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METHOD AND APPARATUS FOR INSPECTING HONEYCOMB PANELS

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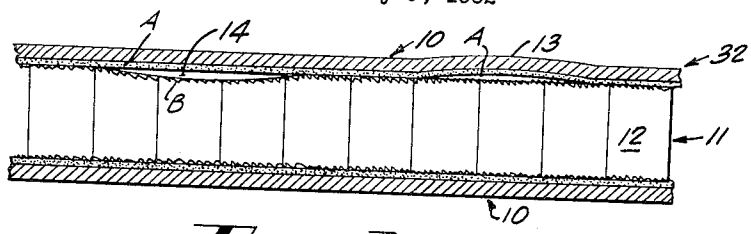


Fig. 1

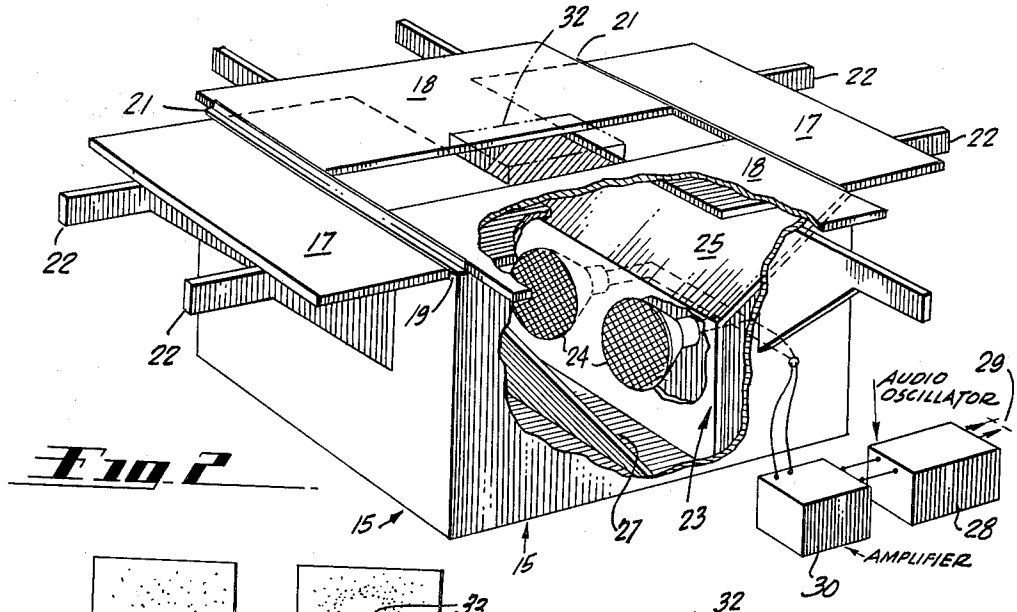


Fig. 2

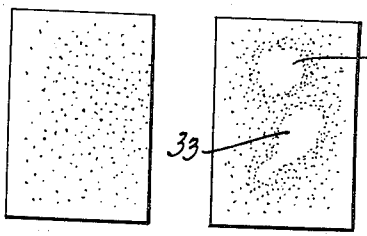


Fig. 4 Fig. 5

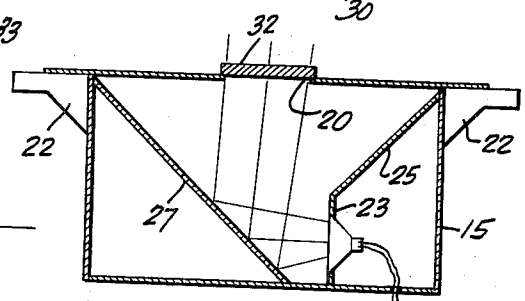


Fig. 3

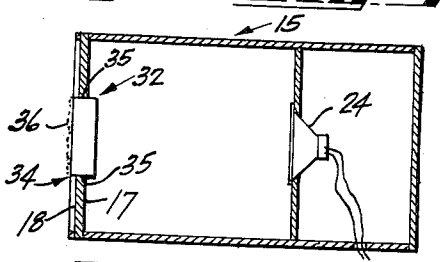


Fig. 6

INVENTORS
ARTHUR L. KLEIN AND
GEORGE G. GRIMM

BY J. Edwin Coates
ATTORNEY.

