Jan. 26, 1965 W. A. JACK ETAL 3,167,151

ACOUSTICAL PANEL

Filed June 7, 1962

Fig. 1.

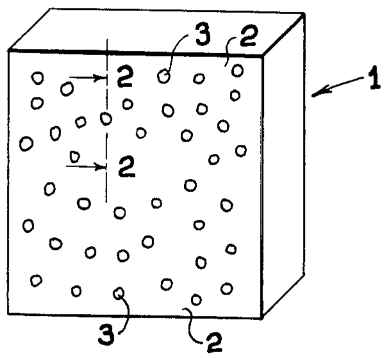


Fig. 2.

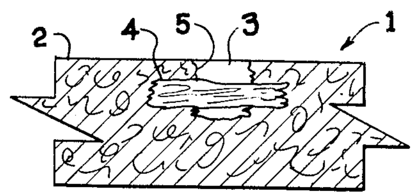


Fig. 4.

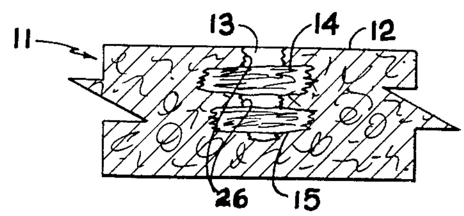


Fig. 3.

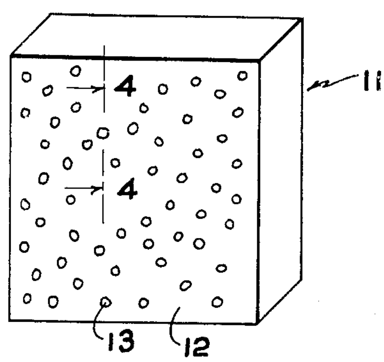


Fig. 5.

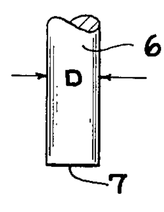
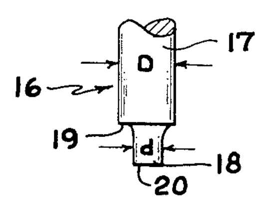


Fig. 6.



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3,167,151
ACOUSTICAL PANEL

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This invention relates to acoustical panels; more specifically, it relates to a method for forming perforations in a surface of an acoustical panel to increase the esthetic effect and the sound absorbing coefficient or sound absorbing efficiency of such a panel.

This application is a continuation-in-part of U.S. patent application Serial No. 780,836, filed December 16, 1958, now abandoned.

It is well known in the art of acoustical panels to form a plurality of perforations in one of the surfaces of a panel, which perforations extend from the surface into the body portion thereof. Such perforations open up the body portion of the panel, which is adapted to be encountered by sound waves, thereby greatly increasing the panel's sound absorbing efficiency or sound absorbing coefficient.

The conventional methods of forming such perforations are either to drill the surface of such a panel or to punch the panel surface with a sharply pointed punch. The perforations are formed either in an irregular pattern or in a regular series of columns and rows.

A novel method of producing such perforations, and the novel panel produced thereby is disclosed in the copending application of William A. Jack and Samuel G. Nelson, Serial No. 87,988, filed February 7, 1961, now abandoned and assigned to the assignee of the present invention. This copending application discloses a method for forming perforations having cavities or marked delaminated areas circumambient such perforations by the use of blunt punches. The present application is an improvement in the formation of such perforations in a surface of an acoustical panel whereby the surface appearance of the perforations is greatly improved and the sizes of the perforations may be increased while maintaining the panel's surface integrity.

An object of this invention is to provide a method of increasing the size of perforations in certain types of acoustical panels using a stepped punch, preferably one having a blunt end, which perforations were, heretofore, difficult to obtain because of the destruction of the surface integrity of the panels during the forming of the perforations.

Another object of this invention is to provide a method of forming neat surface perforations in an acoustical panel while, at the same time producing an acoustical panel having a relatively high coefficient of sound absorption.

In brief, this invention comprises a novel method of forming perforations in an acoustical panel, and the novel acoustical panel formed thereby. According to this method, an acoustical panel surface, adapted to be encountered by sound waves, is perforated by a stepped punch, preferably one with a blunt, pilot end, or a plurality of such punches, to produce a perforation, or a plurality of such perforations, from the surface of the panel into the body portion thereof. Each such perforation formed by the stepped punch in the surface of the acoustical panel is of such a nature that it is of approximately the same cross-sectional area at the surface of the panel as the cross-sectional area of the final diameter of the working portion of the punch. Such perforations formed by the stepped punch present a neater appearance at the panel surface than perforations formed

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by straight-walled blunt punches of the same diameter as the ultimate working diameter of the stepped punch. Also surprisingly, the perforations are also smaller in cross-sectional area at the panel surface than the cross-sectional areas of the perforations formed by a blunt punch without such stepped portion and having the same diameter as the ultimate working diameter of the stepped punch of the present invention.

