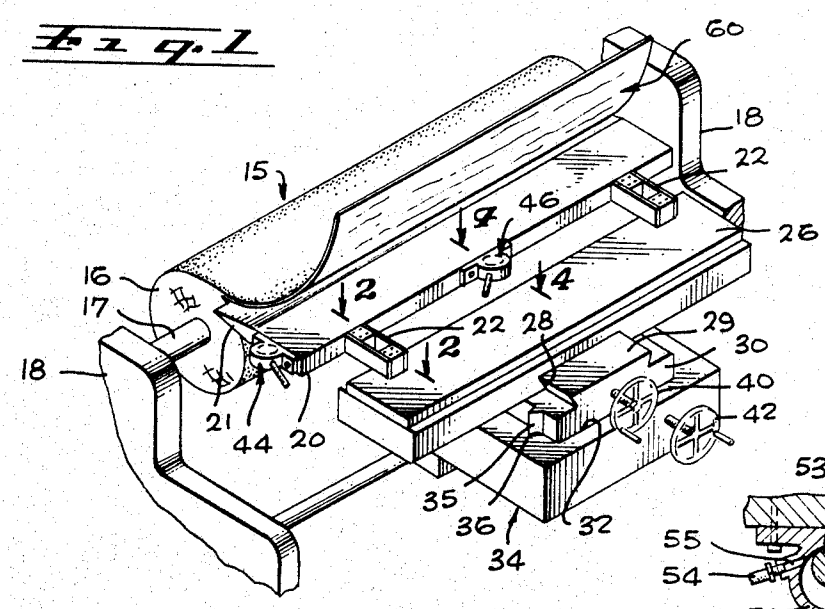
Oct. 14, 1969 A. G. BODINE 3,472,295

SONIC METHOD AND APPARATUS FOR MAKING AND DRYING WOOD VENEER AND THE LIKE

Filed July 5, 1966 2 Sheets-Sheet 1

Fig. 1



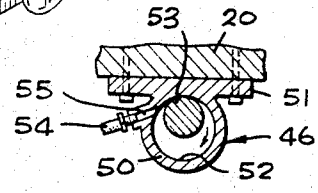


Fig. 4

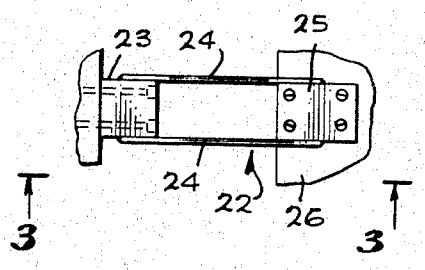


Fig. 2

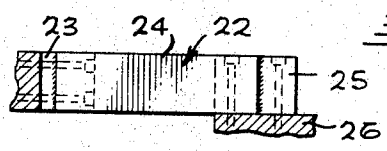


Fig. 3

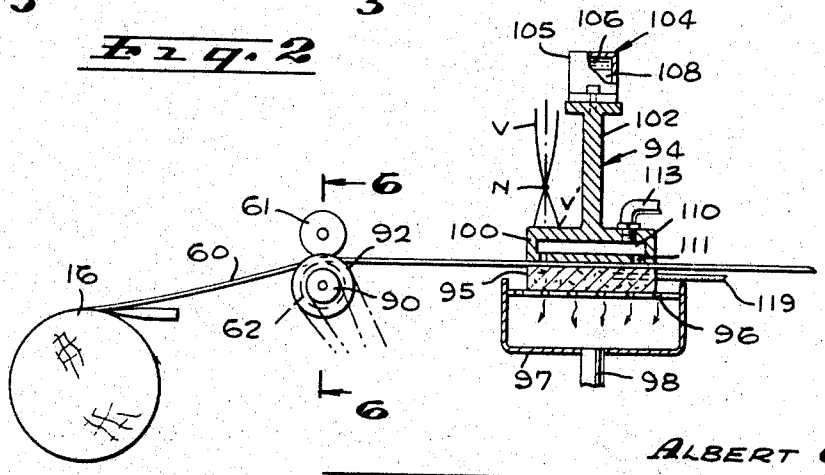


Fig. 5

INVENTOR.
ALBERT G. BODINE
BY Francis J. Tilly
ATTORNEY

Oct. 14, 1969 A. G. BODINE 3,472,295

SONIC METHOD AND APPARATUS FOR MAKING AND DRYING WOOD VENEER AND THE LIKE

Filed July 5, 1966 2 Sheets-Sheet 2

Fig. 6

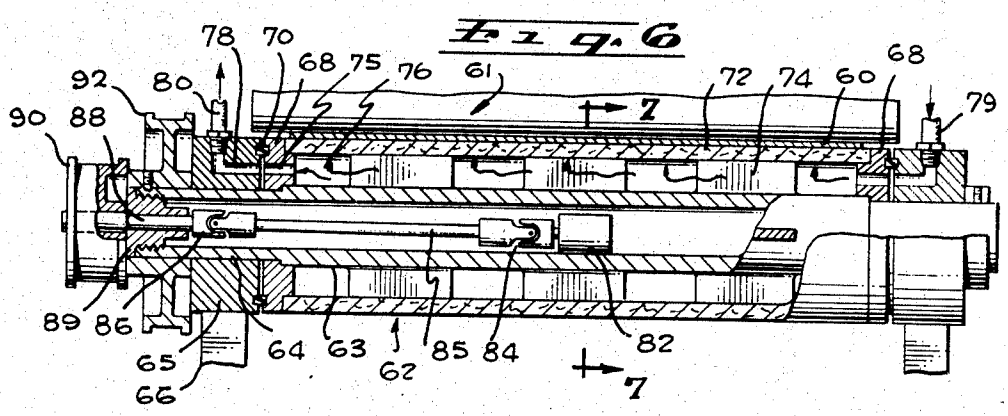
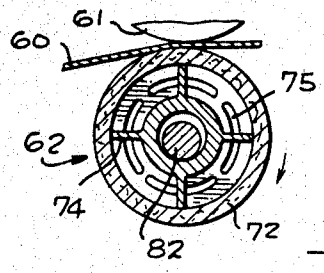


Fig. 7



9

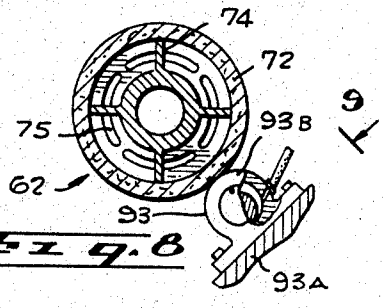


Fig. 8

9

Fig. 9

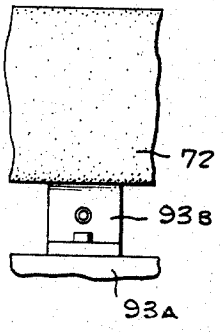


Fig. 10

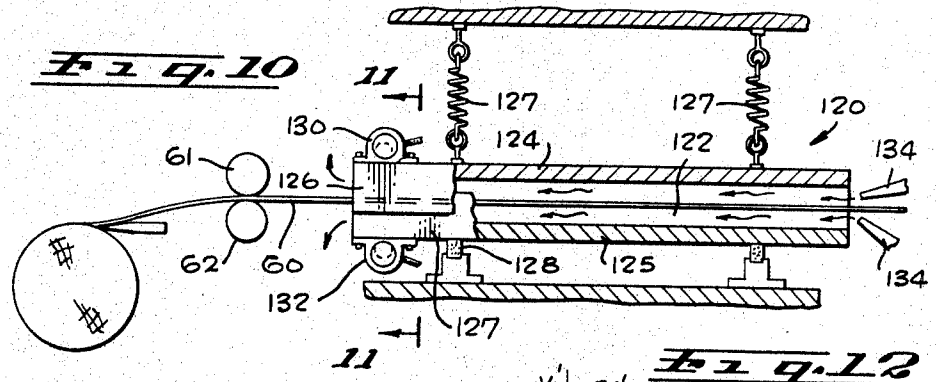


Fig. 11

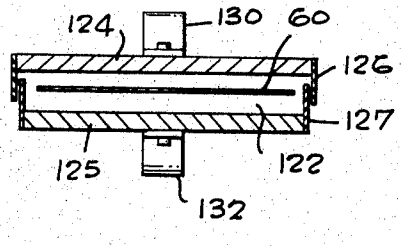
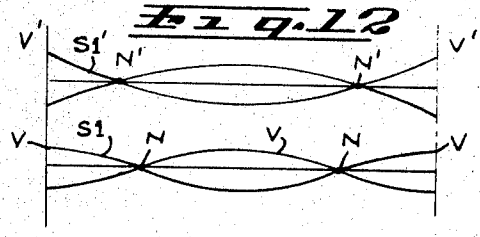