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METHOD AND APPARATUS FOR INSPECTING HONEYCOMB PANELS

Arthur L. Klein, Los Angeles, and George G. Grimm, Pacific Palisades, Calif., assignors to Douglas Aircraft Company, Inc., Santa Monica, Calif.

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16 Claims. (Cl. 73—67.2)

This invention relates to the inspection of adhesively laminated articles, such as "sandwich" type structural panels. These articles essentially consist of a low density, reticulate core oppositely faced by each of a pair of higher density imperforate facing plates bonded thereto.

Such panels are apt, during their fabrication, to be subjected to such stresses from the fabricating apparatus as to cause one, or both, of the plates to locally buckle outwardly away from the layer of adhesive on the adjacent face of the core. Such buckles, of course, are unattached, or insufficiently attached, to the core and are called "oil-cans," for they are so loose that they flex inwardly and outwardly under facewise pressure. Obviously, such regions constitute weaknesses and defects that cannot be tolerated and must be determined before the article leaves the manufacturer's hands. Usually, however, this buckling is so slight as to be imperceptible to the naked eye. Other conventional structural panel inspecting means and methods are also incapable of accurately and rapidly ascertaining the exact locations and extents of these oil cans in an economical and practicable manner.

Oftentimes in the fabrication of such panels, the reticulate core, usually of honeycomb paper construction, may be mashed inwardly, or "dished," locally, as by the adhesive applying roller. Such regions of no attachment or poor attachment cannot be economically determined by any known method or means.

The present invention provides simple but effective methods and means for accurately determining and indicating the location and extent of any defect in the mutual adhesive union of the laminae of such panels.

Essentially, the presently-preferred form of the method of this invention includes the steps of first disposing the laminated article stably in a sound-conducting medium, such as air, with one face thereof arranged to enable it to be visually, or otherwise, observed as to a certain vibratory condition thereof, later described. This face constitutes part of a lamination being inspected for defective mutual union of the laminae composing said lamination. A train of mechanical energy waves of a frequency out of resonance with defectively united portions of these laminae is then impinged on this face. The impingement may take place directly or through the body of the panel. While continuing to impinge this wave train on this face, the frequency thereof is modulated, either up or down, to that empirical frequency at which the portions in question resonate with the modulated-frequency waves. Such resonation of course causes these defectively adhesively united portions to vibrate with greater amplitude and frequency than the other portions of the laminae that include this face. This vibration in these portions may either be simply visually observed or may be picked-up by electrical, hydraulic, mechanical or optical vibration pick-up means of known type.

Preferably, for the aforedescribed panels, the mechanical energy wave train employed consists of acoustic-pressure waves lying in the audio-frequency range of 19 cycles-per-second to 20,000 C. P. S. More specifically, it has been found that frequencies ranging of the order of 1000 C. P. S. to 5000 C. P. S. are most effective in resonating the defective portions of the present panels.

Also, in the now-preferred form of the invention, the aforesaid resonating portions are visually observed by means of sand patterns so as to obviate more expensive electrical, or other, pick-up means. To this end, the structural panel is disposed in horizontal attitude and the upper face (forming a portion of the laminae to be inspected) is loosely covered with free particles of a finely-subdivided material, such as sand. The acoustic-pressure wave train is impinged on this face, usually through the bottom of the horizontal panel. The defectively-united portions of these laminae resonate with the modulated frequency waves and are thereby caused to vibrate at an amplitude and rate which clears the sand from the resonant antinodes. The cleared areas visually indicate on this face, the exact location and extent of the defectively united portions of the lamination. However, as aforestated, the vibrations of these defectively united portions may be detected in other ways than visual observation of sand patterns.

The impingement of the wave-trains may be initiated at a frequency well below the critical frequency lower limit of 1000 C. P. S. and worked up through the upper limit or vice versa. If desired, as a check on the observations, the wave-train impingement may be initiated near the one limit and worked up or down, as the case may be, through the other limit, whereupon the wave-train may be sent back through the laminate in the opposite frequency-direction. By these means, antinodes which recur on repetition can safely be assumed to indicate the exact location and extent of defectively united portions of the laminae in question.

A further important feature of the invention emanates from the fact that the method employs acoustic-pressure waves. If there are any regions in the panel where the adhesive films joining the laminae are so thin as to be unable to withstand the stresses applied thereto in the use of the panel, these waves, after a sufficient period of application at a certain frequency, break apart these thin films. Upon continued application of the wave-train, the method and apparatus will, as hereinbefore, accurately effect indication of the location and extent of the now completely unattached portion.