These and other objects will be readily apparent from the preceding brief description and the following more detailed description and the attached drawings wherein:

FIG. 1 is a perspective view of a perforated acoustical panel having its perforations formed by a straight, cylindrical, blunt end punch;

FIG. 2 is an enlarged cross-sectional view taken along lines 2—2 of FIG. 1;

FIG. 3 is a perspective view of an acoustical panel having its perforations formed according to the present invention;

FIG. 4 is an enlarged cross-sectional view taken along lines 4—4 of FIG. 3;

FIG. 5 is a partial view, in elevation, of a punch used to form the perforations evidenced by FIGS. 1 and 2; and,

FIG. 6 is a partial view, in elevation, of the punch of the present invention used in forming the perforations of the panel of FIGS. 3 and 4.

In the aforesaid copending application of William A. Jack and Samuel G. Nelson, Serial No. 87,988, filed February 7, 1961, a method has been described wherein a unique type of perforation is formed in a fibrous acoustical panel. A panel, formed with these perforations, is shown in FIG. 1 and, as depicted, has a plurality of irregular perforations **3**, in a random pattern, extending from a surface **2** of the fibrous panel **1** into the body portion thereof. If a blunt punch, circular in cross-section, is used to form these perforations, as, for example, the punch **6** having a plunt end **7** shown in FIG. 5, the cross-sectional area of each perforation at the surface **2** of the panel **1** is quite irregular and is much larger in cross-sectional area at the panel surface than the cross-sectional area of the punch used to form such perforations. If such a punch **6** is circular in cross-section, the perforations **3** at the visible surface are not, relatively speaking, also circular. The edges of the perforations at the surface of the panel **1** are quite ragged following no preconceived pattern. The enlargement of the aperture and ragged edge effect results from the fibrous nature of the panel and from the manner that the fibers are interlaced or intertwined. The blunt punch entering the surface of the panel does not sharply shear the main body of fibers adjacent the punch; rather, there is a tendency towards pulling away of the fibers and the creation of compressing shives or clusters of fibers. Some shearing of the fibers, of course, occurs. However, the net result of this punching action is to produce an aperture or perforation having a cross-section at the panel surface noticeably greater in area than the cross-sectional area of the punch, and, because of the pulling away of the fibers, the perforation edges are not cleanly defined but have a somewhat ragged-edge appearance. Within the body portion of the panel, each perforation **3** (FIG. 2) also has a delaminated area or cavity **4** circumambient each such perforation and a ragged wall area **5** forming the wall surface of each perforation.

The preferred embodiment of this invention comprises a panel **11**, similar in nature to the panel **1** described briefly above and in the aforesaid copending application of William A. Jack and Samuel G. Nelson, and which panel has a surface appearance somewhat similar to that of panel **1**, that is to say, a plurality of perforations **13** extend from a surface **12** of the panel **11** into the body portion thereof. However, each such perforation 13 is more circular in cross-section and presents a much neater appearance than the ragged-edge perforations 3 of the panel 1. Referring to FIG. 4, at times the perforations 13 have circumambient thereto pairs of marked delaminated areas or cavities 14, 15. The first is adjacent the surface 12 of each such panel and the second adjacent the bottom of the perforation. The wall surface area 26 is formed of ragged edges, similar in nature to the wall surface area 5 of the acoustical panel 1. This double cavity effect, however, does not occur at all times, even in the same panel. Why it does or does not occur is difficult to determine, since the diameters of the punches are very small. The effect is not produced with rather shallow punching or with relatively thin panels (which results in a situation similar to shallow punching).

The perforations 13 in the surface 12 are formed by pressing a stepped punch 16 (FIG. 6) or a plurality of such punches, from said surface into the body portion of the sheet or panel. The punch is of the stepped type and has a small diameter, cylindrical portion or "pilot" 18, preferably with a blunt end 20, and a larger diameter portion 17 extending from the opposite end. A shoulder or step 19 is formed in the bottom of a cylindrical portion 17 interconnecting the cylindrical walls of the two cylindrical portions. For the purpose of comparison and further description, the diameter D of the larger diameter section or the ultimate working portion 17 has been made equal to the diameter D of punch 6 of FIG. 5.