Fig. 12

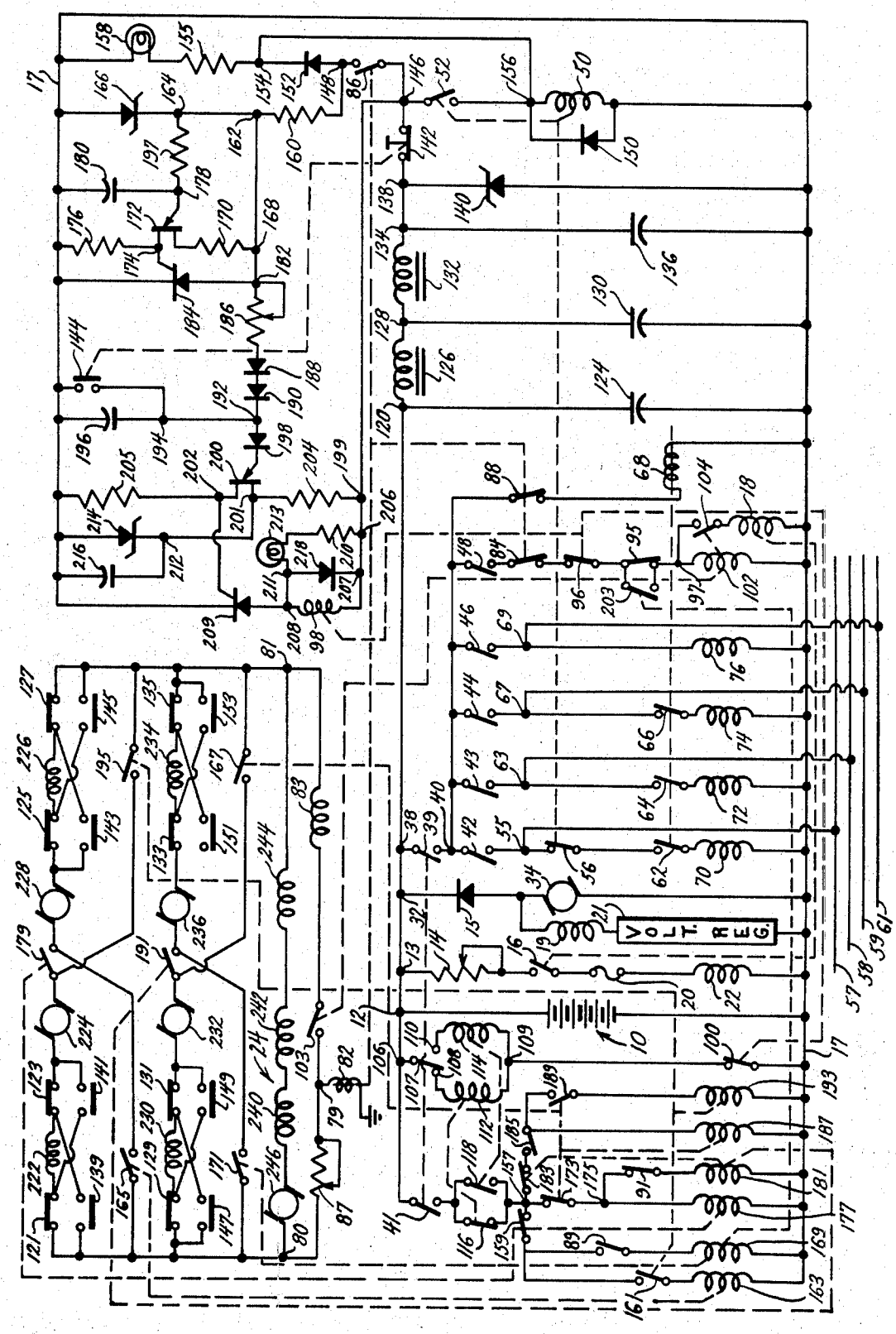


INVENTOR.
ALBERT G. BODINE
BY Forrest J. Filby
ATTORNEY

Oct. 7, 1969 W. L. MICHAEL 3,471,705

CONTROL SYSTEMS FOR DIESEL-POWERED UNIT DURING FLASH CONDITION

Filed Oct. 20, 1966



United States Patent Office 3,472,295
Patented Oct. 14, 1969

3,472,295

SONIC METHOD AND APPARATUS FOR MAKING AND DRYING WOOD VENEER AND THE LIKE

Albert G. Bodine, Los Angeles, Calif.
(7877 Woodley Ave., Van Nuys, Calif. 91406)

Filed July 5, 1966, Ser. No. 562,636
Int. Cl. B27l 5/02
U.S. Cl. 144—309 8 Claims

This invention is concerned with sonic methods and apparatus for manufacture of wood veneer from logs, in a sonic vibration process which facilitates both the cutting or peeling of the vineer from the log and the ensuing drying out of the veneer which is cut in a wet state. The drying-out stage of the over-all process has application to the drying of other sheet stock such as paper, and hence is not limited in application to wood veneer.

A general object of the invention is provision of improved methods and apparatus for cutting and drying wood veneer, as well as the drying of other sheet stock, making use of sonic vibrations to improve the peeling of the veneer from the log, so as to both speed up the process and provide for a cleaner cut veneer, and to improve also the drying-out process, by which the veneer can be simply and expeditiously continuously dried out within a drying station of small compass as rapidly as it is received from the log. A further object, as intimated above, is to apply such sonic vibrational drying process not only to wettened wood veneer, but to other materials found to respond to the process.

The invention is concerned with physical phenomena of mobility in fibrous structures such as those composed of wood, wherein grain structures, with the accompanying varying hardnesses and/or densities of different but immediately contiguous elements of the wood lead to differential mobilities of these elements. The invention is further concerned with application to the cutting blade by which these veneers are peeled from the log of special sonically vibratory activity which takes maximum advantage of these characteristics. The invention is further concerned with certain effects of sonic wave activity on wettened wood structures by which the moisture which has been absorbed into the log is caused to become mobile and more easily and rapidly extracted from the cut veneer.

The commonly known process of manufacturing wood veneer heretofore has been first to water-soak a tree log, so as to give it added toughness and resiliency, and so prevent it against cracking or tearing too severely as the log is worked. The water-soaked log is then mounted in a lathe-type machine and rotated about its longitudinal axis from the power drive of the machine. A long sharp blade is then brought into engagement with the lateral face of the log, so that as the log rotates, a veneer layer is peeled therefrom, something after the manner of the peeling of an apple. In this manner a continuous moving strip of thin wood veneer is peeled from the log. This continuous moving strip is immediately and continuously dried in necessarily long ovens, and then cut up into sections, which are subsequently glued to one another to form plywood.

A little consideration of microscopic wood structure reveals that the tree grows in successive more or less concentric annual "rings," consisting of alternating ring layers of relatively soft wood cells or fibers of large cross-section, and relatively hard and compact or dense wood cells or fibers of substantially smaller cross-section, the former naturally growing in the spring, and the latter in the summer. These cells or fibers differ materially with different kinds of trees, but in general, run primarily longitudinally of the log. In addition, other fibers may run radially, or in other directions. The grain of some

wood is very regular, i.e. the fibers run regularly and in close parallelism longitudinally of the log, and the rings are uniform. In others, the rings may be highly distorted as seen in a cross-section of the log, and may also change direction to a considerable extent longitudinally of the log.

In consequence, the veneer knife has different jobs to do, depending upon the characteristics of the log at hand. If the log is very regular in its ring formations, the knife may act largely to force or chisel its way between layers of fibers. The cutting has heretofore been largely a tearing action in this case, the blade forcing its way between fibers, and thus tearing away a layer of veneer. The surface of the resulting veneer tends to be somewhat rough from the tearing action. The regularity or uniformity and the smoothness of the cut also change whenever the blade, or a portion thereof, emerges from a softer portion of the wood structure and encounters a harder portion thereof, and vice versa.

With wood of less ideally uniform grain, further complications arise, particularly in that now there can be a large amount of transverse cutting of wood fibers or cells. A dense or compact wood fiber, or a layer of such fibers, has the characteristic of hardness, as well as fairly high impedance. When such material is simply rotated against the knife, with the knife engaging across many such fibers, it tends to indent and so compress and crush the softer fibrous wood structures behind it, so that ideal cleanness of cut is not realized.

An object of the invention is the provision of sonic methods and means for imparting to the veneer knife elastically vibratory motion, under a condition of resonance, and sometimes of complex character, such as impart a sonically vibratory longitudinal slicing and/or lateral impacting or chopping action to the veneer blade, thereby to avoid the tearing, crushing and other undesirable effects which may arise from simply holding the blade against the log, and thus to achieve more smoothly and uniformly cut wood veneer.