One of the now-preferred forms of means for performing the present methods is essentially comprised of a framed supporting structure, or box, having a variable-size opening in its upper face adapted to support one of the laminated panels in a horizontal attitude over an air space in the box, the upper face of the panel being covered with sand. Inside the box, near the one end thereof, are mounted means for generating sound waves and directing them impingingly against the laminated panel. Means are also associated with the acoustic-pressure wave generating means for modulating the frequency of these waves, upwardly or downwardly, as, and for the purposes, described.

This form of the apparatuses contemplated by this invention is illustrated, for purposes of further clarification and exemplification, in the accompanying drawings. This apparatus is, hereinafter described in detail in conjunction with these drawings but it is to be definitely understood that these drawings and said description in no manner limit the invention to the exact design shown and described or to the precise method steps employed with this specific design. In fact—and in law—the scope of the

invention is limited only as required by proper interpretation of the annexed claims.

In these drawings:

Figure 1 is a fragmentary transverse section of one of the honeycomb core structural panels with which the invention is concerned, showing an oil-can type of defective adhesion in the upper surface of its upper lamina and illustrating a "dished-in" type of defective adhesion in the upper surface of its intermediate lamina;

Figure 2 is a perspective view of the now-preferred form of apparatus for applying the present method to an article like that of Figure 1;

Figure 3 is a longitudinal, substantially central section of the apparatus of Figure 2, the showing being on a reduced scale;

Figure 4 is a top-plan view of a panel substantially covered with a layer of granular material and ready for processing in the apparatus of Figure 2 in the position shown therein;

Figure 5 is a top plan view of a panel with the granular material formed by the acoustic pressure waves into patterns indicating the location and extent of the defective unions between the laminae; and

Figure 6 is a view similar to Figure 3 showing the test panel mounted in a vertical attitude in the testing apparatus, the one vertical face of the panel bearing an adhesive-coated granular material weakly adherent thereto.

One of the structural panels that is to be inspected by the present method and means to determine the presence or absence of defects is illustrated in these drawings as comprising a pair of comparatively thin metallic face plates **10** transversely spaced apart by a stabilizing core **11**, here shown as a honeycomb type configuration and as made of paper or the like web material. The walls **12** of the cells of the honeycomb core extend substantially normal to the plates and are quite strong in compression. When the core is adhesively united facewise to a plate **10** on each of its opposite faces, it is substantially rigid transversely thereof. The core also acts as a shear-absorbing element between the two plates **10** and, further, stabilizes the skin against buckling, or other local deformations, when fully attached throughout each of its faces to the adjacent plate **10**.

However, because of the obviously limited contact area available between the cell-ends and the plates, it is not always possible in high-speed production, to secure perfect adhesion between all portions of each face of the core and all portions of the adjacent surfaces of the plates. For example, the aforementioned buckling may occur, despite all normal precautions, as under unsuspected longitudinally acting compressive forces. As shown at **13** in Figure 1 in a considerably exaggerated manner, such buckling precludes transverse stabilization of the panel and prevents union of adhesive A with the core, but is usually so minute in transverse extent as to be discoverable only with difficulty by any hitherto known method or means.

Also, as shown at **14** in Figure 1, in the process of coating the face of the core with a cold-setting adhesive, B, such as a phenolic resin, by means of an adhesive-applying roller or the like the roller may unknowingly be so applied to the locally transversely rather yieldable cell-ends of the core as to locally compressively deform the core. This action forms in the core-face, a dished-in portion **14** which is obviously out of contact with the superadjacent plate and is not adhesively connected thereto. This kind of defect, also, is shown in an exaggerated manner in Figure 1. In reality, it is so minute as to be difficult to detect by conventional inspection methods and means, especially in view of the fact that it is located, always, entirely in the interior of the panel.

In order to rapidly and accurately ascertain whether such, or other, defects in the adhesive union of the laminae of the panels are present, the novel methods of the present invention are, so far as concerns all its essential steps, capable of performance in the apparatus shown in Figure 2.

Being functionally coordinated with the steps of this method, this apparatus is adapted to apply mechanical-energy waves to the sand-layered face of the structural panels so as to set up sand patterns by resonation of defectively adhesively united portions of the laminae. To this end, the apparatus first includes means for supporting one of the laminated articles in a fluid-medium, such as air, with the sand-supporting face to be observed facing upwardly, the opposite face being in contact with the air in the enclosure. It is not necessary that the air be confined, however, as the sound-waves can be impinged on the inspected face plate in free air, as with the panel resting on a pair of saw-horses.

