Feb. 13, 1962 J. W. MANN ET AL 3,021,248

RADIO-FREQUENCY EDGE-GLUING PROCESS

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Fig. 1.

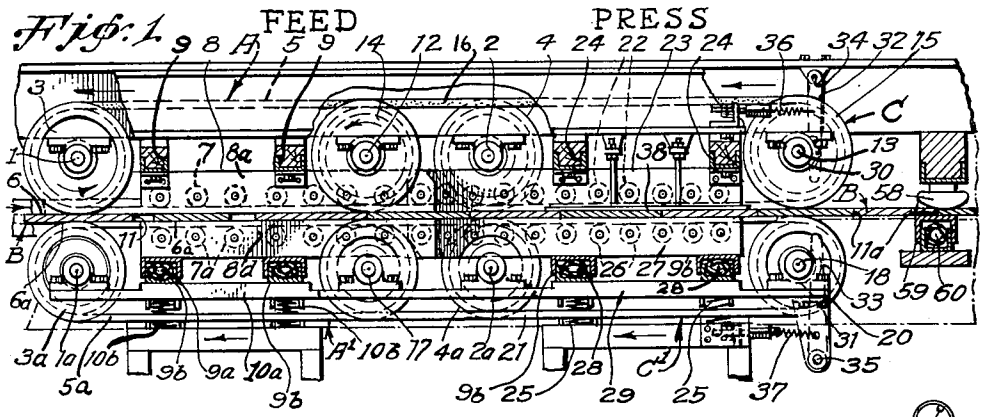
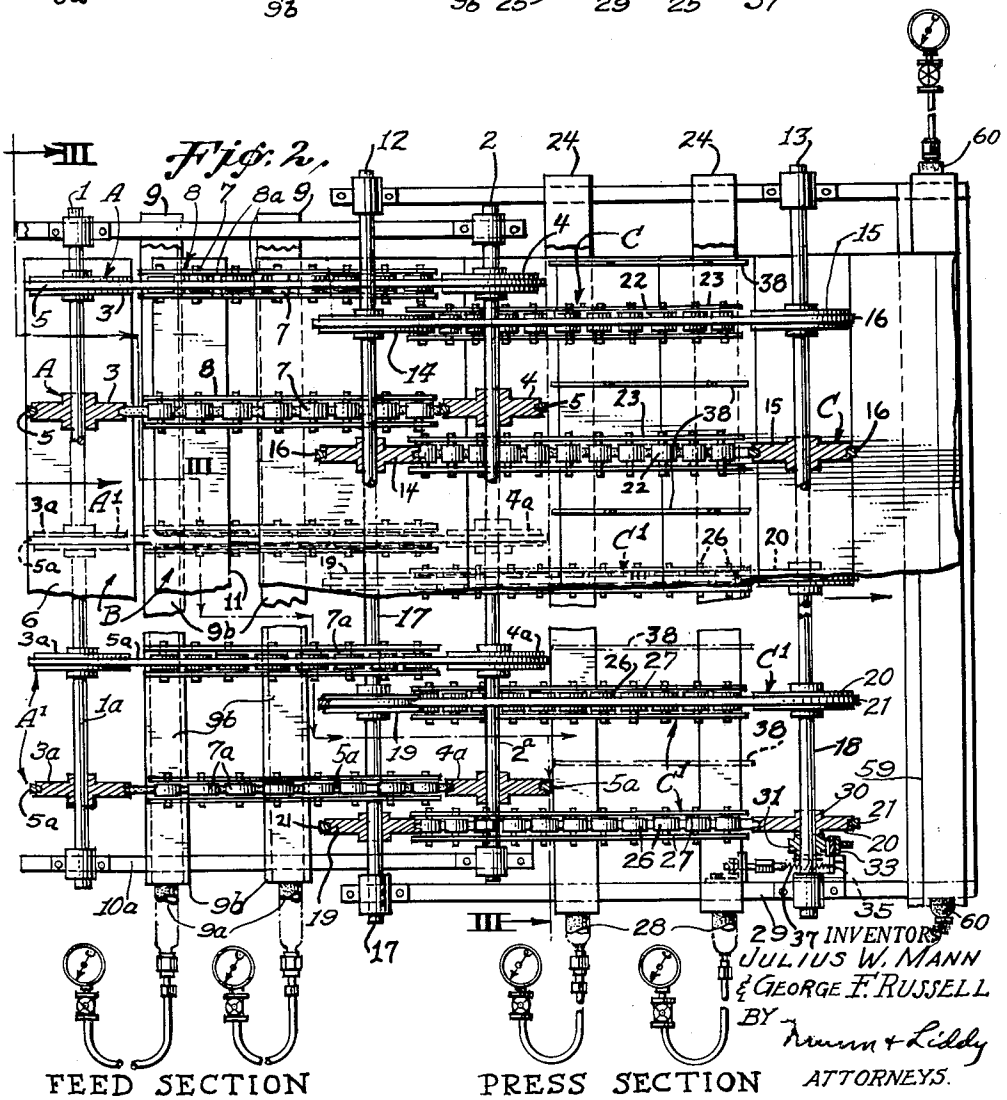


Fig. 2.



INVENTORS
JULIUS W. MANN
& GEORGE F. RUSSELL
BY Mann & Liddy
ATTORNEYS.

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Fig. 3.

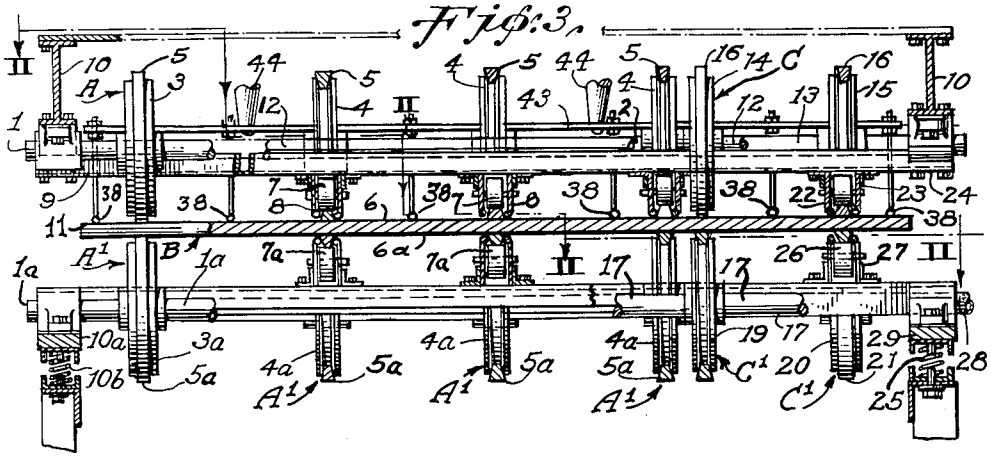


Fig. 4.