In forming the perforations in an acoustical panel, the end 20 of punch 16 is pressed into the surface 12 thereby forming an initial perforation according to the diameter *d* of the smaller section 18. As the punch 16 progresses through the panel, a delaminated area or cavity 14 (FIG. 4) is formed in the acoustical panel created by the tearing away of the fibers circumadjacent the punch. As such progression continues, the resistance to further travel of the punch increases to a maximum until a break-through occurs and a second delaminated area 15 is commenced to be created by further movement of the punch. This break-through is very noticeable during the puncturing of the panel, and is marked by a sudden "yielding" of the panel to the action of the punch. This "yielding" is believed to result from the fact that after the break-through, the punch continues perforating as if a new panel were encountered, that is to say, the action and "feel" of continued perforation is approximately the same as perforating initially from the surface 12. The cavity 15 is enlarged until the rear side of the panel is approached or until the panel resistance mounts such that further penetration of the step punch 16 into the body portion of the panel becomes difficult, at which times the aperture 13 is complete, and the punch is withdrawn. During the travel of the stepped punch 16 into the body portion of the panel, the stepped area 19 mates with the surface of the panel 12 and commences to form a surface perforation 13 according to the diameter D of the larger diameter section 17. However, a cavity 14 lies subjacent the surface 12 and the stepped area 19, so that resistance to penetration of the larger diameter section or ultimate working section 17 is very slight. Consequently, the hole is, in effect, dressed, and the formed hole or aperture closely follows the contours of the larger diameter section 17. On further travel of the stepped punch and approximately at the time the second cavity is being formed, the shoulder 19 engages the bottom of the first cavity 14 and forces the bottom of this cavity further away from the surface 12 and tends to enlarge the cavity. Since, at this time, the second cavity 15 is also being formed by the lower end 18 of the punch 16, the backing support for the first cavity 14 is, in part, removed thereby permitting such enlargement of the first cavity. Upon removal of the punch, and after the panel has been mounted to form a wall surface, the interior areas 14 and 15 are not visible, and the ultimate perforation 13 has an appearance similar to a drilled or pierce-punched perforation or opening having a cross-sectional area equal to the cross-sectional area of the larger section 17 of the step punch 16.

As previously noted, the double cavity effect is not always produced. With some panels, the double cavity effect is produced much less often than a modified single cavity effect (FIG. 2). Moreover, the double cavity effect is difficult to obtain when the perforations are purposely made rather shallow due to the limitations of the material. For example, if the thickness of the panel is ½ inch, or thereabouts, the stepped punch perforation is made deep, but the depth of penetration is not very great. With this depth, a perforation made in thicker boards would be considered shallow. As a result, the double cavity effect is difficult to obtain in such thin, ½ inch thick panels. Nevertheless, the sound absorption of the panels having perforations formed by stepped punches, even where the double cavity effect is not apparent approximates closely the sound absorption of the panels having perforations formed by straight-walled punches. Why this is so is not clear, as it would appear that the sound absorption of the latter panels should be much greater, since the straight-walled punch at its lead extremity is of much greater diameter than the extremity of the stepped punch (with punches of the same ultimate working diameters). One would suspect that the holes formed would be larger, the cavities larger, and, resultantly, the sound absorption greater. Yet, paradoxically, the perforations formed by stepped punches show approximately the same sound absorbing characteristics. One of the factors which might tend to equalize sound absorption is the fact that the bottoms of the perforations formed by stepped punches are believed to have less tendency to "spring back" than the bottoms of the perforations formed by straight-walled, blunt punches. The bottoms of the perforations, formed either by straight-walled or step punches, are compressed to some degree. In the perforation of FIG. 2, for example, the bottom of the perforation has a tendency to "spring back" or to relieve the compression, which may in turn, tend to cause the cavity 4 to decrease in the degree of openness. In the perforation formed by a stepped punch, it appears that the pilot end of the punch tends to pin down or tack the material at the bottom of the perforation. Such action tends to reduce the amount of "spring back" effect, thereby tending to maintain the size of the cavity formed.

To create a commercially acceptable panel, ordinarily a small diametered blunt punch must be used, since, with the larger diametered punches, almost complete destruction of the surface and interior of the panel occurs. Thus with the larger diametered punches of FIG. 5, it is oftentimes difficult to maintain the integrity of the panel.