However, in order to provide—in one unitary article—means for supporting the articles in the aforesaid manner and means for impinging on the face to be inspected, a train of mechanical-energy waves, and the other means hereinafter described, the apparatus includes a substantially hollow box or other framed structure **15**, adapted by components hereinafter described to support the panels as aforedescribed as well as the other equipment employed in the method.

The invention provides a variable-size opening in the upper face of the box through which the operating sound waves may pass to sand-covered panels of various sizes. To this end, two pairs of movable planeal members, **17**, **17** and **18**, **18** are slidably mounted in parallelism with the otherwise open face of the box. The two planeal members **17**, **17** are movably supported in mutual opposition by an indentation or kerf **19** in the upper edge of each end of the box. The depth of kerf **19** is such as to dispose the upper face of planar members **17** flush with the upper edges of the box. The upper boundary of kerf **19** is defined by an angle-member **21** which also serves as a guide for the planeal members **18**. The latter members are slidably supported on members **17** and extend mainly lengthwise of the box, members **18** extending mainly transversely of the box.

Thus, the transverse dimensions of the opening **20** defined by the edges of panels **18**, **18** may be varied by movements of **18**, **18**, while the longitudinal dimensions thereof may be varied by movements of panels **17**, **17**. Hence structural panels of various dimensions may be supported over the hollow interior of the box on the edges of panels **17**, **17**.

Dual function members **22**, provided to serve as box lifting handles and as supports for panels **17**, **17**, project from the end faces of the box.

Inside the box, and disposed fairly close to the one end thereof, there is a septum or similar partition **23** adapted for supporting a source of acoustic-pressure waves, this source here being shown as a pair of loud speakers **24**, actuated by suitable means later described, and emitting sound waves horizontally into the box. Preferably, the loud speakers and the septum are disposed laterally outwardly of the opening **20** so as to prevent the sand from entering the speakers. The upper portion **25** of the septum lies at an angle to the lower portion so as to prevent sand from accumulating on the enclosure defined by the septum and the adjacent end wall.

Arranged in substantial confrontation with the loud speakers is a sound-wave deflecting plate **27** which is disposed at such an angle to the axis of the cones of the sound waves emitted from the loud speakers, as shown in Figure 3, as to reflect waves which strike its lower portion almost vertically upward through the aperture **20**. The conical angle of the sound-waves being indeterminate, the width of the wave-band traversing aperture **20** also varies, but in any event is of such dimensions as to intersect the entire lower face of any of the standard sizes of structural panels.

Any suitable means desired may be employed for gen-

erating and propagating the wave-train, one such means consisting of the audio-oscillator **28** of any conventional type suitable, the input-terminals **29** of this oscillator being preferably connected to a 110-volt plant outlet, not shown. The output terminals of the oscillator are connected to the input terminals of a conventional amplifier **30**. The output of this amplifier is series-connected to the two loud speakers.

In performing the method of this invention with the form of apparatus disclosed, a structural panel **32** is mounted in the opening in the upper face of the box, the upper face of the panel is loosely coated with sand or other finely subdivided material and the method steps aforedescribed are performed. A thin layer of sponge-rubber is advantageously placeable under the structural panel to isolate it from the test box, so that its vibrations will not be affected by vibrations of the latter.

In operating the specific configuration shown, the conventional energizing switch (not shown) of the amplifier is first closed to start a "warm-up" period therefor. The conventional volume switch (not shown) on the amplifier is then turned full clockwise and the sound level in decibels of the system is regulated with the conventional volume switch (not shown) on the oscillator.

The conventional frequency range switch on the oscillator is set to the upper limit (×100) and on the same instrument, the frequency dial is set to the minimum, of the order of 200 C. P. S. This dial is then slowly rotated higher and at least through 5000 C. P. S., in increments of 100 cycles. Throughout this action, the sand layer is observed for patterns indicating local nodes in the upper face of the laminate, these nodes spotting regions of defective union.