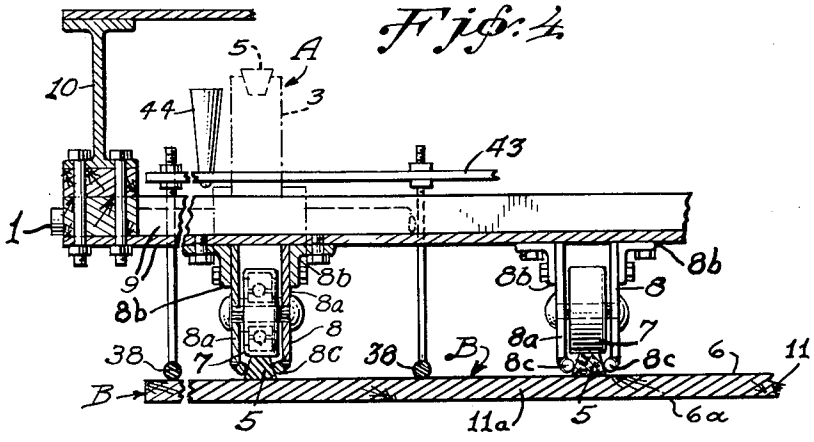
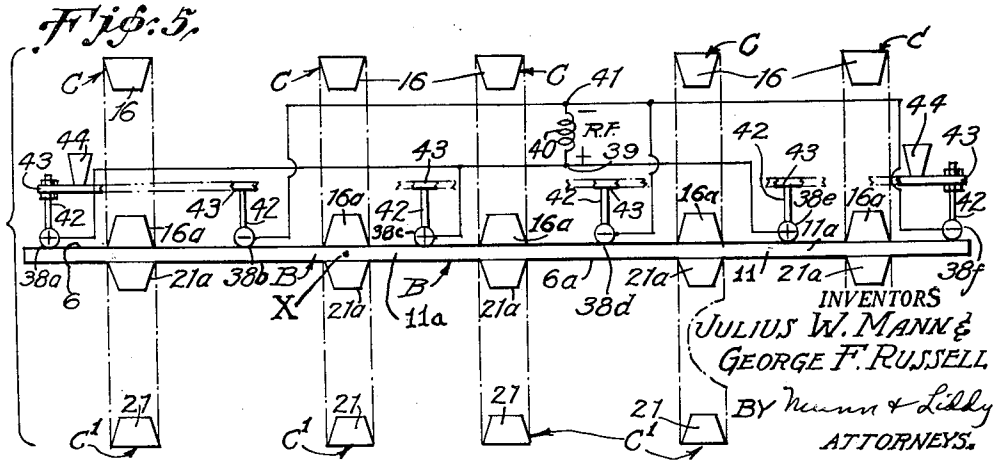


Fig. 5.



INVENTORS
JULIUS W. MANN &
GEORGE F. RUSSELL
BY Mann & Liddy
ATTORNEYS.

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Fig. 6.

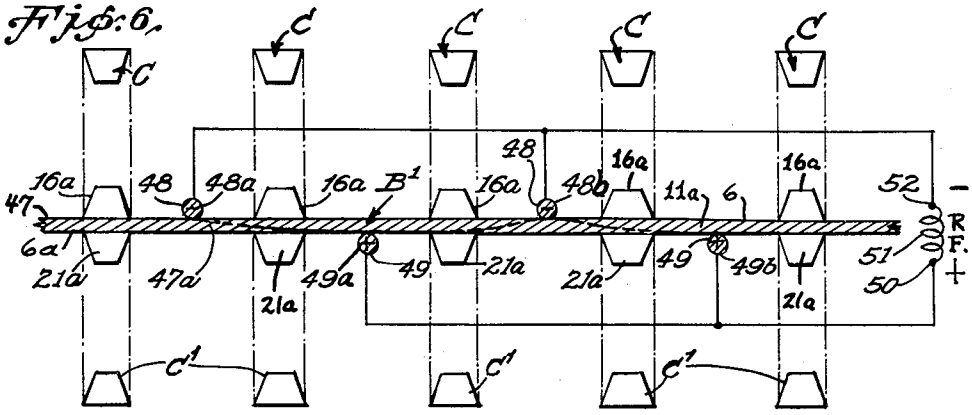


Fig. 7.

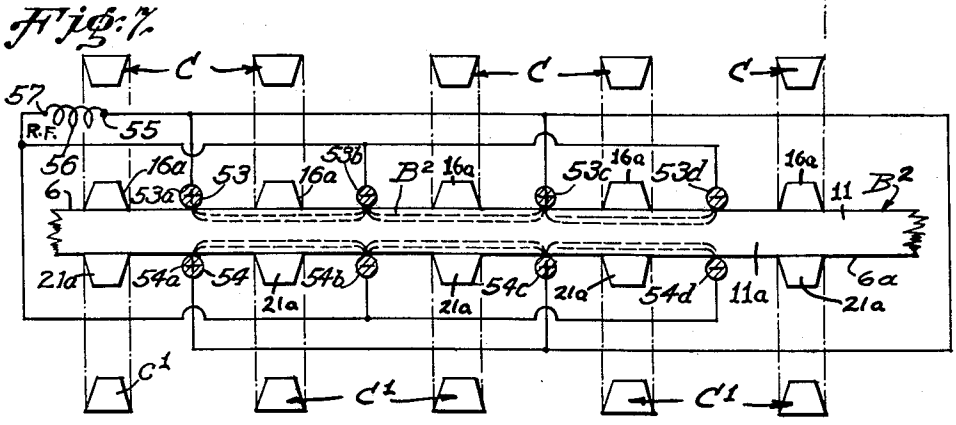
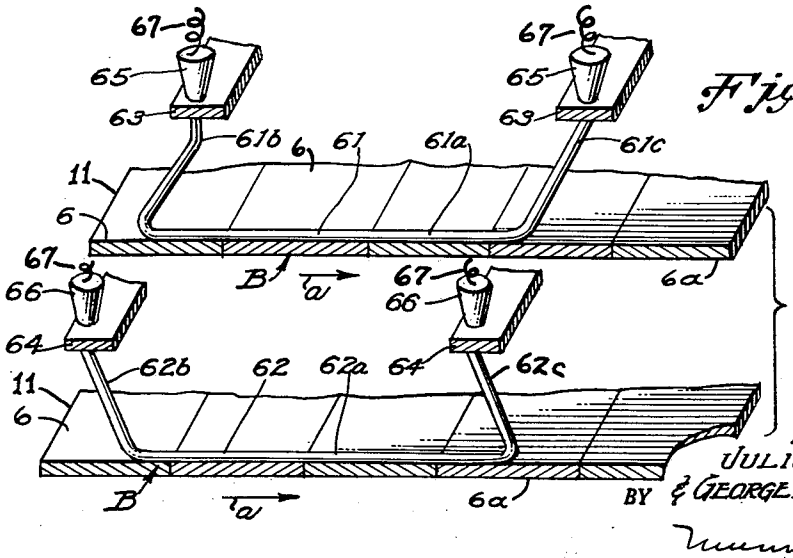


Fig. 8.



INVENTORS
JULIUS W. MANN
BY & GEORGE F. RUSSELL.
Munn & Liddy
ATTORNEYS.