The present invention, both in the aspect of improvement in veneer cutting by application to the veneer blade of elastic sonic vibratory motion under conditions of resonance for improvement in the ease and cleanness of cut and also in the aspect of rapid drying of the cut veneer, is based upon certain discoveries that I have made concerning certain unique reactions of fibrous materials when exposed to sonic vibration. The invention deals with unique methods and apparatus for applying sonic action to the veneer cutting blade, and through the veneer cutting blade to the fibrous wood structure, as well as directly to the veneer structure in the course of the drying operation.

Directing attention now particularly to the veneer peeling or cutting operation, the invention involves the setting up in the veneer blade of a sonic, elastically vibratory motion, and this is preferably done in either of two ways, or a combination thereof. First, I may set up in the blade a longitudinal pattern of resonant standing wave vibration, typically one wavelength long, such that portions of the blade are set into longitudinally oriented elastically vibratory motion. Thus, the blade edge moves longitudinally, in a slicing manner, and at a relatively high frequency, during application of the blade edge to the rotating log. Thus the veneer is cut by a slicing action of the blade, in combination with a chiseling-type action arising out of the log being turned forcibly against the blade. In addition, or alternatively, I may set up in the blade a resonant elastic standing wave pattern of vibration of a lateral type, in this case also preferably a one-wavelength pattern, the orientation being such that vibratory blade motion toward and from the log is achieved.

The blade is preferably of a relatively heavy or massive character, and thus, in moving against the wood in its vibratory action, in either mode of standing wave vibration, engages the wood with considerable inertia, as well as at substantial impedance. With a heavy blade, and lateral vibration, forceful shock impacts at high frequency are thus applied. Impedance in this connection refers to the ratio of force to vibratory velocity. Parenthetically, a similar impedance concept, i.e. ratio of force to vibratory velocity, applies to the wood fiber when subjected to sonic vibration. In view of the use of sonic standing wave patterns along the blade, there are points along the blade which are at nodes of the standing waves, and other points which are at velocity antinodes of the blade, the former of course denoting regions of minimized vibration amplitude and velocity, and the latter denoting the maximized amplitude and velocity. Accordingly, the impedance along the blade, both for the longitudinal mode of standing wave vibration and the lateral mode of standing vibration, will vary between a quite high impedance at or near the nodes, and a lower, but still relatively high, impedance in the region of the antinodes adjacent thereto. The impedances so set up in the blade are, however, made such as to be well matched to or chosen for the impedances of the harder portions of the wood material to be veneered. With a high inertia blade, such that a high level of sonic energy is stored therein, and with the impedances so related, the action of the blade in encountering the wood fiber or cell structure of the log, and in particular, that of the harder and more dense fibrous structure thereof, of relatively high impedance, cuts easily therethrough, without deflection or depression of the hard fibers, and consequent crushing or mashing of the soft wood behind. In other words, because of the impedance effect, each fiber is cut almost independently of the adjacent fibers, thus not requiring a heavy unidirectional bias force interaction between the blade and the log such as often over-stresses and then tears the connecting tissue between fibers, or the contacting and adhering fiber surfaces. It should be understood that the sonic vibratory action of the blade is applied directly to the hard fibers as these fibers engage the blade, and are cut quickly and cleanly, because of the impedance conditions described, and because of the high accelerations of the sonically vibrating blade. To the sonic accelerations involved, the fibers exhibit and present a large mass reactance, with low compliance. While this low compliance normally, as in prior art practices, permits the hard fibers to be deflected and to compress and crush adjacent softer fibers, the sonic action permits the hard fibers to stand and be cut by virtue of their own inertia. Thus the cutting of the hard fiber does not rely upon stiffness support of softer material between the hard fibers.

In the case of the longitudinal standing wave pattern in the knife, the cutting action by the vibrating knife will be seen to be in the nature of a vibratory slicing action, combined with chisel-like cutting, while in the case of the lateral wave pattern orientation, the cutting action is in the nature of sonic frequency impacting or "chopping," with the inertia of the impacting blade together with the substantial impedance characteristics thereof, assuring clean cutting through the harder and denser wood fibers, as well as the softer and less dense portions of the wood structure. The previously known tearing and splitting of the wood that has heretofore been characteristic of the action of a veneer knife on a rotating log is thus replaced by clean cutting vibratory action which severs the fibers cleanly, without tearing or crushing, and thus yields a clean and uniformly cut veneer.

Because of the sonic activation the blade cuts the log with so much less damage the log need not be so highly water soaked. This then means less problems from dimensional changes as the veneer subsequently dries. Also, with less water in the log, drying time is reduced. Additionally, the blade itself is subjected to reduced stress,

and undergoes reduced vibratory flexing as it cuts through the log, with the result that dimensional control of the blade feed can be more accurately determined. This then permits closer held tolerances in controlling the thickness of the veneer peeled off by the knife. Dimensional control is also materially aided by reduced water soaking such as is feasible with sonic vibration of the knife.

Still further, with less water moved through the fibrous structure of the log, a stronger wood is produced.

It is also possible, and sometimes highly desirable, as inferred hereinbefore, to utilize multi-motion vibration of the veneer blade where it engages the wood fibers, and in such cases I preferably employ, simultaneously, both a longitudinal vibration pattern and a lateral vibration pattern.

The invention utilizes, for the setting up of the resonant standing wave patterns in the veneer blade, one or more vibration generators or oscillators acoustically coupled thereto, and a major preferred feature of the invention, responsible for the attainment of its vast effectiveness, is the use of a certain orbital-mass type of vibration generator for this purpose. It has been mentioned earlier that a typical log is made up of hard and soft rings, most often of considerable irregularity, and of various spacings, as well as fibers oriented other than in the longitudinal direction, such as radial. Also, some woods have large proportions of so-called vessels therein, consisting of water-filled cavities, and it is thus evident that a veneer knife cutting against a rotating log must necessarily or inevitably encounter a large number of localized regions of differing hardness, density, and impedance. Thus, at one moment, the blade may be in engagement with a large amount of relatively hard and dense cell structure, and shortly after, a preponderant amount of less compact and softer structure. At any given instant, of course, these localized conditions will be integrated within the blade to some average impedance against which the blade must work, and it will be evident that the impedance in the veneering of a log will vary from moment to moment, as well as throughout the course of the progression of the blade from the periphery of the log to the center thereof. In the latter connection, it is of course to be realized that the outer portions of the log just after cutting, for example, contain more moisture than the inner regions of the log, and it is also known that the central region of "heart wood" of the log is harder than the outer portion of the log. These conditions make for a considerable variation in impedance presented by the log to the blade, and constituting the "load" against the vibartory blade, as the blade progresses radially inward to the center. After soaking of the log, of course, the moisture gradient from the periphery to the center of the log will be substantially modified, depending upon the time of soaking; but in general, there is a considerable variable resistance to cutting, depending upon moisture present, wood hardness and density. Aggravating these variable conditions is the fact that the veneering operation is necessarily carried on in industry at a high rate of speed in order to be economic, and the veneer knife needs therefore to be adaptable to the cutting of the wood structure of the log throughout the varying conditions from start to finish.

The above mentioned mechanical, orbital-mass vibration generator possesses an inherent accommodation feature by which it ideally coacts with the knife and with these varying impedance conditions in the log in veneer cutting, and such a generator, in combination with a resonant elastically vibratory veneer knife vibrated thereby, is accordingly an important feature of the invention.

The "orbital-mass generator" may take any of various mechanical forms, of which the simplest is a roller mass rolling around in a bearing, so that the mass generates a centrifugal force which is reactively opposed by the bearing. The bearing is on a support frame, which in response to the centrifugal force so generated and applied, exerts a periodic inertial force on whatever may support it or be

coupled thereto. Some improved forms of orbital-mass generator or oscillator are disclosed in my Patents Nos. 2,960,314 and 3,217,551. In these patents are disclosed orbital-mass oscillators comprising a cylindrical mass rolling around the inside of a bearing race ring, and a ring-shaped mass spinning on a bearing pin. In some cases, the generator may be driven by an electrical motor such as an induction motor, or, where increased speed responsiveness to load is desired, by a series motor. In others, as in the case of rollers or rings, the drive may be by any air or other fluid jet directed against the roller or ring. Thus, such a "slip"-type drive is generally used. In all cases, there is an orbiting mass comprised of a weight driven so as to travel around a closed circular path, which path is determined by a circular bearing forcibly constraining the weight to travel in this curved path. The bearing then experiences a powerful rotating reaction force caused by the weight moving along its circular path, which force is periodic in nature because each point spaced around the bearing is periodically subjected to this force. Together with its support frame, the bearing is thus a reactive coupling output device.

Also, the bearing has a support frame, as aforesaid, adapted for making the actual coupling to the knife to be elastically vibrated. The mass of the bearing and support frame may be very considerable in relation to that of the orbiting mass. The momentum imparted to this considerable mass must be equal to that of the small orbital mass, and since the velocity of the small orbital mass is quite high, the motion of this considerable mass is thus relatively low. I therefore have the advantage of a large mass moving periodically with great force or momentum, but through small displacement distance at relatively low velocity. This represents a condition of relatively high impedance (defined hereinafter) in the support frame, i.e. in the generator output coupling element, such as is uniquely suited to the circuit requirements of the present invention.