The maximum size of straight punch for the creation of a commercially acceptable panel will vary with the type of panel used, i.e., organic or inorganic, the density of the panel, the thickness, the method of manufacture, the standards of manufacture, the esthetic effects desired to be produced, etc. With the use of the preferred embodiment of the present invention, these various factors do not present such an imposing obstacle, as the pilot diameter *d* is appreciably less than the diameter D of the final working portion 17 of the punch 16, and, ordinarily, well within the range of satisfactory smaller diameter sizes of punhces.

While the perforations 3 of FIG. 1 are somewhat exaggerated in size relative to the perforations 13 of FIG. 3, there is a marked difference between these perforations and the perforations 13 formed according to the preferred embodiment of the present invention. As noted, the perforations 13 have a general appearance as if they were formed by sharply pointed punches or by drills. In contrast to this, the perforations **3** have a surface cross-sectional area formed of ragged edges and, quite noticeably, are much larger in average diameter or in average surface cross-sectional area than the perforations **13**.

Although circular punches **6** and **16** and circular perforations **3** and **13** have been described herein, it is to be understood that the particular cross-section of the punches and the cross-section of the perforations formed may be altered to fit particular design requirements.

The particular stepped punch used had a diameter $D=.08''$ and a diameter $d=.055''$, or roughly the ratio of the two diameters was 0.7. Obviously, these ratios may be altered to fit particular requirements and to produce various acoustical design or esthetic effects. Likewise, these ratios may be altered to fit the particular density or construction of the acoustical panels. The height of the lesser diameter section **18** was $\frac{3}{16}''$; however, this height also may be altered depending upon the density, thickness, and the particular construction of the acoustical panels.

One of the striking advantages of the method of the preferred embodiment of the present invention in forming apertures having delaminated areas is that blunt punches of greater diameter may be used, which, of course, will produce relatively large apertures in a panel surface. If the punch of FIG. 5 were to be enlarged greatly, say to $\frac{3}{16}''$, and if the panel to be perforated were of the wood fiber type, such a blunt punch would produce a tearing of the fibers to such an extent that a large area adjacent the punch would be completely broken up. Even if such a large aperture were to be formed, such a large delamination would be produced that the portion above the delamination adjacent the panel surface would be readily crushed or depressed upon application of the slightest pressure. This phenomenon does not occur with the stepped punches. The ultimate working diameter D of the upper section **17** may be approximately $\frac{3}{16}''$, but the delamination formed by diameter *d* of the lower section **18**, then will, in all probability, be considerably less than $\frac{3}{16}''$. The appropriate pilot diameter would be selected which would produce the desired cavity effect without the destruction of the interior portion of the panel aforementioned and which would present an aperture for the larger diametered section suitable for dressing. With a ratio of 0.5 or 0.7, the range of pilot diameters would roughly be between 0.09 and 0.13, which diameters are considered to be more on the smaller side than on the larger side.

The particular types of panels to which this present invention is applicable have been described in the aforementioned copending application. Briefly, such panels

generally are of the organic or cellulosic type, as, for example, panels made of wood fiber, vegetable fiber, bagasse, etc., or fibrous type panels, both of the inorganic and organic, made according to the "wet process" method of forming such panels. The "wet process" is well-known in the art and follows generally a papermaking process. Basically, the process comprises the mixing of fibers, as, for example, wood fibers, with a suitable binder and water. The solids content in this mixture is very low, being about 2–3%. The solids are picked up or deposited on a vacuum machine and transferred therefrom to a conveyor belt. The conveyed material is pressed into a desired thickness and cut into the desired shapes. Ordinarily, the material is also cooked or baked to evaporate the residue moisture contained therein.

The present invention is particularly adapted to the organic or cellulosic class of acoustical panels, exemplified by wood fiber boards, of densities between 8–20 lb./cu. ft., as such panels have fibers formed therein which are tough, not readily friable, and markedly resistant to the pressing action of straight, blunt punches (FIG. 5).

Having thus described our invention in rather full detail, it will be understood that the details are given for the purpose of illustration, not restriction, and that variations within the spirit of the invention are intended to be included within the scope of the appended claim.

What we claim is:

A method of opening up the surface and body of a fibrous acoustical panel of the water-laid type, said surface being fibrous and relatively planar, comprising the steps of pressing a stepped punch, having a pilot blunt portion and at least one shoulder along the length thereof, into said surface to a depth sufficient to create a delaminated area within the body portion of the panel, and continuing pressure on the punch until the larger diametered portion thereof, including the shoulder, enters the surface of the panel.

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