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3,021,248

RADIO-FREQUENCY EDGE-GLUING PROCESS

Julius W. Mann and George F. Russell, both of 711 St. Helens Ave., Tacoma, Wash.

Filed Apr. 4, 1955, Ser. No. 499,116
4 Claims. (Cl. 156—274)

This case is a continuation-in-part of our application Ser. No. 208,627, filed January 30, 1951, now abandoned. In our copending application on a continuously operated radio-frequency adhesive setter for edge bonding of materials, Serial No. 261,692, filed December 14, 1951, now United States Patent Number 2,870,808, we set forth apparatus claims while in the present case we set forth method claims.

In Douglas fir plywood manufacturing, logs of varying quality are peeled from blocks or sections or logs on large rotary lathes in lengths commonly slightly over forty-eight or slightly over ninety-six inches in length with the grain of the wood. The veneer which results is, for the most part, one-eighth or one-tenth of an inch thick with of course, other thicknesses. The lathes produce continuous strips of veneer which are clipped to widths varying with the quality of the logs peeled. Defects in the veneer are clipped out. The widths of the veneer range from slightly over four feet in width down to a few inches. The pieces of veneer thus produced are dried and stacked for use in producing either face or core stock in the final assembly of completed panels.

In the early days of fir plywood, logs of such high quality were obtainable that it was common to secure clear veneers without defects in sufficient quantity to secure the entire requirements of face stock from single piece veneers without joining small pieces together. Total plywood output, however, has increased to such an extent that the top quality logs are no longer available in unlimited quantity, so narrower pieces must be edge-joined for full size veneer. It is common to use low grade logs to produce the veneers used for cores or the inside plies of plywood. The lower grades carry many defects, which when clipped out, leave most of the stock in narrower than four foot widths.

To eliminate core gaps, to make solid face stock, and to produce sounder panels, it has become the practice of some mills to edge-glue the small width pieces of veneer to secure thereby pieces of full width for ease in handling, for reducing cost and to improve quality. These smaller pieces are now edge-glued together mainly by two methods—first, by the use of a paper tape overlapping two pieces of veneer placed close together and, second, by applying a resin adhesive to the edges of the veneer pieces and registering their edges together, under the influence of steam or hot plates or hot circular drums to cure the adhesive and to secure a bond between the edges. This produces a continuous strip of veneer all edge-glued together.

Major drawbacks in the first or paper tape method arise when the tape is sanded off. There is also the weakness of the tape itself and other handling difficulties arise. In the second method, the heat of the hot plates or drums employed to cure the resin adhesive, sears and case hardens not only the glue lines but the wood itself, necessitating stacking the glued veneer for long periods of time to allow the heat to dissipate and resulting in major changes in the moisture content of the wood.

In the manufacture of panels used in furniture and the like products, the faces of core stock are covered with hardwood veneers of many types and species. These veneers being sliced from cants of expensive stock are usually thin; on the order of one twenty-eighth of an inch in thickness. The edges of such veneer are therefore

tender to rough handling and since the individual pieces are often very narrow with reference to their length along the grain, it is customary to edge-glue several pieces together either in random or matched grains to make a single piece of veneer to cover the face of an inexpensive core of lumber. These faces are commonly taped together with a piece of gummed paper overlapping the two edges of the face of the veneer which is exposed after gluing to the core. Sanding off these tapes sometimes results in the sanding head going completely through the veneers and into the core stock below. The invention herein described is not intended to be limited to the processing of any one type or thickness of veneer any more than any other grade and the illustrations herein contained are illustrative only and not limiting as to the extent of edge-gluing either in grade, thickness, width, length or species of wood being edge-glued.

To overcome the many difficulties of edge-gluing by present methods, we have applied the high-frequency field of force to the glue line by means described in this application as novel, new, useful and revolutionary in the present state of the art. We employ a high-frequency field of force to cure the adhesive between the edges of the veneer because it polymerizes the adhesive, if a thermal setting type resin is used; and it softens it if it is a thermo-plastic type without imparting to the veneer itself heat in an amount which materially changes the moisture content of the wood as the cure or softening takes place, and because it does not burn or case harden the surface of the veneer as in the case of the heated drum type of splicer and because it abolishes the need of surface applied tape which must later be removed by sanding as in the tape splicer. This invention is commercially adaptable to the production process of the plywood, wood veneering and lumber edge gluing industry and has distinct advantages over present methods of edge bonding. It makes possible a continuous strip of edge-glued wood in a form immediately usable in a continuous process of manufacturing plywood which is being now developed and which has been held back because no such process as we here describe has been available to the industry up to this time.

We have invented a process of high-frequency edge-gluing as well as means of and equipment for accomplishing the method, both of which will be fully explained hereinafter, but it should be pointed out that many unique factors must be considered. Plywood veneer when stacked in piles for storage absorbs moisture in its exposed edges to a greater degree than the inside and unexposed portions of the pile. This ripples the edges to such an extent that a straight-edged surface is sometimes difficult to find in an inspection trip through a plant. After being edge-spread with a heat responsive adhesive of a type currently available such as ureas, melamines, phenols, resorcins in the thermo-setting types as well as the many others in the thermoplastic types, these wavy-edged veneers must be held in absolute register while being edge-glued, since out of register edges would adversely affect the end result and means reject panels or faces, uneven cores and non-uniform glue spreads. After many tries at smoothing out the ripples on edges by bending, flexing and other artificial means, we determined the flat plane to be the most advantageous in which to carry the veneers while under the influence of the glue setting process and that relatively closely spaced V belts driven together in a multitude of assemblies would retain the veneer in a relatively flat plane if corresponding sections of a V belt drive were used above and below the moving veneer with spacing so close as to prevent the occurrence of any warpage when the veneers come together edgwise before gluing

and are thereafter retained in register during the glue setting.

Other objects and advantages will appear in the following specification, and the novel features of the device will be particularly pointed out in the appended claims.

Our invention is illustrated in the accompanying drawings forming a part of this application, in which:

FIGURE 1 is a schematic side elevation of our radio-frequency edge-gluing press;

FIGURE 2 is a horizontal schematic section taken along the line II—II of FIGURE 3;

FIGURE 3 is a transverse schematic section taken along the line III—III of FIGURE 2;

FIGURE 4 is an enlarged transverse sectional detail of the skate wheel and electrode support;

FIGURE 5 is a schematic transverse section of a portion of the radio-frequency edge-gluing press and illustrates the electrical circuits for single strength, stray field, parallel bonding;

FIGURE 6 is a schematic view similar to FIGURE 5, and illustrates the electrical circuits used in "Z pattern" parallel bonding;

FIGURE 7 is another schematic view similar to FIGURE 5 and illustrates the electrical circuits used in the split pole parallel bonding; and

FIGURE 8 is a schematic longitudinal section through two portions of the edge-gluing press and shows a modified form of electrode and mounting therefor.

While we have shown only the preferred forms of our invention, it should be understood that various changes or modifications may be made within the scope of the appended claims without departing from the spirit and scope of the invention.

