Aug. 25, 1953 W. S. THOMPSON ET AL 2,649,876

HIGH-FREQUENCY HEATING OF GLUED JOINTS

Filed Sept. 20, 1947 2 Sheets-Sheet 1

FIG. 1.

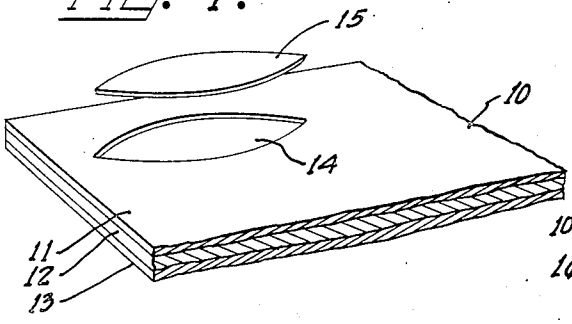


FIG. 2.

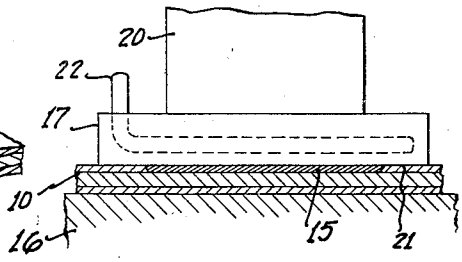


FIG. 3.

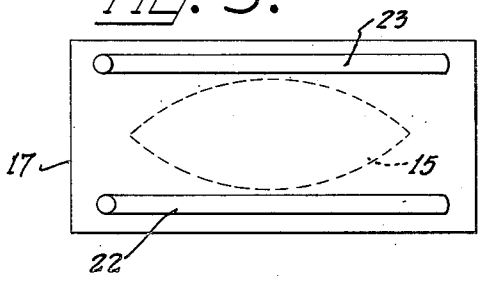


FIG. 4.

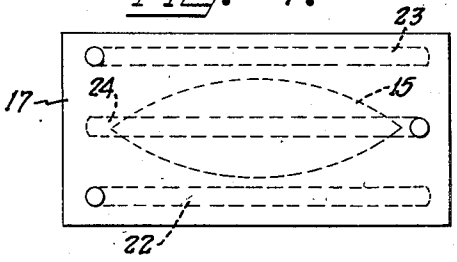


FIG. 6.

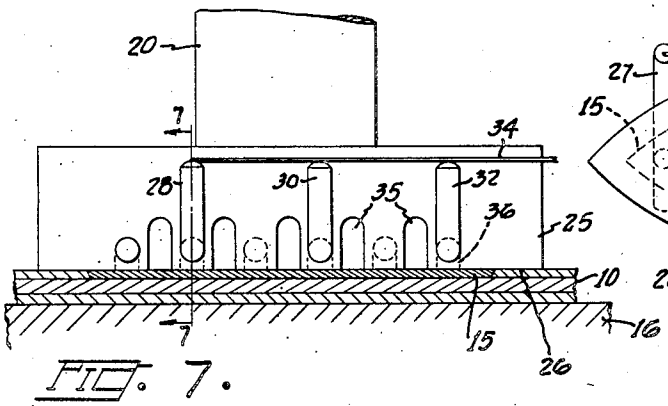


FIG. 5.

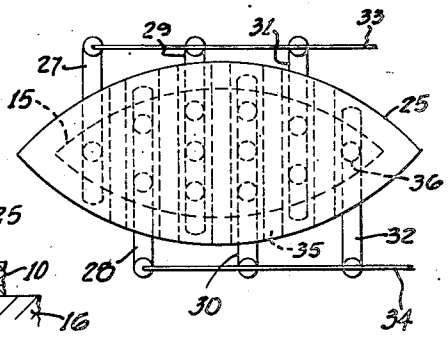
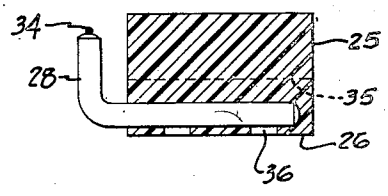


FIG. 7.



