toward the machine by the retracting
arms and soon one would lie with curled edge higher than the carry-
ing arms. The next thrust of the arms would go through the curled
sheet stopping further functioning of the stacking system.

Actually the stacking of the sheets should be quite accurately
done to have them aligned for the joining operation of the scarfed
veneer press. This stacking is quite easily accomplished manually,
but due to the fragile and variable material, defects of splits,
knots, curled sheets, bulged and wavy areas, etc. is difficult to
accomplish automatically. The original stacking system was aban-
donied, and the sheets are stacked by hand, the off-bearer also
sorting out split sheets, those too far out of square to be machined
full width, and other defective stock.

**VENEER JOINING EQUIPMENT**

An overall diagram of the joining equipment is shown in Fig. 21 (A). At the left is shown a stack of scarfed veneer sheets on a hoist. In front of the hoist is the apron and end registering equipment, while on the left side of the apron is a straight edge to aid in keeping the stock straight as it goes thru the machine. (Fig. 23 is an enlarged detail of the apron and registering mechanism.) The next major piece of equipment is the joining press, designated (35) in Fig. 21 (A). Behind the press is seen the rear air clamps of the transport system. Next is the cut-off saw designated (66) and the limit switch (67), which controls the length of cut. After the sheet is cut-off it is carried forward and crowded to the side by slewed rolls, (68). While the right side is trimmed by saw (70) as it is being propelled to the outfeed load.

In operation the trailing end of a sheet in the press is in the position shown in Fig. 22 and 23 (A). This requires the apron assembly to be near the press for short stock and far from it for long stock. As the leading end of each sheet is drawn to the center of the press for joining, the trailing end is pulled across tables (24) just past step (28) on the infeed table. Stops (27) are then rotated down to the position of Fig. 23 (A). The distance between stops (27) and steps is measured overlap, they are both mounted on side plates (15).
Errors in centering the registered sheets in the press are not self-compensating, but become progressively greater. A motor (13) is, therefore, mounted on the apron to adjust it automatically whenever adjustment is required. If the trailing end of the sheet fails to fall over the step, then descending stop (27) will not make full rotation to depress limit switch (57) and motor (13) will reverse the apron until the limit switch is depressed. If the sheet end is more than 3/4 inch past the step it will miss limit switch (56), and will cause the motor to move the apron toward the press. This automatic adjustment is interlocked electrically to only be effective while the carriage is operating in the reverse direction, and is thus limited to a small adjustment. Greater adjustment of the apron can be made by the operator who has push-buttons overriding the automatic control.

TRANSPORT SYSTEM

Sheets are transported from the registering position to the pressing position by a carriage which extends thru the press. The carriage consists of cross girts (43) and (44) which are connected by pipes (45), and run on wheels (55), inside side channels. Cross girt (43) carries air rams (46) which grip the joined sheet back of the press. These air grips maintain the register of sheets as they are drawn to the press. Grips (52) being several inches back of the leading end of the following sheet, allows the joint to be centered under the press platen. Forward travel of the carriage is stopped
by a limit switch located on the press, and reverse travel limit switch (61) mounted on the apron. Clamps (46) also push the leading end of the joined sheet past the cut-off saw to contact limit switch (67), which also stops motor (59), and causes cut-off saw (66) to cut the sheet off. At the conclusion of this cut, motor (59) again starts to complete the carriage cycle to the press.

PRESS

A section of the press is shown in Fig. 25. The top bolster consists of a 12 inch by 12 inch wide flange beam, below which are two 3\(\frac{1}{2}\) inch fire hoses in flattened condition. The fire hoses are between the top bolster and moving platen. The moving platen consists of an 8 inch by 8 inch wide flange beam with a one-half inch steel plate 12 inches wide on top to carry the fire hoses. Five sets of three-eights inch steel plate webs at right angles to the beam stiffen the beam and plate assembly. The bottom bolster consists of an 8 inch by 12 inch wide flange beam. The top and bottom bolsters are 79 inches long, and are connected by one-half by 6 inch flat steel bar at each corner, leaving a clear opening 67 inches wide for veneer.

Between the bottom bolster and the moving platen are the two hot plates. The hot plates are insulated from the press structure by one-half inch thick transit sheets as shown.

The hot plates are laminated from 1 piece 3/8 inch by 3 inch back plate, and 1 piece 5/8 inch by 3 inch face plate, with milled grooves to receive 2200 watt electric heating elements between. The
SECTION
SCARFED VENEER PRESS
Fig. 25
plates are secured together by blind machine screws from the back.

In the original design the hot plates were made of copper bars with a 20 gauge stainless steel channel fitted to the work face. Particles of knots falling from the veneer, and being pressed with it would make dents or "dimples" in the work faces so they would have to be replaced at intervals.

It was thought that the copper was necessary to carry the heat from the electric heating elements. In fact, we had found in other applications that a lack of continuous good contact with the heating element would result in hot spots and burn-out of the electric elements. Our present hot plates are made of solid steel bars with the electric heating elements bedded with a heat transfer cement, in the milled slots. The steel bars resist the "dimpling" by knot fragments.