In FIGURES 1 to 3, inclusive, we illustrate one type of press which may be used for the radio-frequency edge-gluing of veneer. FIGURES 1 and 2 show a feed section and a press section and a plurality of belt-drive assemblies A are spaced one from the other the desired distance and are mounted upon shafts **1** and **2** in the feed section. The belt-drive assemblies A include sheaves **3** and **4** mounted on the shafts **1** and **2**, and these sheaves are grooved to receive rubber V belts **5** that have resilient properties for a purpose hereinafter described. Any means, not shown, may be used for taking up the slack in the belts **5** in order to keep them taut at all times. The belt-drive assemblies A are designed to be positioned above sheets of veneer B that are to be fed into the machine for the edge-bonding of the adjacent pieces together. The grain of veneer runs crosswise to the moving direction of the belt-drive assembly A.

The power-driven feed section of the press comprises the belt-drive assemblies A already referred to and these are designed to contact with the upper surfaces **6** of the veneer sheets B while a second set of belt-drive assemblies A^1 in the feed section of the machine are designed to contact with the under surfaces *6a* of the same veneer sheets B. The lower belt-drive assemblies A^1 include shafts *1a* and *2a* which preferably parallel the shafts **1** and **2**, see FIGURE 1, and are placed below the veneer sheets B. The shafts *1a* and *2a* carry sheaves *3a* and *4a*, see FIGURE 2 and rubber V-shaped belts *5a* are passed around the sheaves. The lower reach of each belt **5** and the upper reach of each belt *5a* provides a path which will support and move the sheets of veneer through the feed section of the machine, as clearly shown in FIGURE 1.

Any means may be used for urging the veneer contacting reaches of the belts **5** and 5a against the adjacent surfaces **6** and *6a* of the veneer B so as to hold the sheets in a flat plane. In FIGURES 1 to 3, inclusive, we show five upper belt-drive assemblies A and a like number of lower belt-drive assemblies A^1 for feeding the sheets of veneer B through the power-driven feed section of the press. We do not wish to be confined to any exact number of assemblies nor to the particular type of veneer feed illustrated because any means for holding the sheets of veneer in a flat plane and moving them from the feed section toward the press section of the device in an edge to edge abutting relation, may be used. We urge the veneer-contacting portions of the V belts against the sheets of veneer by the mechanism illustrated in FIGURES 1 to 3, inclusive. In FIGURES 1 and 4, we show a plurality of wheels **7** such as skate wheels, that are rotatably mounted in a frame **8** and this frame is supported by transversely extending channel irons **9** that in turn are carried by an I-beam frame **10**, FIGURE 4. The wheels **7** are arranged in a row and are placed as close together as possible and contact with the lower reach of the belt **5**. The wheels act as a continuous bed of rollers for the lower reaches of the belts **5**.

In FIGURE 4, the skate wheels **7** are mounted between side members *8a*—*8a*, forming the frame **8**, and angle irons *8b*—*8b* secure the frame **8** to the cross channel **9**. The lower edges of the side members *8a* have guide rods *8c* welded thereto and these constitute guide beads for the lower reach of the V belt **5**. The skate wheels **7** contact with the narrow edge of the lower reach of the V belt **5**. The means for mounting the skate wheels **7** is illustrative only and we do not wish to be confined to the exact means shown.

In FIGURE 1 it will also be noted that we provide a lower set of wheels *7a*, such as skate wheels, and mount them in a frame *8d*, the frame being similar to the frame **8** and urged upwardly by air pressure in hoses *9a*. The air hoses *9a* extend transversely across the machine and are enclosed in telescoping members *9b* that rest on a supporting frame *10a* and will move the upper reach of the V-belt *5a* against the under surface *6a* of the veneer B with a yielding pressure. The frame *10a* has bearings for rotatably carrying the shafts *1a* and *2a* and springs *10b* yieldingly support the frame *10a*. The air hose can have any desired pressure therein and will cause the wheels *7a* to exert the desired pressure against the V belt portions *5a* that contact with the under surface of the veneer. The edges of the sheets of veneer B are provided with a coating of adhesive of the desired type before the veneer is fed into the press.

Any means, not shown, may be used for driving the shafts **1** and **2** and the shafts *1a* and *2a* for moving the sheets of veneer B from the left hand "feed" side of FIGURE 1 toward the right hand "press" side. The veneer may be manually fed between the sheaves **3** and *3a* or a feeder, not shown, may be used for this purpose. The upper wheels **7** provide a non-yielding pressure plate for the veneer. The lower wheels *7a* in actual practice will press the belt *5a* against the veneer surface *6a* and the portion of the belt from the pulley *3a* to the lead wheel *7a* will extend upwardly at a slight angle to form with the belt **5** what we term a "bird's mouth." The feeding of the veneer is made easier and different veneer thicknesses are compensated for in this manner.

The veneer is fed from the feed section into the press section of the machine. This section is preferably a duplicate of the feed section except that the sheaves and shafts are preferably not power driven and the purpose of this will be explained hereinafter. The press section may be power driven if it is thought necessary. Furthermore, it is desirable to have the feed section overlap the press section to a slight extent and therefore the forward sheaves of the press section are placed between the front and rear sheaves of the feed sections. For example, in FIGURES 1 and 2, the press section is shown as being composed of a plurality of upper rubber V-belt assemblies C. The V-belt assemblies C have their front shaft **12** mounted between the shafts **1** and **2** and positioned above the sheets of veneer B. The rear shaft **13** of the upper V-belt assemblies C is placed to the rear of the shaft **2**. A sheave **14** is mounted on the shaft **12** and a sheave **15** is mounted on the shaft **13** for each assembly C. Belts **16** V-shaped in cross-section are passed around

the sheaves 14 and 15. It will be noted in FIGURE 2 that the top belt assembly C of the press section is placed close to one of the top belt-drive assemblies A of the feed section. We prefer to use as many top belt assemblies C as there are top belt-drive assemblies A.

It will also be noted in FIGURE 1 that the bottom V-belt press assemblies C^1 in the press section of the machine have a front shaft 17, and a rear shaft 18. A sheave 19 is mounted on the front shaft 17 while a sheave 20 is mounted on the rear shaft 18. As many sheaves 19 and 20 are placed on the shafts 17 and 18 as are needed to make up the bottom V-belt press assemblies C^1. V-shaped belts 21 made of rubber so as to have resilient properties, are passed around the pairs of sheaves 19 and 20. It will be seen from this structure that the rear portions of the belt feed assemblies A and A^1 overlap the front portions of the V-belt press assemblies C and C^1.

There may be slight spacings between the adjacent sheets of veneer as they are moved through the feed section of the machine, this spacing resulting from the manner in which the pieces of veneer or other material is fed into the machine. This same spacing between adjacent sheets would be maintained in the press section if the V-belt assemblies C and C^1 were driven at the same speed as the V-belt assemblies in the feed section. If the V-belt assemblies in the press section are permitted to idle rather than be driven, the members B moving from the feed section would abut the members in the press section before the V-belt assemblies C and C^1 would be moved. In this way contact between the edges of adjacent members B is established and maintained through the press section.