Such a vibration generator may be arranged and utilized so as to deliver from the generator support frame, or coupling means, to the knife, a continuously rotating force vector. The useful component of this force, however, is an alternating or cyclic force doing work in reverse directions along a given direction line in relation to the veneer knife. If a longitudinal slicing type of vibratory action is desired in the knife, the vibration generator may be coupled, for example, so as to deliver an alternating or cyclic force along a longitudinal direction line of the knife, and at a selected point such as at an end of the knife. For the laterally vibratory or cyclic impacting or chopping type of action the generator may be coupled to the knife so as to deliver an alternating or cyclic force along a line normal to the length of the knife, and in the plane of the knife. Assume for the immediately following discussion the longitudinally applied cyclic force with the generator support frame coupled to an end of the knife. The knife may then, for example, have a length in relation to the frequency or periodicity of the generator (circuits per second of the orbital mass) as to vibrate longitudinally in a full-wavelength resonant standing wave mode. The two ends of the knife then vibrate longitudinally of the knife equally and in the same direction and phase and the mid-region of the knife vibrates in opposite phase to the two ends. Regions of the knife twenty-five percent from its two ends have minimized vibration amplitude. The latter regions are the location of nodes or pseudonodes of the standing wave, while the moving ends and the mid-point are at antinodes of the wave. The two half-lengths of the knife alternately elastically elongate and contract and by this motion may do work. The elastic deformation of course represents compliance reactance. This standing wave performance is a resonance phenomenon, and in this case, assuming a uniform knife, occurs when

$$f=\frac{s}{2h}$$

where f is the fundamental resonant frequency, s is equal to the velocity of sound in the knife, and h is the length of the knife. At resonance, the mass and compliance reactances of the vibratory system are equal and cancel one another, the impedance to vibration of the masses of the system is thereby reduced to that owing to friction (actual work done), and vibration amplitude in the knife is resonantly magnified by a large factor. In effect, the blocking impedance of the mass along the direction line of the knife has been very greatly reduced, generator output force consumed by this impedance along this direction line is correspondingly diminished, and large standing wave vibration amplitude along the direction line of the knife is attained.

In this resonant performance, the large necessary vibratory mass of the system is "tuned out" and consumes none of the output force from the orbital-mass generator. The mass is moved by elastic restoration forces exerted by the deformed compliances, which are in turn elastically deformed, of course, in decelerating the masses. Thus the massive elastic system vibrates with no consumption of force save for that lost in friction and in doing useful work.

A further considerable advantage in the system is that the masses will then vibrate at substantial amplitude (exhibit large vibrational displacement), and become a powerful acoustic flywheel, storing considerable energy. The masses become an advantage. The system exhibits resonant magnification of motion. This gives a system which can build up to high vibratory power level; and the energy storage flywheel effect sometimes known as *"q,"* also gives the ability to "ride over" irregularities presented by the varying wood structure of the log.

The combined system of an orbital-mass vibration generator and elastically vibratory knife, acting as a resonator, has a unique performance which is exhibited in the form of a greater effectiveness and particularly greater persistence and power delivery in sustained sonic action as the work process goes through successive phases involving changes of conditions as the log is peeled down. The orbiting-mass generator in this combination is able to sustain its development of power for the load, i.e. the log upon which work is done, as the sonic energy absorbing environment changes with the variations in sonic energy absorption by the wood structure of the log. It does this by automatically changing its phase angle, and therefore its power factor, with these changes in the resistive impedance of the "load."

This can be explained as follows: Consider the orbital-mass vibration generator used in this invention, say of the type involving a roller mass traveling in a circular path around the inside of a cylindrical bearing, and assume this bearing is to be fixed to a free end of the elastic knife, the axis of the bearing being perpendicular to the length axis of the knife. Assume further that the roller mass is driven around the bearing at a frequency of s/h cycles per second, where s is the velocity of sound in the knife and h is the length of the knife, so that the knife is driven by the cyclic output force exerted by the bearing to undergo full-wavelength standing wave vibration. The two half-lengths of the knife then alternately elastically elongate and contract, at the cyclic frequency of the roller mass. The longitudinal velocity of the driven end of the knife, and also the force exerted by the generator bearing on the knife, can then be plotted as sinusoidal waves. With no net work done on or through the knife, the force wave then lags the velocity wave by ninety degrees. The phase angle of the roller in its race is such that at this time it moves longitudinally of the knife in step with the generator end of the knife. This is a condition of ninety degrees phase angle, a power factor of zero, and zero net work done. Assume now that the vibrating knife is subjected to substantial friction. The velocity wave loses amplitude, and the roller mass automatically undergoes an angular shift in position within its race

so as to bring the sinusoidal force wave more into phase with the velocity wave. The phase angle is thus reduced, and power factor increased the necessary amount for the generator to develop and supply the energy consumption required by the friction now encountered. Correspondingly, if the friction were large to start, and subsequently diminished, the phase angle would be small to start, and would subsequently go towards or to substantially ninety degrees with progressive elimination of friction.

Also, if during operation the "load" on the orbital-mass oscillator-resonator combination should vary in impedance, in either the mass reactance or elastic compliance reactance components thereof, the frequency and phase angle of the oscillator shifts to accommodate these changes. Such a change in reactance results in a change in impedance, phase angle, and resonance frequency. If the prime mover is one which has "slip," e.g., air-driven, or is speed-responsive to torque, there is a resulting automatic feedback of torque to the prime mover which drives the orbiting-mass oscillator such as to re-establish stable operation at a new resonant frequency, and with adjusted phase angle and power factor which automatically accommodate the changed reactance and the energy consuming load (friction factor). Any changes in magnitude of either or both the friction or energy consuming part of the load and the reactive part of the load are thus automatically accommodated by the orbital-mass vibration generator so that the latter generator sustains its development and transmission of power into the load which is the wood fiber being cut; throughout all such changes.

Entirely analogous phenomena take place with a vibration generator coupled in to set up a lateral resonant standing wave in the knife, with the orbital-mass generator again accommodating for variations in impedance in the log as the elastically vibrating knife works its way through the fibrous structure thereof.

Turning now to the drying aspect of the invention, it is clear that after the wood veneer is cut from the water-soaked-log, it has poor dimensional stability because the moisture leaving the woods causes it to change dimension considerably. Therefore, it is necessary that the wood be dried before sheets of the veneer are glued to one another in the manufacture of plywood, or otherwise utilized. The drying ovens must be very large because the exposure time necessary to satisfactory drying is very substantial. Moisture is generally removed from the veneer by applying heat to its outer surface, which dries the very outside surface. Subsequently, the moisture in the center of the veneer works to the outside surface. Thus a moisture gradient is created, causing the moisture to tend to flow from the wet interior to the dried surface. The time factor involved in this process is so great that the drying ovens have to be very large, taking into account the high speed with which the veneer comes from the veneering machine. The use of the present invention in the cutting of the veneer accomplishes an initial drying-out effect by reason of the sonic vibrations set up in the veneer being cut by the vibrating veneer knife, which vibrations tend to fling the surface moisture from the veneer as it leaves the knife.

The veneer drying operation of the invention is further based upon the concept that the equilibrium condition of moisture entrainment by capillary forces can be shifted by a sonic energy field. The elastic vibrations of the veneer, or indeed of any similar matrix containing moisture-filled interstices, shift the equilibrium condition of the moisture in those interstices so that capillary fluid forces are affected by the cyclic change of dimensions of the interstices. This brings about mobility of the fibers or other substance of the matrix, as well as the contained moisture. By this sonic process, it is thus possible to sonically "work" moisture out of the interstices of a moisture-laden matrix.

A further feature of the invention is to accelerate the rate of extraction of fluid from a matrix to an extraction or blotting membrane or element by elastically vibrating the matrix and/or the blotting membrane or element. For example, in the drying of veneer, I may pass the veneer between a sonic transducer and a fluid extraction membrane. The transducer and/or the extraction membrane can be in the form of a porous pad, with the veener sliding thereon, or can be in the form of porous rollers over which the veneer travels. The sonic activation shifts the basic equilibrium condition of moisture retention, and in addition obtains a high degree of moisture mobility so that a porous absorber or blotter can more readily extract the moisture from the veneer, or other matrix to be dried.

It may be obseved here that moisture-laden items such as wood veneer and the like tend naturally to absorb substantial sonic power, thus reducing the Q factor of a sonically vibratory system. My aforementioned orbital-mass generators described hereinabove are especially applicable here because of their ability to furnish the vibratory system with a good Q factor, and thus a sharp resonant curve, as well as because of its frequency and power accommodating characteristics, as referred to hereinabove.