INVENTORS
WALTER S. THOMPSON
HARRELL RENN

BY Cook and Scherpenhorn
ATTORNEYS

Aug. 25, 1953 W. S. THOMPSON ET AL 2,649,876

HIGH-FREQUENCY HEATING OF GLUED JOINTS

Filed Sept. 20, 1947 2 Sheets-Sheet 2

FIG. 8.

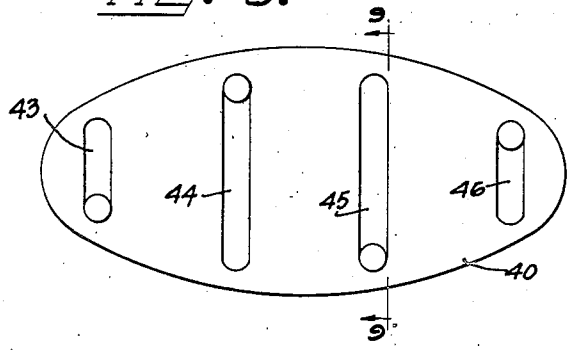


FIG. 9.

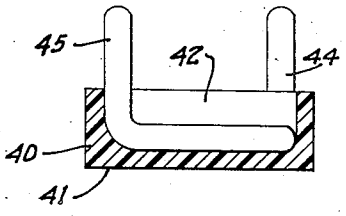


FIG. 10.

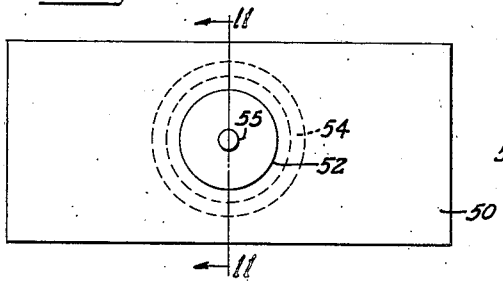


FIG. 11.

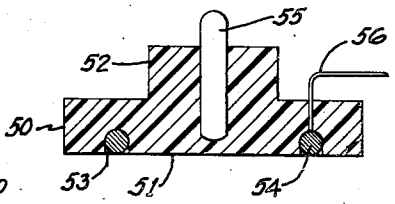


FIG. 12.

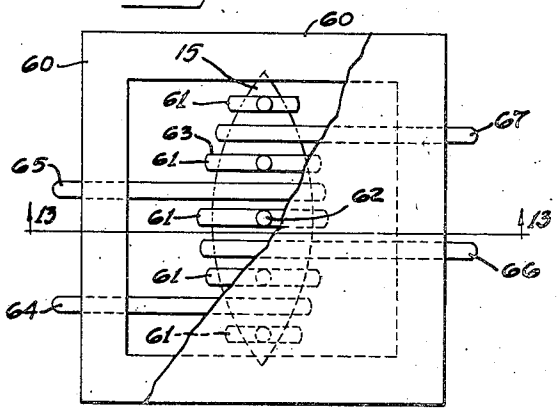
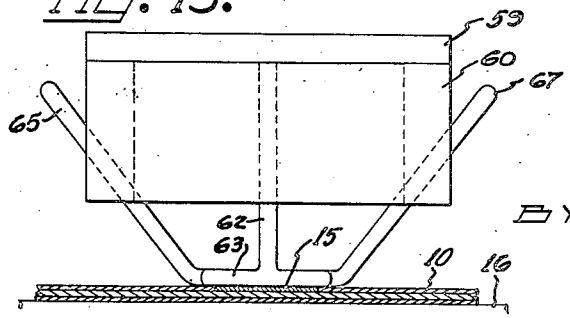


FIG. 13.