The V-belt assemblies C and C^1 have rollers or wheels contacting the portions of the V belts which in turn bear against the upper and lower surfaces 6 and 6*a* of the pieces of veneer B. Again referring to FIGURE 1, it will be seen that we provide wheels 22 mounted in a frame 23 and bearing against the lower reach of the V belt 16 in the rear upper V-belt assembly C. Channel irons 24, similar to the channel irons 9, support the wheel carrying frames 23. The parts 22 to 24, inclusive, correspond to the parts 7 to 9, inclusive.

Another group of wheels 26 for the lower press assemblies C^1 are mounted in a frame 27 and air hoses 28 are placed between the frame 27 and a supporting frame 29 for urging the wheels against the upper reach of the V belt 21. The supporting frame 29 carries the shafts 17 and 18. We provide a group of wheels 26 for the upper reach of each V belt 21, and we also provide a group of wheels 22 for the lower reach of each V belt 16. The result is a continuous pressure against the portions of the V belts that contact with the veneer. Springs 25 yieldingly support the frame 29 in the same manner as the springs 10*b* yieldingly support the frame 10*a*.

The press section comprising the upper and lower V-belt assemblies C and C^1 are not only operated by the pieces of veneer B moved therebetween, but in addition an adjustable braking force may be used for retarding the too free movement of the veneer through the press section if desired. The V-belt assemblies A and A^1 in the feed section not only hold the veneer sheets in a flat plane, but also move the veneer into the press section. The V-belt assemblies C and C^1 in the press section not only maintain the sheets of veneer in the same flat plane, but the movement of the veneer through the press section is preferably accomplished by an edge to edge contact between the adjacent pieces of veneer caused by a forward movement of the sheets in the feed section as they are fed from this section into the press section. This will cause the abutting edges of adjacent sheets of veneer to be held in close contact as the sheets pass through the press section, and in addition the abutting edges will be held in perfect alignment as they pass through the press section. It is possible to power drive the V-belt assemblies in both the feed and press sections and to have the V-belt assemblies in the press section operate at a slower speed. This arrangement would not only close the gap between adjacent pieces B in the press section, but would also apply the desired pressure to urge the abutting edges together so a firm wood to wood contact is maintained during the heating of the adhesive.

We apply the radio-frequency heat to the adhesive that is interposed between the abutting edges and the heat causes the adhesive to set and thus bond the adjacent sheets of veneer to each other along their abutting edges to form a moving web of edge-bonded veneers. If it is necessary to prolong the time of heating, a braking force can be applied to the V-belt assemblies C and C^1 to retard the forward movement of the sheets of veneer B through the press section. In this case the V-belt assemblies in the press section would not be power driven, but would idle. Of course the press section V-belt assemblies could be moved at a slower speed than the feed section to accomplish the same result.

Any braking means may be used and we have shown brake drums 30—31 mounted on the shafts 13 and 18 in FIGURE 1. Brake shoes 32 and 33 are pivoted at 34 and 35, respectively, and adjustable springs 36 and 37 urge the shoes into frictional contact with the brake drums to create the desired braking force. This will cause the edges 11 of the strips of veneer to remain in contact with each other so that the adhesive 11*a* applied to the edges, will be heated by the radio-frequency energy and set so as to bond the adjacent veneer sections into a continuous web.

It is now best to refer to FIGURE 5 wherein we illustrate one method of parallel bonding for the sheets of veneer that are being moved through the press section of the machine. The lower reaches 16*a* of the V belts 16 in the V belt assemblies C are indicated as contacting with the upper surface 6 of the veneer B. The same figure also illustrates the upper reaches 21*a* of the V belts 21 in the V-belt assemblies C^1 contacting the under surface 6*a* of the veneer B. The veneer will therefore be held in a flat plane and its edge 11 will be maintained in a straight line.

We place a plurality of electrodes 38 between the lower reaches 16*a* of the V belts and these electrodes are preferably placed midway between the lower reaches of the adjacent V-belt assemblies C and parallel the lower reaches 16*a*, see FIGURE 2. The electrodes may be of any length desired and they preferably extend throughout the length of the press section as shown in FIGURE 2.

Again referring to FIGURE 5, it will be seen that every other electrode 38*a*, 38*c* and 38*e* starting from the left hand side of the figure is electrically connected to one side 39 of a radio-frequency coil 40. In like manner the remaining electrodes 38*b*, 38*d* and 38*f* are electrically connected to the other side 41 of the radio-frequency coil 40. The radio-frequency coil preferably forms a part of the radio circuit shown in our Patent No. 2,506,158, issued May 2, 1950. Since the radio-frequency current flowing through the coil 40 alternates, the electrodes 38*a*, 38*c* and 38*e* will be positive at one instant while at the same time the electrodes 38*b*, 38*d* and 38*f* will be negative. When the current reverses itself in the coil, the positive electrodes will become negative and the negative ones will be changed to positive.

The use of elongated electrodes 38 are employed to answer the requirement that the glue plane 11*a* shown in FIGURE 1, be under the influence of the high-frequency field for a considerable duration of time compared to that of an instantaneous exposure, should the electrodes be short in length. A special characteristic of the high-frequency field of force should be understood to be able to fully appreciate the reason for the particular arrangement herein disclosed. When alternately charged spaced electrodes connected to a source of high-frequency alternat-

ing current are arranged so as to have parallel faces, they alternately possess opposite electrical charges which are in step with the frequency of the generated source of radio-frequency energy. The field between adjacent electrodes **38** will be relatively non-uniform, varying from one electrode of a high negative charge such as the electrode **38***b* in FIGURE 5, to a zero electrical charge midway between the electrode **38***b* and then to either the electrode **38***a* or the electrode **38***c* which have a positive charge. The peculiar characteristic of the high-frequency standing wave field, set forth in our patent above-mentioned, has led us to the invention of the novel electrode arrangement herein described and the method of edge-bonding herein disclosed.

The point X midway between parallel electrodes oppositely charged is a point of zero electrical charge and hence a V belt such as the one shown at **16***a* in FIGURE 5, or even a metal shaft, chain, plate or the like, can be placed midway between the electrodes **38***a* and **38***b* without substantially affecting the distribution of the electric field of force between the oppositely charged and parallelly faced electrodes. So long as the distribution of capacity along the length of the electrodes and between the electrodes and the mass placed midway therebetween does not vary substantially throughout the electrode length, the zero electrical charge will be in the vicinity of the V-belt portion **16***a*. The exact placing of the belt at the midway position is not critical, but varies with the width of the mass employed between the charged electrodes in relation to the total width between the parallel electrodes.

The electrodes **38** are preferably spaced apart the same distance as are the V-belt portions **16***a*. The electrical connections between the electrodes **38** and the coil **40** are designed so as to feed into the upper framework of the V-belt assemblies C as shown in FIGURE 5. It is obvious that the electrical network could be placed in the lower V-belt assemblies C^1.