Due to the expansion of the hot plates they cannot be bolted solidly to the press frame. They are secured by tight bolts at the center of their length, and by spring loaded bolts through slotted holes at other points, all bolts threaded into blind tapped holes in the back of the bars.

A two inch air cylinder through a bell crank system holds the moving platen in the elevated position with the hoses deflated.

The use of inflatable hoses for pressure elements is not new (3, p. 38-39). The area of contact of such an element is the flattened sides of the restrained hose. The effective area, thus, decreases as it pushes the moving platen down. In this application the contact area of each hose varies with the thickness of the stock being treated, being approximately 3.8 inches with 3/16 stock.
Sixty pounds air pressure on the hoses will apply a pressure of approximately 220 pounds per square inch on 3/16 inch stock 50 inches wide.

In the operation of the joining system it is desirable that the press should remain closed on the joint until the following sheet can be aligned in register and gripped by the transport carriage. This requires the press to be closed during the reverse travel of the carriage, which is about seven seconds. It has been mentioned that the previous press operated on a four second cycle with temperature of the hot plates of 450 to 500° F. With the longer time available in this press the hot plates were operated at 300 to 300° F. The lower temperature materially reduced the shrinkage checks along the edges of the hot plates.

PRESS INFEED AND OUTFEED TABLES

Extending between the apron and the press are "T" bars (62), to support the trailing end of the joined sheet. These T-bars run through slots in the lower press bolster and into pipes which form a similar table between the press and the cut-off saw. Slots in the apron end of the T-bars match slots in an angle on the back of the apron. When running narrow sheets the outside T-bars are lifted out of their slots and slid inside the pipes out of the way.

CUT-OFF SAW

A swing clipper was used for several years for recutting sheets to length, with satisfactory results. It was very fast, requiring a
very short stop for the transport motor (59). However, with the addition of the large diameter cutter heads on the scarfer, hardboard was added to the items to be processed. The clipper was not adequate for hardboard so a traveling saw was installed to replace it. The saw assembly slides on ways beneath the table with the saw blade projecting thru a slot above the table. A throat board carried on air cylinders, descends from above to hold the sheet while it is being sawed. A similar saw setup was used on the original processing arrangement, except that the saw was located closer to the press, and the throat board was foot operated.

The limit switch (67) is adjustable over a wide range of lengths.

OPERATION OF VENEER SCARFER

Prior to operation of the veneer scarfer the machine must be "set-up" for the particular run. The cut-off saws require no adjustment. The scarfer’s heads require adjustment only when changing from veneer to hardboard. The glue spreaders are removed for cleaning, and must be set for the width of scarf to be produced. The movable side of the machine is set to accommodate the length of stock to be run. The movable side is electric motor driven for adjusting to length. The variable speed feed motor is manually adjusted for feed speed appropriate to the stock to be run.

The operator lays veneer sheets singly on the infeed table, one sheet between each set of lugs of the infeed chains. As the lugs of the infeed chains push the sheet into the machine the tractor
chains grip the sheet and carry it past rim saws at each end, past the over and under scarfer heads, past the glue spreaders and discharge the sheet to the off-bearer who stacks it. The operation requires two men, but the production rate is much higher than the preliminary machine. The production rate of the scarfer is also much higher than the joining and processing machine.

OPERATION OF VENEER JOINING AND PROCESSING MACHINE

The "set-up" of veneer joining and processing machine consists of:

1. Setting the infeed table for length of stock.
2. Adjusting the end registering stops for length of scarf. These stops must be adjusted when changing thickness of stock only.
3. Adjustment of hot plate thermostats if required.
4. Adjust the press timer if required.
5. Adjustment of reducing valve on air to press pressure hoses if required.
6. Adjust limit switch controlling recut length desired.
7. Adjust side trim saw to desired width.

In operation, a package of scarfed veneer sheets from the veneer scarfer is positioned in front of the infeed apron of the joining machine on a hoist. The operator stands at the rear of the package of sheets, where he can push a sheet from the top of the package against the aligning stops as required. As the operator urges the sheet forward against the stops with one hand at each edge, he can feel when the leading end is in contact with the registering stops.
at each side. By use of a mirror mounted a few inches above the registering stops and tilted at 45° he can also see the alignment of the scarfed ends in juxta-position. When the alignment is correct the operator depresses a foot switch which operates a solenoid air valve to close the air clamps on the carriage. All other operations are automatic, and are electrically and pneumatically interlocked. The carriage clamps can be set only if the carriage clamps operate a pressure switch to move the carriage to the press, but only if the press platen is raised. A limit switch at the press stops forward travel of the carriage, and initiates closing of the press. A pressure switch on the press air line trips out the solenoid valve on the carriage air clamps, assuring that the press is closed before the clamps are released. Decline of air on the carriage air clamps reverses the carriage feed motor.

Actuation of limit switch (67), by the forward traveling sheet, stops the carriage motor, and activates the cut-off saw drive motor to cut off the sheet. Alternate cuts of the cut-off saw are made from right to left, and left to right.

After the sheet is cut off by the cut-off saw it is propelled forward and urged to the left by slewed rolls (68), until the left edge is in contact with side channel (69). With the left edge of the sheet sliding along side channel (69), forward motion is maintained to propel the sheet past right edge trimming saw (70), and onto a stack of sheets at the end of the machine.