INVENTORS
WALTER S. THOMPSON
HARRELL RENN

BY Cook and Eckermeyer

ATTORNEYS

Patented Aug. 25, 1953

2,649,876

UNITED STATES PATENT OFFICE

2,649,876

HIGH-FREQUENCY HEATING OF GLUED JOINTS

Walter S. Thompson, Portland, and Harrell Renn, Albany, Oreg., assignors to M and M Wood Working Company, Portland, Oreg., a corporation of Oregon

Application September 20, 1947, Serial No. 775,341

8 Claims. (Cl. 144—281)

1

This invention relates to improvements in the use of high frequency electrical heating to set the glue in the gluing of wood veneers, and has particular reference to the patching of plywood.

There are many advantages inherent in the use of high frequency heating to set a glue line between different layers of veneer and the like which tend to make this mode of heating superior to hot platen pressing. Perhaps the greatest advantage in high frequency heating arises from the fact that a major portion of the energy expended may be developed as heat directly in the glue lines, whereas with hot platens the heat must be applied to the exterior surface of the panel and then transmitted through the wood by conduction to the glue line which is to be heated. When thermosetting glues of the usual synthetic resin type are employed, a certain critical temperature must be attained in the glue line in order to set the glue, or at least to set it quickly, which necessitates a temperature gradient through the wood from the hot platen depending upon the value of the critical temperature of the glue, the time which may be allowed for the heating step, and the maximum temperature to which the surface of the wood can be subjected without being damaged to an extent that would lower the grade of the finished product. It is evident, therefore, that if the surface temperature is to be minimized in hot platen pressing, the time factor, and consequently the heat losses, are increased. Also, the output of the plant equipment is correspondingly reduced. Conversely, if the time and loss factors are minimized, the temperature gradient is increased, making higher surface temperatures necessary.

In the patching of plywood in the course of its manufacture by inserting small patches where defects have been removed from a face veneer, it is particularly important to accomplish the operation with speed and dispatch to avoid slowing down the whole line of work flow in the plant. Thus, with the increasing use of thermosetting resin glues in the manufacture of plywood, it is highly desirable to conduct the patching operations with the same kind of glue, and to accomplish such operations with a speed commensurate with the flow of finished panels from the hot presses. The advantages of high frequency heating are, therefore, especially desirable in the gluing of such patches in order to keep up with the steady flow of production and avoid occasioning excessive handling and delay in the patching process. Most previously known applications of high frequency heating, however, do not lend

2

themselves without considerable modification to the gluing of wood veneer, and those high frequency heating systems which have been previously applied to the gluing of veneers are usually found to be unsuited to the particular requirements which must be satisfied in patching plywood in the course of production.

For the sake of efficiency and economy, it is desired to confine the heating effect substantially to the area of the glue line on the patch without heating the various other glue lines underneath, which would be five in number in the case of a seven-ply panel. In order to make a good bond and make the patch lie flush with the face of the panel, pressure must be applied substantially uniformly over the area of the patch while the glue on the patch is being heated to the desired temperature. Many limitations arise through the use of high voltage, high frequency fields which must be reckoned with to make the heating system satisfactory for the present purpose. Some of the most persistent difficulties arise from the ever present tendency toward the development of corona discharges from the electrodes and the formation of electrical leakage paths along insulating surfaces and on the surface of the work.

In general, the object of the present invention is to provide an improved apparatus for high frequency heating which will overcome the objections to prior art heating and pressing arrangements, and which will meet not only the particular limitations hereinabove pointed out in connection with high frequency heating, but also all other limitations inherent in the heating system and in its application to different kinds of work. Other objects are to provide an improved apparatus for applying a high frequency heating effect economically to an area of curved or irregular outline, particularly where such area lies beneath the exterior surface, to provide for heating a plurality of small contiguous areas which in the aggregate substantially fit within a total area to be heated, and, more specifically, to heat different parts of a total area by a plurality of dielectric circuits established between a series of interfingered electrodes arranged to cover the total area. Another object is to provide a novel and improved form of dielectric pressure member which will apply the necessary pressure to the work and which will hold a plurality of electrodes in proper relation to the work without objectionable corona or leakage effects. Another object is to provide a skeletonized dielectric pressure member having openings to provide

ventilation and to reduce the mass of the dielectric body included in the heating field. Other objects and advantages will become apparent and the invention will be better understood from the appended specification with reference to the accompanying drawings illustrating certain preferred embodiments of apparatus for carrying out the method.