It is advisable that the electrodes **38** actually contact with the wood B as it moves through the machine. If there are air spaces or if there is a non-uniform contact between the electrodes and the wood, electric sparks or undesirable arcs may be induced. It is also necessary that the edges of the pieces of veneer contact each other throughout their lengths so that no voids will be formed, across which undesirable arcing may take place when establishing contact between the electrodes and the sheets of veneer B. The electrodes **38** are preferably suspended from rods. FIGURE 5 shows a simple arrangement with the electrodes **38** being supported by rods **42**. The rods in turn are suspended from bus bars **43** and electrical insulators **44** connect the bars to the machine. The bus bars **43** preferably extend transversely across the machine. One set of bus bars will be connected to the electrodes **38***a*, **38***c* and **38***e*, while another set will be connected to the other electrodes **38***b*, **38***d* and **38***f*. We do not wish to be confined to this particular type of support for the electrodes **38** because any means for supporting the electrodes and holding them in contact with the veneer would suffice.

The principle taught by us in our Patent No. 2,434,573, is that parallel bonding utilizes that path for the field of force which is more conductive than some other path, and places such a more conductive path parallel to the dominant field lines of force of an electric field when the field is established between alternately and oppositely charged electrodes such as for example, the electrodes **38***a* and **38***b*. The glue plane **11***a* should substantially parallel a straight line connecting the alternately charged electrodes **38***a* and **38***b* at their closest points. All of the electrodes **38***a* through **38***f*, inclusive, in FIGURE 5, are parallel bars or tubes and it will be seen that an infinite number of lines may be drawn between the adjacent electrodes **38***a* and **38***b* for example, and these lines will be parallel to each other. The passage of a glue plane **11***a* through the machine will cause this plane to parallel the radio-frequency lines of force just mentioned. The glue plane **11***a* will be substantially perpendicular to the running direction of the V-belt portions **16***a*. The radio-frequency will therefore pass along the glue planes from one electrode to the other and this will cause the adhesive to set. The diagrammatic view of FIGURE 5 is of a single strength "stray field" parallel bonding.

When gluing thicker pieces of lumber together, the **Z** pattern parallel bonding arrangement shown in FIGURE 6 may be used. The same upper and lower V-belt assemblies C and C^1 are employed so that the lower reach **16***a* of each upper V-belt assembly C and the upper reach **21***a* of each lower V-belt assembly C^1 will hold the thicker pieces of lumber B^1 in the desired position. Boards of random width may be glued together adjacent to their edges **47**.

In our Patent No. 2,457,498 on **Z** pattern parallel bonding, we disclose corrugated electrodes which provide staggered points that contacted the edge-glued boards on opposite surfaces. This arrangement concentrated the field lines of force in the glue plane to form a zig-zag or sawtooth pattern rather than spot gluing or solid gluing. The **Z** pattern type of parallel bonding can be used with the machine shown in FIGURES 1 to 3, inclusive, but the network of electrodes **48** and **49** would have to be altered from the electrodes **38** shown in FIGURE 5.

In FIGURE 6, we show the electrodes **48***a* and **48***b* placed above the piece of lumber B^1. Between the electrodes **48***a* and **48***b*, two of the V-belt assemblies C are disposed. There will therefore be two of the lower reaches **16***a* of the V-belts placed between the pair of electrodes. The other set of electrodes **49***a* and **49***b* are disposed under the piece of lumber and here again two of the upper reaches **21***a* of the lower V-belt assemblies C^1 will be disposed between the pair of electrodes. The electrodes **49***a* and **49***b* are connected by wires to an end **50** of a radio-frequency coil **51**, and wires lead from the electrodes **48***a* and **48***b* to an end **52** of the radio-frequency coil **51**. The coil forms a part of the radio-frequency circuit shown in our Patent No. 2,506,158.

At any given instant the electrodes **49***a* and **49***b* are positive while the electrodes **48***a* and **48***b* are negative and when the alternating current reverses itself, the reverse is true. Radio-frequency lines of force will therefore be established from the negative electrode **48***a* to the positive electrode **49***a* and then from the same positive electrode **49***a* to the negative electrode **48***b*, and finally from the negative electrode **48***b* to the positive electrode **49***b*, as shown by the dash **Z** pattern line in FIGURE 6. If more electrodes are used the zig-zag, the sawtooth or **Z** pattern would merely be increased in length. The **Z** pattern should extend throughout the entire length of the glue plane **47***a* provided on the edge **47** of the piece of lumber B^1.

It will be found less necessary as the thickness of the stock increases, to have the V-belt assemblies placed close together. When one-inch boards are glued together, the V-belt assemblies may be spaced four inches apart instead of two or three inches apart as is the case when stock $\frac{1}{10}$ of an inch thick has its edges bonded together. As the thickness of the stock increases, the necessity to maintain close control of the stock edge registration diminishes.

Furthermore, as the thickness increases, it will be found that at a certain point where a full and symmetrical cure in the adhesive line or plane is desired, two sets of electrodes of the type shown in FIGURE 7 can be used. We term this arrangement of electrodes, split pole parallel bonding. Again, the lower reaches **16***a*, of the upper V-belt assemblies C contact with the upper surface of the piece of lumber B^2 at the same time the upper reaches **21***a* of the lower V-belt assemblies C^1 contact with the under surface of the same piece of lumber. An electrode **53** is placed between each pair of lower reaches **16***a*. In like manner another set of electrodes **54** contacts with the

under surface of the piece of lumber B^2 and an electrode is placed between each pair of upper reaches **21***a* of the V-belt assemblies C^1. Every other electrode in the upper group, namely: the electrodes **53***a* and **53***c* are connected to an end **55** of a radio-frequency coil. It will further be seen that the electrodes **54***a* and **54***c* in the lower set which are disposed directly under the upper electrodes **53***a* and **53***c*, are also connected to the same end of the coil. For example, the electrodes **54***a* and **54***c* will be connected to the same end **55** of the coil **56**. The other pairs of electrodes **53***b* and **54***b*, and **53***d* and **54***d* will be connected to the opposite end **57** of the radio-frequency coil **56**.

The result is a split pole electrode network. At any given instant, the electrodes **53***a*, **53***c*, **54***a* and **54***c*, will be charged positive, while at the same time, the other electrodes **53***b*, **53***d*, **54***b* and **54***d*, will be negatively charged. When the electrodes are placed midway between the V-belt assemblies, as indicated in FIGURE 7, and as the spacing between the belts is increased, the pairs of electrodes each forming a split pole, will be spaced further apart from each other. If, at the same time, the thickness of the board is increased, requiring a deeper penetration of radio-frequency lines of force to cure a wider glue plane depth, then there comes a point as the thickness of the board increases, where a parallel network of electrodes below the board can duplicate the work performed by the electrodes placed above the board. Such a case is depicted in FIGURE 7 and the electrical charges on the electrodes in the upper group will be the same as the electrical charge on the lower group. This we term split pole parallel bonding and we refer to this method of bonding in our co-pending application Serial No. 208,626, now Patent No. 2,678,897, issued May 18, 1954.