SONIC DISCUSSION

Certain acoustic phenomena disclosed in the foregoing and hereinafter, are, generally, speaking, outside the experience of those skilled in the acoustics art. To aid in a full understanding of these phenomena by those skilled in the acoustics art, and by others, the following general discussion, including definition of terms, is deemed to be of importance.

By the expression "sonic vibration" I mean elastic vibrations, i.e. cyclic elastic deformations, such as longitudinal, lateral, gyratory, torsional, etc., generated in a structure, or which travel through a medium with a characteristic velocity of propagation. If these vibrations travel longitudinally, or create a longitudinal wave pattern in a medium or structure having uniformly distributed constants of elasticity and mass, this is sound wave transmission. Regardless of the vibratory frequency of such sound wave transmission, the same mathematical formulae apply, and the science is called sonics. In addition, there can be elastically vibratory systems wherein the essential features of mass appear as a localized influence or parameter, known as a "lumped constant"; and another such lumped constant can be a localized or concentrated elastically deformable element, affording a local effect referred to variously as elasticity, modulus, modulus of elasticity, stiffness, stiffness modulus, or compliance, which is the reciprocal of the stiffness modulus. Fortunately, these constants, when functioning in an elastically vibratory system such as mine, have cooperating and mutual influencing effects like equivalent factors in alternating-current electrical systems. In fact, in both distributed and lumped constant systems, mass is mathematically equivalent to inductance (a coil); elastic compliance is mathematically equivalent to capacitance (a condensor); and friction or other pure energy dissipation is mathematically equivalent to resistance (a resistor).

Because of these equivalents, my elastic vibratory systems with their mass and stiffness and energy consumption, and their sonic energy transmission properties, can be viewed as equivalent electrical circuits, where the functions can be expressed, considered, changed and quantitatively analyzed by using well proven electrical formulae.

It is important to recognize that the transmission of sonic energy into the interface or work area between two parts to be moved against one another requires the above mentioned elastic vibration phenomena in order to accomplish the benefits of my invention. There have been other proposals involving excusively simple bodily vibration of some part. However, these latter do not result in the benefits of my sonic or elastically vibratory action.

Since sonic or elastic vibration results in the mass and elastic compliance elements of the system taking on these special properties akin to the parameters of inductance and

capacitance in alternating current phenomena, wholly new performances can be made to take place in the mechanical arts. The concept of acoustic impedance becomes of paramount importance in understanding performances. Here impedance is the ratio of cyclic force or pressure acting in the media to resulting cyclic velocity or motion, just like the ratio of voltage to current. In this sonic adaptation impedance is also equal to media density times the speed of propagation of the elastic vibration.

In this invention impedance is important to the accomplishment of desired ends, such as where there is an interface. A sonic vibration transmitted across an interface between two media or two structures can experience some reflection, depending upon differences of impedance. This can cause large relative motion, if desired, at the interface.

Impedance is also important to consider if optimized energization of a system is desired. If the impedances are adjusted to be matched somewhat, energy transmission is made very effective.

Sonic energy at fairly high frequency can have energy effects on molecular or crystalline systems. Also, these fairly high frequencies can result in very high periodic acceleration values, typically of the order of hundreds or thousands of times the acceleration of gravity. This is because mathematically acceleration varies with the square of frequency. Accordingly, by taking advantage of this square function, I can accomplish very high forces with my sonic systems. My sonic systems preferably accomplish such high forces, and high total energy, by using a type of orbiting-mass sonic vibration generator taught in my Patent No. 2,960,314, which is a simple mechanical device. The use of this type of sonic vibration generator in the sonic system of the present invention affords an especially simple, reliable, and commercially feasible system.

An additional important feature of these sonic circuits is the fact that they can be made very active, so as to handle substantial power, by providing a high "Q" factor. Here this factor Q is the ratio of energy stored to energy dissipated per cycle. In other words, with a high Q factor, the sonic system can store a high level of sonic energy, to which a constant input and output of energy is respectively added and subtracted. Circuit-wise, this Q factor is numerically the ratio of inductive reactance to resistance. Moreover, a high Q system is dynamically active, giving considerable cyclic motion where such motion is needed.

Certain definitions should now be given:

Impedance, in an elastically vibratory system, is, mathematically, the complex quotient of applied alternating force and linear velocity. It is analogous to electrical impedance. The concise mathematical expression for this impedance is

$$Z=R+\sqrt{-1}\left(2\pi fM-\frac{1}{2\pi fC}\right)$$

where M is vibratory mass, C is elastic compliance (the reciprocal of stiffness, or of modulus or elasticity) and f is the vibration frequency.

Resistance is the "real" part R of the impedance, and represents energy dissipation, as by friction.

Reactance is the "imaginary" part of the impedance, and is the difference of mass reactance and compliance reactance.

Mass reactance is the positive imaginary part of the impedance, given by $2\pi fM$. It is analogous to electrical inductive reactance, just as mass is analogous to inductance.

Elastic compliance reactance is the negative imaginary part of impedance, given by $\frac{1}{2}\pi/fC$. Elastic compliance reactance is analogous to electrical capacitative reactance, just as compliance is analogous to capacitance.

Resonance in the vibratory circuit is obtained at the operating frequency at which the reactance (the algebraic sum of mass and compliance reactances) becomes zero. Vibration amplitude is limited under this condition to resistance alone, and is maximized. The inertia of the mass elements necessary to be vibrated does not under this condition consume any of the driving force.

A valuable feature of my sonic circuit is the provision of enough extra elastic compliance reactance so that the mass or inertia of various necessary bodies in the system does not cause the system to depart so far from resonance that a large proportion of the driving force is consumed and washed in vibrating this mass. For example, a mechanical oscillator or vibration generator of the type normally used in my inventions always has a body, or carrying structure, for containing the cyclic force generating means. This supporting structure, even when minimal, still has mass, or inertia. This inertia could be a force-wasting detriment, acting as a blocking impedance using up part of the periodic force output just to accelerate and decelerate this supporting structure. However, by use of elastically vibratory structure in the system, the effect of this mass, or the mass reactance resulting therefrom, is counteracted at the frequency for resonance; and when a resonant acoustic circuit is thus used, with adequate capacitance (elastic compliance reactance), these blocking impedanes are tuned out of existence, at resonance, and the periodic force generating means can thus deliver it full impulse to the "work," which is the resistive component of the impedance.

Sometimes it is especially beneficial to couple the sonic oscillator at a low-impedance (high-velocity vibration) region, for optimum power input, and then have high impedance (high-force vibration) at the work point. The sonic circuit is then functioning additionally as a transformer, or acoustic lever, to optimize the effectiveness of both the oscillator region and the work delivering region.

For very high-impedance systems having high Q at high frequency, I sometimes prefer that the resonant elastic system be a bar of solid material such as steel. For lower frequency or lower impedance, especially where large amplitude vibration is desired, I use a fluid resonator. One desirable specie of my invention employs, as the source of sonic power, a sonic resonator system comprising an elastic member in combination with an orbiting-mass oscillator or vibration generator, as above mentioned. This combination has many unique and desirable features. For example, this orbiting-mass oscillator has the ability to adjust its input power and phase to the resonant system so as to accommodate changes in the work load, including changes in either or both the reactive impedance and the resistive impedance. This a very desirable feature in that the oscillator "hangs on" to the load even as the load changes.

It is important to note that this unique advantage of the orbiting-mass oscillator accrues from the combination thereof with the acoustic resonant circuit, so as to comprise a complete acoustic system. In other words, the orbiting-mass oscillator is matched up to the resonant part of its system, and the combined system is matched up to the acoustic load, or the job to be accomplished. One manifestation of this proper matching is a characteristic whereby the orbiting-mass oscillator tends to "lock in" to the resonant frequency of the resonant part of the system.

The combined system has a unique performance which is exhibited in the form of a greater effectiveness and particularly greater persistence in a sustained sonic action as the work process proceeds or goes through phases and changes of conditions. The orbiting-mass oscillator, in this matched-up arrangement, is able to hang on to the load and continue to develop power as the sonic energy absorbing environment changes with the variations in sonic energy absorption by the load. The orbiting-mass oscillator automatically changes its phase angle, and therefore its

power factor, with these changes in the resistive impedance of the load.

A further important characteristic which tends to make the orbiting-mass oscillator hang on to the load and continue the development of effective power, is that it also accommodates for changes in the reactive impedance of the acoustic environment while the work process continues. For example, if the load tends to add either inductance or capacitance to the sonic system, then the orbiting-mass oscillator will accommodate accordingly. Very often this is accommodated by an automatic shift in frequency of operation of the orbiting-mass oscillator by virtue of an automatic feedback of torque to the energy source which drives the orbiting-mass oscillator. In other words, if the reactive impedance of the load changes this automatically causes a shift in the resonant response of the resonant circuit portion of the complete sonic system. This in turn causes a shift in the frequency of the orbiting-mass oscillator for a given torque load provided by the power source which drives the orbiting-mass oscillator.