The range switch is then set to approximately its lowest limit, ×10, and the observer begins exploration with the frequency dial, starting at 5000 C. P. S. and approaching 20,000 C. P. S. gradually. The patterns of bare spots **33** observed in these actions can easily be demarked, as with a crayon. However, it is not obligatory to run the test waves fully up to their limits, since the dialling may, if desired, be halted as soon as the regions of poor adhesion are discovered. If none are discovered "on the way up," however, it is best to run the frequency all the way down again from its upper limit of 20,000 C. P. S. to its lower limit of around 200 C. P. S.

Since there is very little damping present, the resonant frequency of any one antinode is extremely sharp; hence, the operator changes of the frequency slowly or the resonance-produced node in the defectively united area will not be clearly seen.

Actually, the small-area defects will become visible at the higher frequencies whereas the large-area defects will become visible at at the lower frequencies.

Preferably, when sand is employed as the sub-divided material, the layer should be so spread that the grains lie no closer together together mutually than five to six grain diameters, in order that they will not mutually collide in moving around even under the resonance effect aforedescribed.

The invention also contemplates that, as shown in Figure 6, the structural panel **32** be mounted in a vertical attitude in the box **15**, if desired, the attitude of plate **27** being altered to the vertical and provided with any suitable substantially centrally located opening on the edges of which the panel **32** may be suitably supported in a vertical attitude; or, as shown in Figure 6, the sliding cover-panels **17** and **18** may occupy one end of the box and mutually adjusted to provide an opening **34** on the edges **35** of which the panel may be supported in vertical attitude. The loud speakers **24** are mounted as before so that the acoustic-pressure waves generated thereby impinge substantially perpendicularly on the adjacent vertical face.

This face of the structural panel is provided with a

layer of granular or pulverulent material **36**, each particle of which bears an evelope of slightly adherent material, such as an adhesive resin. Such particles are thereby enabled to weakly adhere to the vertical surface of panel **32** at all vibratory frequencies thereof except those which are in resonance with the frequency of the excitation source. At the latter frequencies, the vibrations of the unattached portions effect clearance of these weakly adherent particles therefrom sufficiently to give a visual indication of the location and extent of the unattached portions of the lamina of which this face of the panel is a portion.

As made manifest hereinabove, the vibrations of the unattached portions may be registered otherwise than visually, hydraulic, electrical or optical means being provided to this end as aforedescribed.

Although certain specific illustrative details have been described, it is to be apprehended that these details are presented merely to assist in the construction of a suitable form of apparatus and in the performance of the method and in no wise constitute the invention per se.

We claim:

1. The method of determining, from one face of a laminated article, the presence of defects in the union between the face lamina and the adjacent lamina, comprising: stably disposing the laminated article in a fluid medium with said face lamina uppermost disposing finely subdivided material on said face; impinging on said face a train of sonic pressure waves at a frequency in resonance with the period of the defectively bonded portions of said face to cause said portions to vibrate; and continuing to impinge said train on said face until the vibrating portions are substantially clear of the subdivided material.

2. The method of determining from one face of a laminated article, the presence of defective adhesive union between said face and the adjacent lamina, comprising: disposing the adhesively laminated article stably in a fluid-medium with a major face oriented to enable access thereto; applying a layer of granular material to said face; passing through the lamina a train of acoustic-pressure waves incapable of resonating with the natural period of the defectively adhesively united portions of said face; and continuing to pass said waves through said laminae while varying the frequency thereof to that which is in resonance with the natural period of the defectively adhesively united portions of said face so as to effect demarkation on said face in said portions of the presence of defective adhesive union of those laminae which include said portions.

3. The method of determining defective union of laminae in a laminated article, comprising: disposing the laminated article stably in a fluid-medium with one face thereof arranged and disposed to afford indication of the defective union of the face lamina with the adjacent lamina; disposing a layer of finely subdivided material on said face; impinging on the lamina a train of mechanical energy waves having a frequency of the order of 20,000 C. P. S., said waves being incapable of resonating with the nautral period of the defectively united portions of said face lamina; and continuing to impinge said train on said face lamina while lowering the frequency thereof to a frequency of the order of 1000 C. P. S. so as to cause said impinging train to resonate with the natural period of said defectively adhesively united portions, thereby to effect indication in said layer of the presence of defective mutual union of said laminae.