It will be seen, therefore, that several choices of wiring arrangement are available to the user even though the same type of press as shown in FIGURES 1 to 3, inclusive, is employed. The choice of bonding method depends upon the thickness of the lumber which is being edge-glued. Each arrangement shown in FIGURES 5, 6 and 7, has a distinct advantage for a particular spacing of the V-belt assemblies and for the particular thickness of the wood being edge-glued. The electrode network in FIGURES 5, 6 and 7 is long enough to give exposure time for curing urea adhesives in relation to the characteristics of the resin and the speed of movement. In gluing veneers edge to edge, a speed of twenty to thirty feet per minute is sufficient. The speed is slower when edge-gluing pieces are used to make up chair bottoms.

The radio-frequencies used range from six to just over forty megacycles. Other frequencies may be employed, however, and we do not wish to be confined to the frequencies mentioned.

Little has been said as to the possibility of the stock buckling or overlapping in its transfer from the feed to the press section or on actual edge to edge contact between fast moving veneers and those already edge contacting whether the contact be made in the press section or in the feed section or in an overlapping portion of the two sections. It was found that if the feed and press sections overlapped slightly, a better transition and contact can be expected. If the upper V belts A of the feed section therefore enclose besides their own two shafts, the leading common shaft of the upper unit of the press section C and the V belts spaced between the sheaves of the other section, an overlapping of the feed and press sections may be employed with good results. Without this overlapping, edge register could not be maintained between the pieces being bonded without complicated mechanical structures being required. When the multiplicities of V-belt assemblies are spaced two and one-half inches apart in the feed and press sections, they will be spaced only one and one-quarter inches apart in the overlapping portion of the two sections. This forms a firm table where edge contact may be made without the feat of buckling or the over-creeping of veneers one upon the other—even if of this cross section and width. This overlap of the two sections should be long enough so that as the veneer leaving the feed section passes the last skate wheel roller **7** holding its V belt flat from the inside, will immediately enter the press section and the first skate wheel roller **22** of the press section holding its V belt in position from the inside. The overlap acts as though no gap exists between the feed and the press section. A firm backing of the veneer is accomplished in the initial portion of the press section due to this overlapping feature.

Varying degrees of edge pressure may be applied to the veneers being pressed together by either one of the two means: (1) by increasing or decreasing the pressure applied to the opposing sets of skate wheels **22** and **26**; or (2) by increasing or decreasing the drag which may be applied to the press section. In the first case, the compressed air to the hose sections **28** is increased to the desired extent. In the second case, the brake shoes **32** and **33** apply the desired braking force on the brake drums **20** and **31**.

The veneer pieces B are run through the machine so the grain of the wood is perpendicular to the running direction of the V-belt assemblies of the press section. The glue planes between the abutting edges of adjacent pieces of veneer will likewise be in the direction of the grain of the wood. Tapered pieces of veneer may be inserted in the web intentionally to correct malalignment of the veneer web as it progresses through the machine.

Heat responsive adhesives of the thermal setting type cure in a well defined time-temperature relationship. Therefore an instantaneous exposure at one point to a hilgh-frequency alternating current field of force would in most instances be insufficient exposure to polymerize the resin adhesive. Longer exposure allows the internal heat introduced into the adhesive line by the high-frequency field to bring the temperature of the glue plane up to that required to turn over or polymerize the resin, and to fulfill the basic requirements of the adhesive to cure in a certain time and at a certain temperature.

The V-belt assemblies A^1 in the feed section can be moved as a unit and independently of the V-belt assemblies C^1 in the press section. The amount of compressed air in the air hose sections **9***a* controls the pressure exerted by the frames **8***d* with their wheels **7***a* against the undersurface **6***a* of the veneer B. In like manner, the amount of compressed air in the air hose sections **28** controls the pressure exerted by the frame **27** and wheels **26** against the undersurface of the veneer. It is possible for example to place two pounds of air pressure in the left hand hose **9***a* in FIGURE 1, ten pounds in the right hand hose **9***a*, and then place two pounds in the left hand hose **28** and ten pounds in the right hand hose **28**.

The air hose will also permit pieces, wedge-shaped in cross section to be edge-glued. For example, shingles can be fed through the machine and edge-glued together. The thicker butt ends of the shingles would be placed near one side of the machine and the thin ends would be positioned near the other side. The hose sections **9***a* and **28** would accommodate the V-belt sections A^1 and C^1 to the shingles even though they were wedge-shaped in cross section.

In certain cases where thicker lumber is being edge-glued, the press section V-belt assemblies C and C^1 do not offer sufficient retarding force to the pieces to hold them in contact with each other with sufficient pressure to provide a good bond during the curing of the adhesive. This is true even if a braking force is exerted by the brake shoes **32** and **33** on the drums **30** and **31**. We therefore show in FIGURE 1, an auxiliary air pressure controlled means for retarding the movement of the boards through the machine to the desired extent.

A stationary member **58** contacts with the upper surface **6** of the web of veneer B just as it leaves the press section of the machine. A movable member **59** yieldingly

contacts with the undersurface 6*a* of the veneer web B and an air hose 60 applies the desired amount of pressure on the member 59. The air hose 60 has compressed air therein at a pressure of about sixty pounds per square inch when thicker lumber than the veneer B is being edge-glued. A great deal of force is needed to move the thicker lumber between the members 58 and 59 when a clamping pressure of about sixty pounds is being exerted. The pieces in the press section will move more slowly and will be held more tightly together resulting in a more perfect bond.

In FIGURE 8, we show electrodes of a different shape from those shown in FIGURES 1 to 5, inclusive. Instead of rods 42 connecting the electrodes 38 to the bus bars 43 as illustrated in FIGURE 5, the electrodes 61 and 62 have upwardly bent ends. In actual practice, the base portions 61*a* and 62*a* of the electrodes 61 and 62 would lie in the same horizontal plane and bear against the upper surface 6 of the veneer B. The movement of the veneer through the machine is in the direction of the arrows "*a*." When the electrode 61 is charged positive, the electrode 62 will be charged negative, and vice versa. The two electrodes 61 and 62 would be spaced from each other in much the same manner as the electrodes 38 in FIGURE 5 are spaced apart.

The bus bars 63 are similar to the bus bars 43 of FIGURE 5 and support the upturned ends 61*b* and 61*c* of the electrode 61. Insulators 65 support the bus bars 63 and the bars are in electrical connection with one end of a radio-frequency coil, not shown, of the type illustrated in FIGURE 5. In like manner, the bus bars 64 support the upturned ends 62*b* and 62*c* of the electrode 62. Insulators 66 support the bars 64 and the bars are in electrical connection with the other end of the same radio-frequency coil. The bars 64 lie in the same plane as the bars 63. If desired, the insulators 65 and 66 may be spring suspended, by using coil springs 67.

Although the ends 61*b* and 61*c* of the electrode 61 extend upwardly and rearwardly at an angle and the ends 62*b* and 62*c* of the electrode 62 extend upwardly and forwardly at an angle, the base portions 61*a* and 62*a* of the two electrodes are of the same length and contact with the veneer or other piece being edge-glued, at approximately the same transverse point. The arrangement makes it possible for the bus bars 63 and 64 to lie in the same plane and the base portions of the electrodes to occupy the same relative positions when considering the length of the machine. Of course the base portions 61*a* and 62*a* of the electrodes 61 and 62 are spaced from each other. The bus bars 63 and 64 will also be spaced from each other.