All of the above mentioned characteristics of the orbiting-mass oscillator are provided to a unique degree by this oscillator in combination with the resonant circuit. As explained elsewhere in this discussion the kinds of acoustic environment presented to the sonic source by this invention are uniquely accommodated by the combination of the orbiting-mass oscillator and the resonant system. As will be noted, this invention involves the application of sonic power which brings forth some special problems unique to this invention, which problems are primarily a matter of delivering effective sonic energy to the particular work process involved in this invention. The work process, as explained elsewhere herein, presents a special combination of resistive and reactive impedances. These circuit values must be properly met in order that the invention be practiced effectively.

Reference is now directed to the following detailed description of certain illustrative embodiments of the invention, and to the drawings, in which:

FIG. 1 is a perspective view showing a veneer machine in accordaice with the invention;

FIG. 2 is a detail plan view taken in the aspect of the arrows **2—2** on FIG. 1;

FIG. 3 is a detail elevational view taken in the aspect of the arrows **3—3** on FIG. 2;

FIG. 4 is a detail section through an illustrative orbital-mass vibration generator, taken in accordance with the section line **4—4** of FIG. 1;

FIG. 5 is a schematic view showing a layer of veneer being peeled from a log and showing, in vertical medial section, a drying means for the cut veneer;

FIG. 6 is a section taken on line **6—6** of FIG. 5, showing a drying roller means for the veneer;

FIG. 7 is a transverse section taken on line **7—7** of FIG. 6;

FIG. 8 is a view similar to FIG. 7, but showing the use of an additional vibration generator for vibrating the roller;

FIG. 9 is a view taken in the aspect of the arrows **9—9** on FIG. 8;

FIG. 10 is a view similar to FIG. 5 but showing an alternative drying system;

FIG. 11 is a transverse section taken on line **11—11** on FIG. 10; and

FIG. 12 is a standing wave diagram representative of vibratory action imparted to the veneer knife in accordance with the invention.

FIG. 1 shows somewhat diagrammatically, a veneer cutting machine **15** in accordance with the invention. This machine has lathe-type arrangements for rotating a log **16** from which the veneer is to be cut, and includes shafts such as **17** for engaging, or clutching to the two ends of the log, these shafts being supported in suitable bearings in frame members **18**, and one of which is rotated by conventional power gear and a prime mover, not shown, for the purpose of rotating the log.

A veneer knife **20** has a tapered blade **21** leading to a sharp edge which engages the log somewhat tangentially, and this blade **21** is provided with mounting arrangements enabling it to be properly positioned, and then fed radially inward as the veneer is cut from the log. As here shown, the blade **21** is supported at its rear edge by two flexible mounting devices **22**, located preferably at some point between twenty and twenty-five percent of the length of the knife from each of its two ends. In the present instance, the flexible mounting device generally designated by numeral **22** comprises a mounting block **23** secured to the rearward edge of the knife, a pair of parallel, flat, flexible springs **24** fastened at one end to opposite sides of the block **23**, and a mounting block **25** to which the opposite ends of the springs **24** are fastened, the block **25** of the two mounting devices being secured to an adjustable and continuously fed platen or slab **26**. The platen **26** is formed in the bottom with a dovetailed way **28**, extending generally perpendicular to the log, and which slidably receives a dovetail **29** on the top of a vertically movable mounting slide block **30**, the platen being supported by said slide block **30**, as indicated. The latter is vertically movable in a vertical slot **32** in a sub-frame block **34**, which is rigidly mounted in the frame of the machine by any suitable mounting structure. The slide block **30** is here shown to be formed with a vertical V-shaped guide **35** slidably receivable in a complemental way **36** formed within the vertical slot **32** in the aforementioned sub-frame block **34**. Arrangements are made for adjusting the platen **26**, and therefore the knife **20**, horizontally toward and from the log by sliding on the slide block **30**, guided by dovetail **29**, and such arrangements may involve a hand wheel **40** and a suitable or conventional lead screw device, not shown. Also, means are provided for vertical movement of the slide block **30** with reference to the stationary sub-frame block **34**, and while in practice, for precision of work, suitable conventional power-operated feed mechanism can be used for this purpose. I have here conventionally indicated simply a hand wheel **40** on a shaft journalled in platen **34** and which will be understood to be connected to any suitable gearing and leadscrew arrangements to the slide block **30** to permit gradual vertical downward feeding of the slide block **30**, table **26**, and therefore the knife **20**, as the veneer is progressively cut from the log.

Two orbital-mass vibration generators **44** and **46** are shown mounted on and thus sonically coupled to the vibratory knife **20**, the former being secured to an end of the knife, and the latter, in this example, to the rearward edge of the knife at substantially the mid-point thereof. These may be used alternatively, and in some cases together. The generator **44** at the end of the knife is to be understood as positioned appropriately for setting up in the knife a resonant standing wave vibration pattern extending longitudinally of the knife, and the generator **46** at the back edge of the knife is positioned to set up in the knife a resonant standing wave pattern in a lateral mode, the vibration taking place in the plane of the blade. Reference being directed to FIG. 12 the longitudinal-type standing wave pattern, shown in a typical one-wavelength mode, is diagrammed at the bottom of the figure, while the lateral standing wave pattern, also of one wavelength, is diagrammed at the top of the figure. As stated hereinabove, the generators **44** and **46** can be used alternatively or together, and the patterns shown in FIG. 12 may thus occur either alternatively, or superimposed over one another.

The orbital-mass generators **44** and **46** are identical, and FIG. 4 shows a medial sectional view through one of the generators, in this instance the generator **46**. The generator comprises a cylindric case or housing **50** having on one side a mounting plate **51** secured to the knife **20**,

and the housing **50** contains a cylindrical cavity **52** receiving an orbital-mass rotor **53**, in this instance in the form of a metal disc of a diameter somewhat less than than of the cylindrical cavity **52**. Air under pressure is supplied via a hose **54** leading to a nozzle or jet **55** which opens tangentially into the peripheral region of the cylindrical cavity **52** in housing **50**, such that the injected air impinges upon the orbital-mass rotor **53** and causes it to gyrate in an orbital path around the inside of the chamber **52**. A better or more complete design of such an orbital-mass generator appears in FIGS. 5–9 of my Patent No. 2,960,314, and may be referred to for a more detail showing of such a generator. The air pressure to hose **54** is controlled so as to bring about a driving force on the rotor **53** such as will cause its spin frequency, i.e. number of trips around cylindric cavity **52** per second, into the range of the resonant frequency of the knife **20** for the particular standing wave pattern to be produced.

It will be clear that the orbital-mass rotor **53**, running around the inside of the housing **50**, will, by virtue of centrifugal force, produce a rotating force vector intersecting the axis of the cylindric housing chamber **52** and exerted against the housing **50**, and thus against the blade **20** to which the housing **50** is secured and coupled. A force rotating about the axis of the cylindric rotor chamber **52** is thus applied to the knife **20**.

Consider now the generator **44** coupled to one end of the knife **20**, with the axis of the cylindric rotor chamber **52** vertical, as indicated in FIG. 1, or in other words, at right angles to the plane of the knife **20**. The rotating force vector generated by this generator **44** will be seen to be applied to the end extremity of the knife, and in the orientation illustrated, this rotating force vector turns in the plane of the knife. It will be seen that this rotating force vector will have components longitudinally of the knife, and also transversely thereof, both acting in the plane of the blade. Assuming the cyclic frequency of rotation of the rotor **53** to correspond to the frequency of the knife **20** for a full-wavelength longitudinal standing wave pattern, the component of alternating or cyclic force exerted by the generator **44** in the direction longitudinally of the blade will then set up a one-wavelength resonant standing wave pattern in the knife, as earlier mentioned, and as diagrammed at *s*1 in FIG. 12. A substantial component of vibration amplitude will then be developed at the antinodal regions of the standing wave in the blade, as at V in FIG. 12. Also, nodes N, which are regions of zero or minimized vibration amplitude, will occur at points twenty-five percent inwardly from each end of the standing wave diagram. To explain the diagram *s*1 somewhat further, it is to be understood that this diagram represents by the vertical distance between the two sinusoidal lines the vibration amplitude at different points along the length of the knife, the points V being at the two extremities of the knife and at the midpoint thereof, with the points N at twenty-five percent of the length of the knife inwardly from each of its ends. The knife **20** thus vibrates by elastic deformation movements taking place in the longitudinal direction of the knife, and with amplitudes as represented by the diagram. The component of force applied to the knife by the generator **44** in directions transversely of the blade are not at a resonant frequency of the blade, and hence are blocked by the reactance of the blade from developing material vibration amplitude in directions laterally of the blade. It should also be pointed out that the vibration generator **44** need only be oriented so as to develop a component of cyclic force longitudinally of the blade, and it is therefore immaterial whether the axis of the cylindric rotor chamber **52** is transversely of the knife **20**, as illustrated, or in the plane thereof. In other words, the generator **44** could be rotated through ninety degrees about the horizontal axis longitudinally of the blade from the position illustrated in FIG. 1, and the necessary cyclic or alternating force longitudinally of the knife would still be applied.