In the drawings:

Figure 1 is a perspective view of a plywood patch immediately above an opening in the top veneer of a plywood panel from which a defect has been removed;

Figure 2 is a side elevation view of one form of patch press embodying the principles of the invention, the work and work table under the press being shown in section;

Figure 3 is a top plan view of the pressure member shown in Figure 2;

Figure 4 is a top plan view of a pressure element having a different electrode arrangement;

Figure 5 is a top plan view of a boat-shaped skeletonized pressure member;

Figure 6 is a side elevation view of the pressure member shown in Figure 5 and showing also in section a work table with a piece of work thereon;

Figure 7 is a sectional view of the pressure member taken on the line 7—7 of Figure 6;

Figure 8 is a top plan view of another form of pressure member;

Figure 9 is a cross sectional view taken on the line 9—9 of Figure 8;

Figure 10 is a top plan view of another form of pressure member;

Figure 11 is a cross sectional view taken on the line 11—11 of Figure 10;

Figure 12 is a top plan view with parts broken away of still another form of pressure member; and

Figure 13 is a cross sectional view taken on the line 13—13 of Figure 12.

Figure 1 illustrates an effective manner of patching plywood panels to remove surface defects and improve the grade of the panel. The panel 10 is made from three veneers 11, 12 and 13 which have been glued together with the veneers 11 and 13 constituting face sheets, and the veneer 12 constituting a core sheet. A defect in the face sheet 11 was removed by special tools to leave a boat-shaped opening 14 with beveled edges, the surface of the core veneer 12 being exposed in the opening 14. Such openings are usually cut in three standard sizes depending upon the size of the defect, and boat-shaped patches 15, also with beveled edges and cut from good clear veneers, are provided to fit snugly and inconspicuously into the opening of each standard size such as the opening 14. If the panel 10 is glued with a thermosetting resin glue, the patch 15 should be glued in place with the same kind of adhesive, which requires the application of heat and pressure to set the glue. If the patch were to be pressed into place with a hot platen, the platen would have to be hot enough and it would have to be applied to the patch long enough to establish a temperature gradient through the patch sufficient to heat its glue line to its critical setting temperature. However, by including the glue line in a dielectric circuit or circuits according to the present invention, the glue may be heated very quickly to its critical temperature without appreciable heating of the wood so that the patching operation is accomplished almost instantaneously and with no damage to the surface of the panel.

According to the present invention, the panel 10 is placed on a work table 16 as shown in Figure 2 and the patches pressed in place with a pressure member 17 urged against the work table by the action of a pneumatically operated piston 20 or other suitable pressure applying means. The pressure member 17 has a flat pressure face 21 adapted to engage the surfaces of the patch and panel and force the glue spread undersurface of the patch into intimate pressure contact with the core veneer 12, with the top surface of the patch approximately flush and smooth with the top surface of the face veeneer 11. The pressure member 17 carries a pair of electrodes 22 and 23 disposed in parallel relation as shown in Figure 3 and positioned closely adjacent the pressure face 21. These electrodes may be molded into the dielectric body of the pressure member 17 or they may be contained within parallel grooves in the body and provided with upstanding ends by which they may be energized from an output circuit of a high frequency oscillator. The spacing of the electrodes is preferably just slightly greater than the width of the largest patch to be used so that the glue line on the under side of the patch is included in a relatively short dielectric circuit between the electrodes. Since the face veneer is usually quite thin and the electrodes are disposed close to the top surface of the panel, the dielectric circuit is largely confined to the small area of the glue line on the top side of the core veneer 12 included between the electrodes and only a relatively minor part of the dielectric circuit passes through the more remote glue line on the bottom side of the core veneer 12 and the intervening wood. Moreover, the dielectric and other losses are highest in the wet glue on the patch whereby the principal heating effect is produced in the wet glue where it is needed. It is to be understood, however, that the glue on the patch need not be in a wet state, because even if it is dry the heating effect will still be greatest in the glue line which is closest to the electrodes regardless of how many other glue lines there may be between the veneers below in plywood having more than three layers of veneer.