4. The method of determining from one face of an adhesively laminated article the location and extent of attenuated adhesive union of the face lamina with the adjacent lamina, comprising: disposing the adhesively laminated article stably in a fluid-medium with said face available to effect indication of the defective adhesive union of the laminae; disposing a layer of finely subdivided material on said face; impinging on said face a train of

mechanical energy waves of a frequency inadequate to resonate with the natural period of the defectively united portions of said face lamina, said waves having a frequency that is adequate to vibratively rupture the attenuated and defective adhesive unions of said laminae; and continuing to impinge said train on said laminae while varying the frequency thereof to that frequency which is in resonance with the natural period of said defectively adhesively united portions of said face, thereby to locally shake off the subdivided material from said face so as to cause said face to effect indication of the presence of lack of union between said laminae.

5. Apparatus for use in inspecting a laminated article for defects in the union of the laminae, comprising: a framed structure; means forming a part of said framed structure for stably supporting the laminated article with one face oriented to be accessible for observation, said face having a surface condition and an attitude such as to enable it to receive and support a layer of finely subdivided material thereon; means on another portion of said structure for generating and impinging upon such face a train of mechanical-energy waves; and control means positively connected with the waves-generating means for varying the frequency of said waves while they are impinging upon said face thereby to cause said waves to resonate with the natural period of those portions of said face that are defectively united with the adjacent lamina.

6. Apparatus for use in inspecting a laminated article for defects in the union of the laminae, comprising: a substantially hollow enclosure having an opening in its upper wall; the opposed edges of said opening being arranged and adapted to support said article in a substantially horizontal condition and in two rectangularly varied attitudes therein; the one face of said article confronting the interior of said enclosure and the opposite face thereof being adapted to support a granular material thereon; means opening into said enclosure for generating a train of mechanical-energy waves and directing it to the first-said face; and means for varying the frequency of said waves so as to effect resonance of the natural period of said defectively united portions of the opposite face of said article with the frequency of said varied frequency waves thereby to effect indication on said opposite face of the location of said defective portions.

7. Apparatus for inspecting a laminated article for defects in the union of the laminae, comprising: means for supporting said article in air with the face to be inspected facing upwardly; said upwardly facing face having a surface-condition and an attitude such, and being so organized with the supporting means, as to enable said face to support a layer of granulated material on said face; means for passing a train of mechanical-energy waves thicknesswise through said article and thru said layer; and means for varying the frequency of said waves to that frequency which is in resonance with the natural period of said defectively united portions of said face so as to locally shake-off the granulated material from defectively united portions of said face thereby to indicate the locations of the defects.

8. Apparatus for use in inspecting an article, comprising: a substantially hollow air-containing enclosure adapted to be disposed substantially horizontally and having an open top face; a first pair of substantially horizontally disposed members slidably arranged in parallel adjacency to said top face, said members being adapted to be slid to define a variable-size opening in said top face of said enclosure; a pair of spaced guide members arranged on the enclosure above the first-said pair of face-closing members; a second pair of substantially horizontally disposed members slidably arranged in substantially parallel adjacency to the first-said pair of members and adapted to be moved relatively to each other and to the first-said pair so as to vary said variable-size opening and enable the edges thereof to support variable-sizes of said article in either of two different horizontal positions; mounting means disposed at the one end of said enclosure; means mounted in said mounting means for generating a free train of mechanical-energy waves and directing them into the interior of the enclosure; means confronting said generating means for reflecting the waves impinging thereon outwardly through said opening; and means operatively connected to said generating means for varying the frequency of said waves.

9. Apparatus for use in inspecting a laminated article for defects in the union of the laminae, comprising: means defining an enclosure having an opening therein; said opening having a plurality of pairedly opposed edges, any two of said opposed edges being adapted to support said laminate with one face confronting the interior of the enclosure, the opposite face of said article lying in a position adapting it to support a granular material thereon; means opening into said enclosure for generating therein a train of mechanical-energy waves and passing said train into that face of said article which confronts the interior of the enclosure; and means connected to the last-said means for varying the frequency of said waves to that at which said waves resonate with the natural period of the defectively united portions of said opposite face thereby to locally shake-off said granular material from the defectively united portions of said face so as to visually indicate the location of said portions.

10. Apparatus for use in inspecting a laminated article for defects in the union of the laminae, comprising: means defining an enclosure with an open end, said opening having a pair of movable opposed edges adapted to support said article in said opening in a substantially vertical attitude with one face of the article confronting said opening, the opposite face bearing a loosely adhering layer of a finely subdivided material; means opening into said enclosure for generating and passing thereinto a train of mechanical-energy waves, said train passing first into that face of said article that is opposite to the face bearing said layer; and frequency-varying means positively connected with the generating means for varying the frequency of said waves to that at which said waves resonate with the natural period of said defectively united portions of said opposite face with said varied-frequency wave train thereby to effect indication in said finely divided material of the location of said portions.