Considering now the generator **46** mounted to the rearward edge of the blade, and oriented with the axis of the rotor chamber vertical, i.e. transversely of the blade, it will be seen that the rotor **53** of the generator **46** will similarly develop a rotating force vector which will be applied by the rotor housing **50** to the rearward edge of the blade, with components of this force extending both laterally of the blade, and longitudinally thereof. The air pressure in this case is controlled to be such as to drive the orbital-mass rotor **53** at the resonant standing wave frequency for a lateral rather than a longitudinal mode of standing wave vibration. Thus, the component of force developed longitudinally of the blade will not be near a longitudinal resonant frequency, and will produce only negligible amplitude vibration in the longitudinal direction. The lateral component of vibration, on the other hand, at the resonant frequency for a lateral mode of standing wave vibration, will develop substantial amplitude in a lateral wave mode, and for the full wave preferred pattern, the resulting standing wave pattern is as indicated at *s*1′ in FIG. 12. The space between the two curved lines of this diagram again are proportional at every point along the diagram to the corresponding amplitude of lateral vibration of the blade, and there are velocity antinodes V′ at the ends and at the mid-point, as diagrammed, while there are velocity nodes N′ at points which in this case are at approximately twenty percent of the length of the blade inwardly from each of its two ends.

Thus, by virtue of the longitudinal standing wave pattern *s*1 set up in the blade by the orbital-mass generator **44**, longitudinal or slicing-type motion occurs along the cutting edge of the knife, this taking place by elastic deformation movements set up in the blade by the described longitudinal standing wave action. Also, by virtue of the lateral standing wave pattern set up in the blade by the orbital-mass generator **46**, cyclic movements of the blade of an impacting or chopping type, i.e. toward and from the line along which the log is engaged by the knife edge, are set up in the knife, these being elastic deformation movements of the knife taking place in accordance with the lateral wave pattern *s*1′ in FIG. 12. Two types of vibratory cutting action are thus available, and can be used alternatively or simultaneously, depending upon requirements of particular woods to be veneered.

It is to be noted that the mountings **22** for the knife **20** are located in the general regions of the nodes N and N′ of the two wave patterns possible, and thus the flexible mounting straps **24** need undergo only minimized vibration amplitude while supporting the knife during either of its modes of vibration. It will be further seen that the spring straps **24** can be easily flex laterally or longitudinally to accommodate the small vibration amplitude of the knife in the regions where the straps are connected to the knife.

In operation, the knife **20** preliminarily to engage the periphery of the log so as to start the cutting of a veneer of the desired thickness, and the log **16** is then rotated by the prime mover, not shown, coupled to one of its mounting shafts. As the veneer **60** is cut, the blade **21** is moved progressively radially inward towards the center of the log, the rate of this movement of course being nicely regulated so that the veneer **60** will be cut at uniform thickness. As explained earlier, this inward movement is accomplished by conventional mechanism known in the art, and only diagrammatically suggested here by the slide block **30** working up and down inside the frame component **34**, under a feed control merely suggested by the hand wheel **40**. The action of the elastic standing wave vibration set up in the knife by either one or both of the two vibration generators **44** and **46**, and the improvement in veneer cutting obtained thereby, has been

described in full detail in the introductory portion of the specification, and need not be repeated at this point.

Also, the virtue of the orbital-mass type of vibration generator in cutting of veneer has been described fully in the introductory portion of the specification. At this point it will only be necessary to recall that variations in the fiber structure of the log from point to point, such as changes in hardness and density, as well as contained moisture, result in corresponding changes in impedance from point to point, and that these point-to-point changes in impedance can take place not only along the log, but also around the log, and still further, from the initial periphery of the log to its center. All such changes in impedance are accommodated by the orbital-mass generator utilized in the practice of the invention, to the end of maximized power output under changing conditions of impedance, and the incorporation of the orbital-mass type of vibration generator is deemed by me to be a major feature of the veneer cutting process and apparatus of the invention. This subject was exhaustively treated in the introductory portion of the specification.

Illustrative examples of the sonic veneer drying process and apparatus of the invention will next be described. Referring to FIGS. 5–7, the veneer **60** from the log **16** passes first between a pair of sonically vibratory moisture extracting rollers **61** and **62** mounted parallel to one another and with just sufficient spacing therebetween to permit passage of the veneer **60** through the intervening gap, with the veneer in contact with both rollers. The two rollers **61** and **62** may be identical, and only the roller **62** will be described in detail. It should be noted, however, that the two rollers **61** and **62**, in the arrangement here suggested, are rotated from opposite ends in order to avoid interference between the driving pulleys for the two rollers. With reference to FIG. 6, the roller **62** will be seen to have a hollow axle or sleeve member **63**, with a reduced extremity **64** mounted in bearings **65** on supports **66**, and furnished, inside the bearings **65**, with tightly mounted end plates **68**. The end plates **68** are rotatable relatively to the bearings **65** and the gap therebetween is effectively closed by seals such as indicated at **70**. Between the end plates **68**, and forming the periphery of the roller **62**, are mounted porous cylinders **72**, composed of a suitable porous material with inter-communicating interstices formed therewithin and forming passageways therethrough. Suitable materials for the cylinders **72** are sintered metal, porous ceramic, a fibrous matrix, microporous absorbent plastic felt, or the like. As here shown, the cylinder **72** is further supported by radial webs or spokes **74**. The end plates **68** are provided inside the location of the seals **70** with arcuate passages **75** providing communication between the interior space **76** of the roller and passageways **78** formed in the bearing **65**, the ends of these passages **78** having coupled thereto inlet and outlet conduits **79** and **80**, respectively, for intake and discharge of drying air. As shown, the end plates **68** are spaced somewhat from the adjacent bearings **65**, permitting free communication from the arcuate passageways **75** to the passageways **78**. As shown in FIG. 6, the length of the exterior porous cylinder or sleeve **72** is somewhat wider than the width of the veneer **60** cut from the log, as clearly shown in FIG. 6.

To accomplish vibration of the roller **62**, I employ preferably a special form of vibration generator arrangement of the previously described orbital-mass type, and comprising in this instance an orbiting-mass roller **82** inside and of somewhat lesser diameter than the bore of sleeve **63**, and positioned, in this illustrative instance, near the center of the sleeve **63**. This roller **82** is driven rotatably through a universal joint at **86**, and an axial shaft **88** rotatably mounted in an end bearing **89** fixed in one extremity of the sleeve **63**, together with a driving pulley **90** on the outer extremity of shaft **88** and driven by a suitable belt and prime mover, not shown. On the end of the roller sleeve **63** is mounted a drive pulley **92**, driven by a belt and prime mover, not shown. The pulley **92** is preferably driven at such a rate of rotation that the peripheral speed of the external porous sleeve **72** of the roller **62** is as closely as possible equal to the linear speed of travel of the veneer **60** coming from the veneering machine **15**.

The pulley **90** for driving the orbital-mass rotor **62** around the inside of the sleeve **63** is driven at a rate of speed sufficient that the roller **82**, gaining rolling traction against the inside surface of the sleeve **63**, rolls around the inside of the latter, with centrifugal force holding the roller in tight pressural contact with the inside of the sleeve throughout the trip around. Further, the pulley **90** and roller **82** are driven at such a frequency, in orbital trips, or cycles, per second, relative to the rotating sleeve **63**, such as to correspond to a resonant standing wave frequency for the tube **63** for a lateral mode of resonant standing wave vibration. In the present instance, the standing wave frequency may be that for a full-wavelength standing wave, of the same nature as that diagrammed at the top in FIG. 12. The orbital mass **82**, thus running around the inside of the sleeve **63**, which is of an elastic nature, such as steel, then exerts against the inside of the sleeve **63**, near its mid-point a radially oriented force vector which turns relative to the sleeve **63** at the resonant standing wave frequency for a full-wavelength lateral mode of standing wave vibration. In result, there is created in the sleeve **63** a gyratory type of elastic deformation movement, which is, in effect, the resultant of two linear vibrations taking place in planes at right angles to one another, with a phase difference of ninety degrees. This type of gyratory standing wave vibration was described in my Patent No. 2,960,317, in connection with FIGS. 1–4 thereof, and for a further description, reference may be had to said patent. It will suffice herein to state merely that a gyratory type of wave action, in a pattern akin to that in the upper portion of FIG. 12, is set up in the sleeve **63**, and that corresponding gyratory vibratory action is transmitted from the sleeve **63** through the webs or spokes **74** to the veneer engaging external cylinder **72**. Such sonically vibratory gyratory action is thus applied to the veneer **60**. The roller **61** above the veneer has a similar action, which may be phased with that of the lower roller in any way desired, for example such that the plywood is alternately squeezed between two rollers, and the sonic vibration thus applied to the plywood works the moisture therein to the surfaces thereof, from which it is then absorbed in the porous external cylinders **72** of the two rollers **61** and **62**. Drying air is continuously introduced via the tubing **79**, travels longitudinally through the roller adjacent the inside surface of the porous sleeve **72**, and is discharged via tubing **80**, and this drying air picks up the moisture on the inside surface of the porous sleeve and carries it out. Thus a moisture gradient is established in the veneer by which the moisture, mobilized by the vibratory action against the surfaces of the veneer, is moved out of the veneer to the porous cylinders **72**, inwardly through the latter, and then out with the current of drying air as described.