In Figure 4 the rectangular heated area between the outside electrodes 22 and 23 is divided into two smaller rectangular areas by the interposition of a third electrode 24. In this arrangement the electrodes 22 and 23 may be connected together on one side of a two-wire circuit with the middle electrode 24 connected to the other wire. This electrode arrangement is also suitable for a push pull circuit wherein the center electrode is connected to the central or neutral wire and the outside electrodes 22 and 23 are connected to the respective outside wires of the three-wire circuit. With either circuit arrangement two distinct dielectric circuits are formed on opposite sides of the center electrode which may be of advantage in reducing the necessary voltage, and in obtaining more uniform heating in different parts of the heated area. The outside area of the dielectric fields, however, is rectangular in plan view in both of Figures 3 and 4 and when this is applied to a boat-shaped patch, some heating effect is dissipated outside the margins of the patch.

In the embodiment shown in Figures 5, 6 and 7 a plurality of electrodes are arranged to divide the area within the outline of the patch into contiguous rectangular or trapezoidal subareas which in the aggregate thereby conform to the

shape of the patch to avoid wasting heat beyond the edges thereof. In this case the pressure member comprises a boat-shaped skeleton body **25** of dielectric material adapted for mounting on the end of a piston rod **20** or other pressure applying means operating above a work table **16**. The pressure member **25** has a pressure face **26** having an outline in plan view slightly larger than the outline of the largest patch to be used therewith to facilitate centering the patch under the pressure member so that it may be subjected to a uniform pressure over its area to secure a good bond. The member **25** carries a plurality of electrodes **27** to **32**, inclusive, of different lengths mounted in parallel relation in a plane closely adjacent the pressure face **26**. The electrodes **27**, **29** and **31** are connected to a wire **33** and the electrodes **28**, **30** and **32** are connected to a wire **34**, which two wires comprise the output circuit of a high frequency oscillator to energize the electrodes and establish dielectric circuits therebetween. Each electrode is of a length to extend across the width of the boat-shaped patch at the station where it is situated when the patch is properly centered under the pressure member.

Thus, the dielectric circuit between the electrodes **29** and **30** covers a substantially rectangular subarea in the center of the patch, the circuits between the electrodes **28** and **29** and between electrodes **30** and **31** cover slightly smaller rectangular or trapezoidal areas contiguous to the central area, and the dielectric circuits between the relatively short end electrodes **27** and **32** and their next adjacent electrodes **28** and **31**, respectively, produce additional dielectric circuits covering smaller rectangular or trapezoidal areas contiguous to the last mentioned areas. Since dielectric circuits are not as sharply defined in dielectric materials as electrical circuits are in insulated conductors, the dielectric circuits from the end electrodes **27** and **32** also include the glue line at the ends of the patch to set the glue at these points even though they extend slightly beyond the electrodes. This interfingered arrangement of the electrodes results in a rather close spacing obviating the necessity for extremely high voltages to cover a given area, and by dividing up the area into contiguous rectangles and trapezoids the energy field is confined substantially to the curved outline of the patch itself without wasting energy in the sourrounding plywood. All surfaces of the electrodes are rounded and the electrode tips are preferably contained within the dielectric body of the pressure member to avoid high electrical field stresses at the juncture of different dielectric media.