11. The method of determining, from one face of a laminated article, the presence of any defect in the union between said face and the adjacent lamina, comprising: disposing the laminated article stably in a fluid medium with one face thereof uppermost; disposing finely subdivided material on said face; impinging on the laminae a train of acoustic-pressure waves of a frequency incapable of resonating with the natural period of the defectively united portions of said face; and continuing to impinge said train of waves on said laminae while modulating the frequency thereof to that frequency which resonates with the natural period of the defectively united portions of said face so as to clear said face of said subdivided material in said portions sufficiently to visually indicate the presence of said defectively united portions.

12. The method of determining from one face of an adhesively laminated article the presence of defective adhesive union between said face and the adjacent lamina, comprising: disposing the adhesively laminated article stably in a fluid-medium with the one face uppermost; spreading a layer of granular material loosely on said face; passing through the laminae a train of acoustic-pressure waves incapable of resonating with the natural period of the defectively adhesively united portions of said face; continuing to pass said waves through said laminae while modulating the frequency thereof to that frequency which is in resonance with the natural period of said defectively adhesively united portions of said face so as to clear said face of said granular material in said portions sufficiently to visually indicate the presence of said defectively united portions; and demarcating the general outlines and loca-

tions of the areas on said surface which are cleared of said granular material.

13. The method of determining, from one face of an adhesively laminated article, the presence of defective adhesive union between said face and the adjacent lamina, comprising: disposing the adhesively laminated article stably in a fluid-medium with one face uppermost; spreading a layer of granular material loosely on said face; passing through the laminae a train of acoustic-pressure waves incapable of resonating with the natural period of the defectively adhesively united portions of said face; continuing to pass said waves through said laminae while modulating the frequency thereof to that frequency which is in resonance with the natural period of said defectively adhesively united portions of said face so as to clear said face of said granular material in said portions sufficiently to visually indicate the presence of said defectively united portions; demarcating the general outlines and locations of the areas on said face which are cleared of said granular material; terminating the aforesaid passing of said wave-train; and removing the inspected and marked article from the zone of operations.

14. The method of determining, from one face of a laminated article, the presence of defective union between said face and the adjacent lamina, comprising: disposing the laminated article stably in a horizontal position in a fluid-medium with one face uppermost; disposing a finely-subdivided material on said face; passing through the laminate's lower face and thence through the face lamina supporting said material, a train of acoustic-pressure waves of a frequency incapable of resonating with the natural period of the defectively united portions of said face; and continuing to pass said waves through said laminae while modulating the frequency thereof to that frequency which is in resonance with the natural period of said defectively adhesively united portions of said face so as to clear said face of said granular material in said portions sufficiently to thereby visually indicate the presence of said defectively united portions.

15. The method of inspecting a laminate constructed of a low-density, substantially transversely rigid core adhesively united by a substantially brittle adhesive on its opposite faces to laminae of higher density, less rigid material, comprising: disposing the laminate of the type described in a fluid-medium with one of said less rigid laminae facing upwardly; disposing a finely subdivided material on the upwardly facing lamina; impinging on said lamina a train of acoustic-pressure waves of a frequency incapable of resonating with the natural period of the defectively adhesively connected portions of said upwardly facing lamina; and continuing to impinge said waves on said lamina while modulating the frequency thereof to that frequency which is in resonance with the natural period of said defectively adhesively united portions of said upwardly facing lamina so as to cause said portions to indicate their presence in said subdivided material.

16. A method of determining from one face of an adhesively laminated article the presence and absence of defective union between said face and the adjacent lamina, comprising: disposing the article stably in a fluid-medium with one face lying substantially parallel to gravitational forces; disposing on said face a layer of adhesive-coated granular material adherent thereto sufficiently to resist the force of gravity but insufficiently adherent to resist displacement by a predetermined vibratile condition; passing through said lamina and through said face a train of acoustic-pressure waves incapable of resonating with the natural period of defectively united portions of said face lamina; and continuing to so pass said train while varying the frequency thereof to that frequency which is in resonance with the natural frequency of said portions so as to effect bare-spot indication, in the defectively united portions of said face, of the locations of said defective unions.

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