FIG. 8 shows a modification, wherein an orbital-mass generator **93** of the air-driven type described hereinabove is mounted on a support **93A** with its housing **93B** in engagement with the periphery of a veneer drying roller, such as the roller **62**. The support **93A** has sufficient flexibility to permit sonic vibratory action of the generator housing against the roller **62**, and thus imparts sonic vibration to the porous cylinder **72** of this roller, with corresponding improvement in moisture extraction as described hereinabove.

In FIG. 5 is shown a further drying unit **94** which may be used with the drying rollers **61** and **62**, in series therewith, or alone. At this station, the plywood **60** passes over a porous pad or slab **95**, under which is a perforated mounting plate **96** for the slab. Moisture draining from the porous blotter or slab **95** through the perforations in

plate **96** may be caught by a tank **97** and carried away by pipe line **98**.

Engaging the upper surface of the veneer **60**, above and substantially coextensive with the slab **95**, is a vibratory foot **100** on the lower end of an elastic bar or beam **102**, at the top of which is mounted an orbital-mass vibration generator **104** of the general character heretofore described. Thus, the generator **104** may comprise a housing **105** having a cylindrical chamber **106** therein, disposed with its axis horizontal, and in which is an orbital-mass roller **108** driven by any suitable means as an air jet, illustrated more particularly, for instance, in FIG. 4, but omitted, for simplicity, from FIG. 5. The air pressure is again so regulated as to cause a cyclic output force from the generator housing such as will set up in the structure a longitudinal half-wavelength standing wave, of a longitudinal type, such as diagrammed in FIG. 5, the standing wave in this instance having a node at N, and velocity antinodes V at the top and V' at the bottom, i.e. at the foot **100**. Because of the mass of the foot, the node is displaced downwardly from the mid-point of the standing wave pattern, and there is a reduced amplitude of vibration at the lower velocity anode V', i.e. at the foot, as compared with that at the upper velocity antinode V, where the vibration generator is coupled in. The lower face of the foot **100** is thus vibrated against the veneer, setting up conditions within the veneer which are generally equivalent to those produced by the two vibratory rollers **61** and **62**. The action again is to mobilize the moisture within the veneer, causing it to flow from or be squeezed from the veneer, and absorbed by the porous blotter or slab **95**. The porous material of the slab **95** may again be sintered metal, porous ceramic, a fibrous matrix, microporous absorbent plastic felt, or the like.

Preferably, and in the present instance, the foot **100** has a cavity **110** therein and perforations **111** in its bottom through which fluid within the cavity **110** may pass to the upper surface of the veneer **60**. A pipe **113** is coupled to chamber **110**, and may be used to convey to said chamber a volatile liquid, which, under the influence of the vibrating foot **100**, is worked into the veneer, forcing the water out ahead of it and down into the porous plate **95**. This volatile liquid subsequently evaporates from the veneer. As an alternative, a non-evaporative liquid, such as a preservative, can be used in this system, and will then stay in place.

I have also shown in FIG. 5 the use of pipe **119** leading into the porous plate **95**, and which can be used for introduction to the porous plate of a salt solution for improvement of desired osmotic action in the porous plate.

Reference is next directed to FIG. 10, showing an alternative drying system **120**. In this case, the veneer **60**, after typically passing through rollers such as the rollers **61** and **62** of FIG. 5, passes through a long rectangular chamber **122** defined by a pair of parallel resonator plates or sounding boards **124** and **125** at the top and bottom, and at the sides or edges by overlapping edge plates such as **126** and **127** (FIG. 11). The upper resonator plate is spring supported at points located approximately twenty-five percent from each of its ends by means of suspension springs **128**. The lower plate **125** is spring supported at positions approximately twenty-five percent inward from each of its ends by means of rubber insulation supports **129**. Orbital-mass generators **130** and **132**, of the general type previously described, are mounted on the ends of the plates **124** and **125**, and are oriented such as to produce sonic resonant standing wave vibration of the resonator plates, the wave pattern being preferably a lateral type, such that the plates **124** and **125** move toward and from the veneer **60** passing therebetween. Hot air nozzles **134** introduce hot drying air into the chamber **122** between the resonator plates **124** and **125**, and this air travels longitudinally through the chamber **122** and out the front end thereof. The sonically vibrating resonator plates **124** and **125** acoustically couple to the hot drying air, which is thus set into sonic vibration, so that a sonic wave train is established at the interface between the hot drying air and the veneer. The sonically vibratory air at this interface then couples to the veneer, producing sonic pressure pulses therealong and resultant vibration in the veneer such as contribute to mobilizing the moisture in the veneer and bringing it to the surface to be dried and carried away by the circulated hot air. A moisture gradient is thereby established in the veneer, between its medial plane and each of its two outside surfaces, such as leads to accelerate travel of moisture from the interior to the outside. Improved drying is thereby obtained.

The invention should now be understood from the several illustrative embodiments thereof described and illustrated, and from the discussion of the basic principles of the invention contained in the introductory portion of the specification. It will now be entirely evident to those skilled in the art how the theoretical discussion given preliminarily applies to each of the several illustrative physical embodiments of the invention.

It will of course also be understood that the embodiments here chosen for illustration are not exhaustive of all of the various physical forms in which the invention may be carried out in practice, and that numerous changes in design, structure, and arrangement may be made without departing from the spirit and scope of the invention or of the appended claims.

I claim:

1. In a machine for cutting veneer from a wood log, having means for supporting the log for rotation on a longitudinal axis, the combination of:

a veneer knife having a cutting edge positionable to engage substantially tangentially against the log near the periphery thereof and supported for travel generally radially inwardly of the log so as to peel a continuous strip of veneer from the log; and

an orbital-mass vibration generator sonically coupled to said knife for setting up a resonant pattern of elastic standing wave vibration in said knife along said cutting edge.

2. The subject matter of claim **1**, wherein said orbital-mass vibration generator is coupled to said knife to exert thereon a cyclic force oriented longitudinally of said knife and at a frequency in the range of resonance for a longitudinal pattern of resonant standing wave vibration in said knife.

3. The subject matter of claim **1**, wherein said orbital-mass vibration generator is coupled to said knife to exert thereon a cyclic force oriented laterally of said knife and at a frequency in the range of resonance for a lateral pattern of resonant standing wave vibration in said knife.

4. The subject matter of claim **1**, wherein said pattern of standing wave vibration in said knife has nodal regions therelong; and

regions for supporting said knife in the vicinity of said nodal regions.

5. The subject matter of claim **1**, wherein said pattern of standing wave vibration in said knife has nodal regions therealong; and

means for flexibly supporting said knife in the vicinity of said nodal regions.

6. The process of cutting veneer from a rotating wood log, which comprises:

applying generally tangentially to the log, near the periphery thereof, the cutting edge of an elastically vibratory veneer knife;

driving a mass repeatedly around a closed orbital path at a frequency in the range of a resonant frequency of said knife for a mode of elastic standing wave vibration of said knife wherein said vibration takes place along said cutting edge, and with said mass confined to said path so as to create a periodic impulse; and

impressing said periodic impulse on said knife and thereby setting said knife into said mode of standing wave vibration.

7. The process of claim 6, wherein said periodic impulse is impressed on said knife longitudinally therealong, at a frequency for a mode of longitudinal standing wave vibration of the knife, and in the region of an antinode of such a longitudinal standing wave.

8. The process of claim 6, wherein said periodic impulse is impressed on said knife laterally thereof, at a frequency for a mode of lateral standing wave vibration of the knife, and in the region of an antinode of such a lateral standing wave.

References Cited

UNITED STATES PATENTS

2,384,435	9/1945	Bodine.	
2,960,314	11/1960	Bodine.	
3,224,477	12/1965	Sarv	144—212
3,381,727	5/1968	Hayes	144—212
3,416,398	7/1966	Bodine	83—647.5

DONALD R. SCHRAN, Primary Examiner

U.S. Cl. X.R.

83—4; 144—212