Intersecting the pressure face **26** are deep channeled transverse grooves **35** between the electrodes. These grooves interrupt the surface continuity of the pressure face between the electrodes to reduce the short circuiting effect of wet glue and other foreign material on the pressure face, and materially increase the length of the surface path on the dielectric body between electrodes of opposite polarity. It is apparent that even though the pressure face **26** may tend to get somewhat contaminated with glue and foreign material, the relatively long wall surfaces in the sides and bottoms of the grooves **35** will remain clean and dry and thereby divide the work engaging areas of the pressure face into mutually isolated islands. The grooves **35** are preferably of a width and depth to remove a considerable amount of dielectric material from the body of the pressure member which has the effect of reducing the capacitance between electrodes and reducing the amount of dielectric material in the pressure member subject to dielectric loss and heating effects. For this purpose the grooves should extend up into the pressure member well above the level of the electrodes in the manner illustrated. These grooves also provide for ventilation to reduce the temperature of the pressure member, and by communicating directly with the surface of the work they perform the further additional important function of providing vents for steam from the moisture which is boiled out of the glue and the wood during the heating interval.

To further skeletonize the dielectric body of the pressure member a plurality of vertical holes **36** may be provided to intersect the pressure face directly beneath the electrodes, and still other openings may be provided in different directions through the body to leave only a skeleton framework of dielectric material having sufficient strength and bearing area on the patch **15** to hold the patch flat and firmly in place. The principal functions of the dielectric pressure member are to apply pressure to the patch and to support the electrodes slightly above the surface of the patch. Consistent with these requirements it is desirable to skeletonize the pressure member as much as possible to reduce dielectric losses therein, to ventilate the member and to vent moisture escaping from the surface of the wood. It is apparent that by making the interfingered parallel electrodes of the proper lengths the rectangular and trapezoidal subareas included therebetween may in a similar manner be arranged to cover any other shape of area of irregular or curved outline.

Figures 8 and 9 disclose an elliptical pressure member particularly adapted for boat-shaped patches which combines certain features of the different embodiments thus far described. The member **40** in this case has a smooth, flat, work engaging pressure face **41** and a plurality of transverse grooves **42** which bottom just above the pressure face. In these open grooves are disposed the electrodes **43**, **44**, **45** and **46**. These electrodes are preferably formed of cylindrical conductors having rounded ends and no sharp corners, to reduce corona effects. The electrodes **43** and **45** have upstanding ends on one side of the pressure member for connection with a circuit wire and the electrodes **44** and **46** have upstanding ends on the other side of the pressure member for connection with another circuit wire as in the manner of the electrodes shown in Figure 5, whereby adjacent electrodes in the pressure member are of opposite polarity. Thus, the electrodes **44** and **45** produce a dielectric circuit therebetween covering a rectangular area in the center of the patch while the dielectric circuits between the electrodes **43** and **44** and between **45** and **46** cover areas of trapezoidal shape at the ends of the patch. The dielectric circuits from the end electrodes **43** and **46** also produce heating effects a short distance outwardly from these electrodes whereby the glue line on the patch is properly heated even if the patch is slightly longer than the distance between these electrodes. In this modification as in Figures 3 and 4 no vents or grooves are shown in communication with the pressure face of the dielectric body, but such venting means may be provided if desired, as illustrated in the other embodiments.

In the embodiment shown in Figures 10 and 11 one electrode is exposed on the pressure face

of the dielectric body and the other electrode is insulated from the pressure face. In this arrangement the pressure member 50 may be rectangular as shown or it may be circular, having a flat pressure face 51 on one side and a boss 52 on the other side for connection with a pneumatic piston rod or other pressure applying member. A circular groove 53 is formed in the pressure face to receive an annular electrode 54 substantially flush with the pressure face. Concentrically within the annular electrode 54 is a vertical electrode 55 having a rounded lower end seated in the dielectric material of the body 52 a short distance from the face 51. This electrode may be grounded to the piston rod which carries the pressure member, and the other electrode may be connected with the high frequency oscillator circuit by a flexible wire 56. This arrangement is best suited for heating a circular area and the size of the area may be increased if desired without increasing the voltage by adding one or more larger annular electrodes concentric with the electrodes 54 and 55. In such an expansion of the arrangement shown in Figure 11, the next ring electrode outside of the electrode 54 should be isolated from the pressure face in the same manner as the centering electrode 55. Still another annular electrode might then be added, and this electrode could be mounted in a groove in the pressure face in the manner of the electrode 54. The two electrodes in the pressure face would then be connected together to one circuit wire, and the two electrodes isolated from the pressure face connected together to another circuit wire whereby the system might be expanded to include any number of additional concentric electrodes without danger of short circuit by conductive material on the pressure face.