FIGURES 2 and 3 illustrate the V belts C and C^1 in the press section as being placed adjacent to certain V belts A and A^1 in the feed section. In actual practice we have found it advisable to position the V-belt assemblies C and C^1 in the press section, midway between the adjacent V-belt assemblies A and A^1 in the feed section. A more uniform pressure on the sheets of veneer B or other material results from this construction as the material passes from the feed section into the press section, and therefore we do not wish to be confined to the particular arrangement of the V belts illustrated in FIGURES 2 and 3. The equal spacing of the V-belt assemblies C and C^1 between the V-belt assemblies A and A^1 not only causes a more uniform pressure on the material being glued at the point of transition from the feed to the press section, but also produces increased pressure on the material at this critical point of travel through the machine.

The electrodes 38 are also preferably positioned midway between the adjacent V-belt assemblies C and C^1. This arrangement is clearly shown in FIGURES 2 to 7, inclusive. Where the overlapping portions of the V-belt assemblies C and C^1 in the press section are disposed midway between the adjacent V-belt assemblies A and A^1 in the feed section, the forward ends of the electrodes 38 will terminate at points adjacent to the sheaves 4 and 4*a*, because the electrodes will be in line with the V-belt assemblies A and A^1 in the feed section.

In FIGURE 3 the left hand electrode 38 is shown disposed closer to the V-belt assembly A in the feed section than the next electrode 38, but reference to FIGURE 2 illustrates the V-belt assembly C in the press section is disposed adjacent to the left hand V-belt assembly A in FIGURE 3 and therefore in reality both electrodes 38, disposed on opposite sides of the uppermost V-belt assembly C shown in FIGURE 2, will be spaced equal distances from their common V-belt assembly C. The left hand V-belt assembly C in FIGURE 3, corresponding to the uppermost V belt C in FIGURE 2, is not shown in FIGURE 3 because the drawing would become too complicated. The point that we wish to advance is that the electrodes 38 will be spaced midway between adjacent V-belt assemblies C or C^1 in the press section.

The underlying principle in using resilient rubber belts in the "feed" and "press" sections and in power driving the belts 5 and 5*a* in the "feed" section while retarding the movement of the belts 16 and 21 in the "press" section, is to maintain continuously the edge pressure between adjacent pieces of veneer or lumber, by using the resilient properties of the rubber belts 5, 5*a*, 16 and 21. The lower reaches of the belts 5 in contacting with the upper surfaces of the veneer strips B are in a stretched state due to the fact that these reaches are pulling the veneer strips through the "feed" section. The same is true of the upper reaches of the belts 5*a* when contacting with the under surfaces of the veneer strips B and this is due to the fact that these reaches are pulling the veneer through the "feed" section.

When the veneer strips B reach the "press" section and are engaged on their upper and lower surfaces by the lower reaches of the belts 16, and the upper reaches of the belts 21, these reaches are moved only by the veneer strips entering therebetween. The veneer strips as they move from the "feed" section into the "press" section, have their adjacent edges brought into abutting relation because the veneer strips in the exit end of the "press" section must move the strips into the "press" section by edge to edge contacting therewith. The reaches of the belts in the "press" section that are engaged by the veneer strips are therefore placed under compression. The stretched state of the belt reaches in the "feed" section, oppose the compressed state of the belt reaches in the "press" section and, as a result, a continuous edge pressure between adjacent pieces of veneer is maintained while the stock is advancing through the high-frequency electric field.

The process is also unique because the intermeshed top tractors A and C, and the intermeshed bottom tractors A^1 and C^1, never release their edge register holding of the veneer strips during the transition of the still unset joints as the strips move from the drive or "feed" section into the idling or "press" section. In summing up it will be seen that:

(1) The use of rubber belts to utilize their resilient properties to maintain edge pressure between adjacent pieces of veneer or lumber is unique.

(2) The intermeshed tractors A and C and A^1 and C^1 insures the complete registry of the opposed edges of the adjacent pieces of veneer or lumber during transit of the stock through the intermeshed portions and on through the remainder of the "press" section.

(3) The combination of the "stray field" parallel bonding as illustrated in FIGURE 5, and the split pole type parallel bonding, shown in FIGURE 7, with the intermeshed tractors is also unique. The contact of the belt reaches with the stock is made at the neutral points of the high-frequency field through which the stock travels in the "press" section.

We claim:

1. In a continuous method of bonding dielectric materials lying in a single layer and in abutting relation with adhesive therebetween; which comprises the steps: establishing a high-frequency field of force with at least one zero voltage gradient extending along a path in the field; continuously moving the pieces of dielectric material through the field while maintaining adjacent pieces in contact with each other and in a single flat plane; and in applying pressure from opposite surfaces of the pieces for holding the pieces in a flat plane while still permitting them to move continuously, the pressure on the surfaces being at points along the path of the zero voltage gradient.

2. In the herein described continuous method of edge-bonding plurality of flat members together into a unitary flat web structure, the steps of: applying adhesive to at least one edge of each flat member, which edge is to be bonded to a confronting edge of an adjacent flat member; contacting the flat members from opposite sides at points directly above and below each other, the pairs of points of contact being spaced laterally across the widths of the flat members and being used for gripping and continuously moving the flat members in yielding processional relation following one behind the other with the flat members being held in the same flat plane; yieldingly contacting the moving leading flat member and progressively contacting succeeding flat members from opposite sides and at spaced points that lie between the original points of contact for maintaining the leading flat member and the succeeding flat members in a flat plane and thereafter freeing the original points of contact on the leading flat member and successively on the succeeding flat members; whereby the next succeeding continuously moving flat member following the leading flat member will be brought into abutting yielding contact with the leading flat member and will abut thereagainst at a certain pressure for continuing to move the leading flat member, and the succeeding flat members will be brought progressively into abutting contact with the flat member thereahead to form a continuously moving unit composed of the flat members; and in directing radio-frequency lines of force through

the adhesive planes while the abutting flat members are yieldingly held in contact while maintained in continuous movement for setting the adhesive and edge-bonding the flat members together.

3. In a continuous flat plan process of edge bonding flat members together which comprises the steps: gripping a plurality of adhesive edge spread flat members at transversely spaced apart points above and below the members for holding the members in a flat plane and moving the members forwardly in a continuous manner; gripping the same flat members at transversely spaced points above and below the members and between the points already gripped and prior to the releasing of the first gripped points, and applying a less retarding force on the second gripped points than on the forward driving force to apply edge pressure between adjacent members while permitting continuous movement of the members to form a web.

4. The sequence of steps as set forth in claim 3: and exposing the web of continuously advancing members in edge abutting pressure applied relationship to the heating effect of a high frequency alternating current field of force during the second gripping of the members and after releasing the first gripping of the members for edge bonding the plurality of flat members into a unitary flat structure.

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