The concentric electrode arrangement can also be applied to heat areas having shapes other than circular. To heat a boat-shaped patch, for example, the electrode 54 may be made elliptical and the electrode 55 made as a smaller ellipse in plan view, and spaced equidistantly on all sides within the outer electrode. Thus, the embodiment shown in Figures 10 and 11 may be said to represent an elemental form of pressure member having one side of the high frequency circuit exposed on the pressure face of the member, and having the other side of the circuit isolated from the pressure face.

Figures 12 and 13 illustrate an embodiment suitable for use on work and materials of a nature which do not require isolation of the electrodes from the work. In this arrangement, a pressure face is formed by the electrodes themselves, and the dielectric body of the pressure member is removed from the pressure face and the heating zone. Such arrangement minimizes dielectric losses in the pressure member, and provides a maximum venting for the escape of heat and moisture from the face of the panel. In this embodiment the dielectric body of the pressure member comprises a hollow skeleton or frame 60 containing only sufficient dielectric material to rigidly support the electrodes which form the pressure face for the pressure member. There are a plurality of electrodes 61 having vertical shanks 62 rigidly secured on a medial line in the member 60 and having inverted T heads 63 of different lengths disposed in a common plane, and constituting island pressure surfaces for engagement with the work. Interfingered between the electrodes 61 are other electrodes 64, 65, 66 and 67 mounted in angular positions in opposite sides of the member 60 and having horizontal lower ends lying in the plane of the T heads 63, whereby all of these electrodes constitute a discontinuous pressure face to bear against the work and perform the function of the dielectric pressure faces in the other embodiments. The member 60 may be mounted on a pneumatic piston rod or other device for applying the proper pressure to the work.

The electrode arrangement shown in Figures 12 and 13 is well suited for use with a push pull high frequency oscillator circuit. In such a circuit the electrodes 61 may all be grounded in a common metallic supporting plate 59 carrying the frame 60, which plate is connected to the center or neutral wire, the electrodes 64 and 65 being connected to one outside circuit wire and the remaining two electrodes 66 and 67 being connected to the other outside circuit wire. The area of the boat-shaped patch 15 is thereby divided into contiguous rectangular and trapezoidal subareas each heated by a separate dielectric circuit between the center wire and one of the outside wires of the push pull circuit. The electrode lengths may, of course, be varied to cover areas of other shapes without dissipating the heating effect outside of the area to be treated.

There are various well known synthetic materials suitable for the dielectric pressure member. The material used should have good high voltage insulating properties, a low power factor, low dielectric constant and low dielectric loss, and should be able to sustain the necessary pressure at the temperatures produced therein.

A separate pressure head may be employed to force the patch into place, which head may then be withdrawn leaving the electrode containing head to merely hold the patch in place. Less pressure and strength are thereby required in the electrode head permitting thinner sections of dielectric material and lower losses in the head.

The invention is, of course, not limited to the specific forms of pressure members and electrode arrangements shown and described as the same are merely illustrative of the principles of the invention, and other forms and arrangements will occur to persons skilled in the art. Also, while the present heating method and apparatus are described in the specification for application to the gluing of patches on plywood panels and the like, it is to be understood that the invention is to be broadly interpreted within the scope of the appended claims.

Having now described our invention and in what manner the same may be used, what we claim as new and desire to protect by Letters Patent is:

1. A high frequency glue curing press comprising a skeleton pressure member of dielectric material having a pressure face for pressing a joint to be glued and electrodes adjacent said face for establishing dielectric circuits through the glue line in said joint, said skeleton member including air spaces interrupting the surface continuity of said face between said electrodes and having only sufficient solid body adjacent the pressure face for carrying said electrodes and for transmitting the necessary gluing pressure to said pressure face.

2. A high frequency plywood patch press comprising a dielectric pressure member having a boat-shaped pressure face, a plurality of electrodes of different polarity disposed transversely of said pressure member to establish a plurality of dielectric fields substantially coextensive in

the aggregate with said face, and a series of deep channeled transverse grooves in said face extending into said member between said electrodes to interrupt the continuity of said face between the electrodes and ventilate the pressure member.

3. A pressure and heating member for application exclusively to one surface of a workpiece over an exposed glue line, to set a heat setting glue in said glue line by electrical high frequency dielectric heating effects, comprising a plurality of spaced electrodes of different polarity to establish dielectric fields covering a predetermined area, a rigid island contact surface under each electrode to engage and apply pressure to said one work surface under each of said electrodes, and air gaps between said electrodes separating said island contact surfaces.

4. A pressure and heating member for application exclusively to one surface of a workpiece over an exposed glue line to heat the glue in said glue line by electrical high frequency dielectric heating effects, comprising a body of dielectric material carrying a plurality of spaced electrodes of different polarity to establish dielectric fields covering a predetermined area, and a rigid ventilated pressure face on said member having air separated island work engaging surfaces at a distance from the main mass of said body.

5. A high frequency plywood patch press and the like comprising a dielectric pressure member having a work engaging pressure face, a plurality of parallel electrodes of different polarity mounted in said member adjacent said work engaging face to establish a plurality of dielectric fields substantially coextensive in the aggregate with said face, and a series of deep channelled grooves extending across said face and into said member between said electrodes, said grooves interrupting the continuity of said face between the electrodes and communicating with atmosphere to ventilate said member.

6. A high frequency heat and pressure applying member comprising a dielectric body having a single work engaging pressure face, a plurality of parallel electrodes of different polarity mounted in said body adjacent said work engaging face to establish a plurality of dielectric fields for stray field heating of a workpiece engaged by said pressure face, and a series of deep channelled grooves extending across said face and having opposite ends open to atmosphere to ventilate said body and the surface of the workpiece, said grooves extending into said member between said electrodes and interrupting the continuity of said face between the electrodes.

7. A high frequency heating and pressure member for relatively stationary application to a surface of a work piece, comprising a plurality of spaced electrodes of different polarity to establish dielectric fields covering a predetermined area, and a rigid island contact surface under each electrode to engage and apply substantial pressure to said work surface under each of said electrodes, all of said island contact surfaces being insulatedly interconnected mechanically to constitute a single discontinuous pressure face wherein the contact surfaces are separated by air gaps extending between the electrodes and communicating with atmosphere.

8. A high frequency heating and pressure member for relatively stationary application to a flat surface of a work piece, comprising a plurality of spaced electrodes of different polarity to establish dielectric fields covering a predetermined area, and an island contact surface under each electrode to engage and apply substantial pressure to said work surface under each electrode, all of said contact surfaces being disposed in a common plane and insulatedly interconnected mechanically to constitute a rigid discontinuous flat pressure face wherein the contact surfaces are separated from each other by air gaps extending between the electrodes.

WALTER S. THOMPSON.
HARRELL RENN.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,079,708	Hart	May 11, 1937
2,189,277	Anderson	Feb. 7, 1940
2,228,136	Hart	Jan. 7, 1941
2,263,536	Dike	Nov. 18, 1941
2,275,430	Hart et al.	Mar. 10, 1942
2,342,846	Crandell	Feb. 29, 1944
2,385,554	Stratton	Sept. 25, 1945
2,397,615	Mittlemann	Apr. 2, 1946
2,412,982	Hart	Dec. 24, 1946
2,416,137	Auxier et al.	Feb. 18, 1947
2,422,979	Pecker	June 24, 1947
2,426,267	Hart	Aug. 26, 1947
2,438,952	Te Grotenhuis	Apr. 6, 1948
2,492,187	Rusca	Dec. 27, 1949

OTHER REFERENCES

Electronics, pages 108–113, May 1946.