May 25, 1937. T. M. PRUDDEN 2,081,765

ACOUSTICAL STRUCTURE

Filed May 21, 1935 2 Sheets-Sheet 1

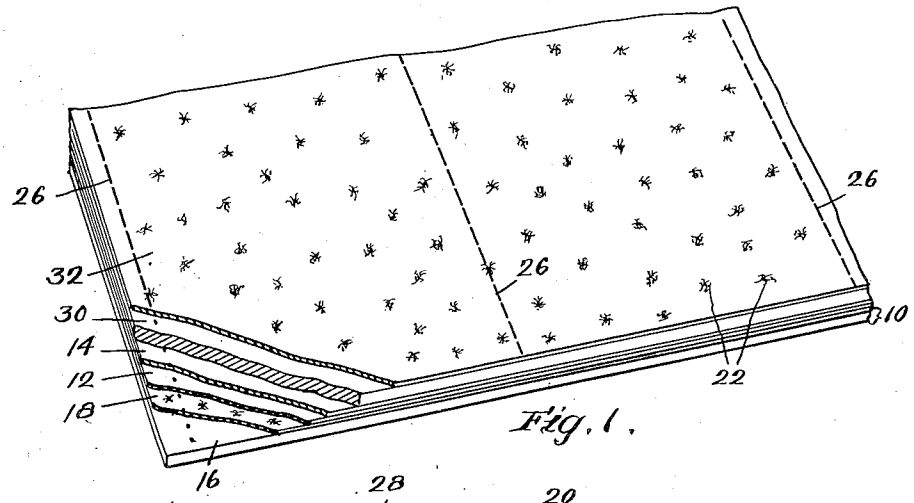

Fig. 1.

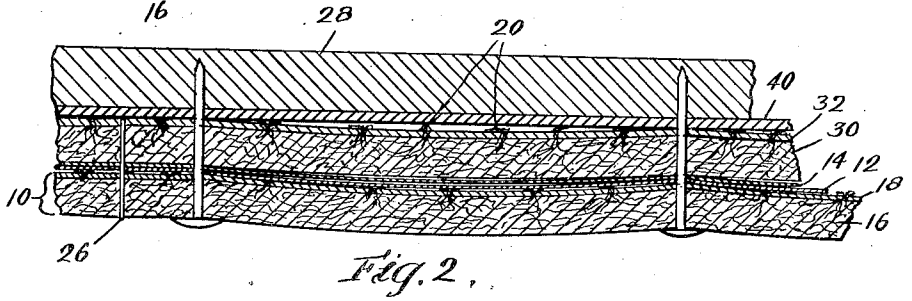

Fig. 2.

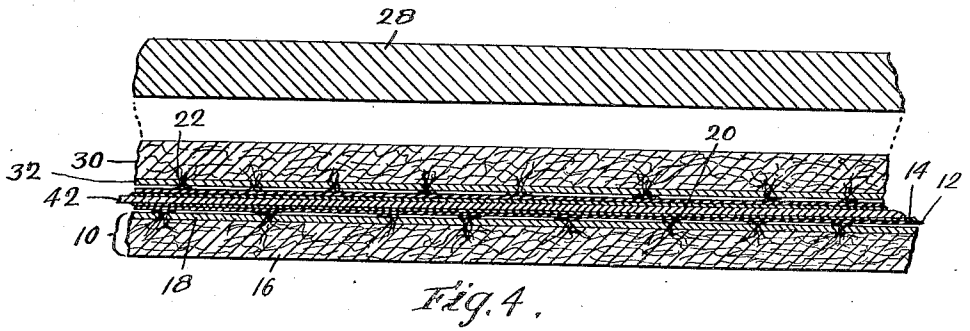

Fig. 4.

Inventor.
Theodore M. Prudden
by
Fraser atty

May 25, 1937. T. M. PRUDDEN 2,081,765

ACOUSTICAL STRUCTURE

Filed May 21, 1935 2 Sheets-Sheet 2

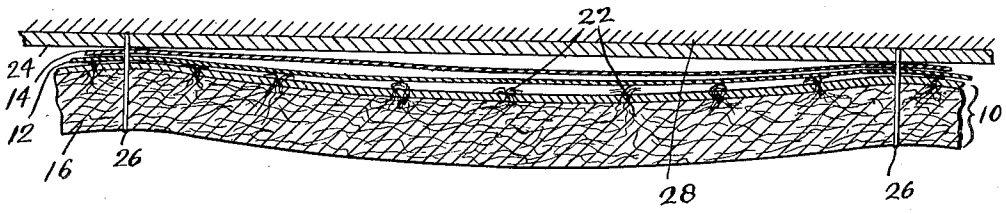

Fig. 3.

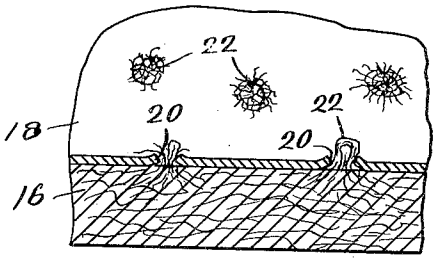

Fig. 6.

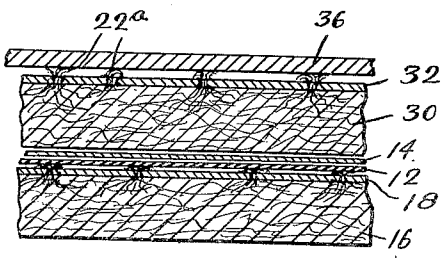

Fig. 5.

Inventor,
Theodore M. Prudden
by
T. J. Greenwood
atty

Patented May 25, 1937 2,081,765

UNITED STATES PATENT OFFICE

2,081,765

ACOUSTICAL STRUCTURE

Theodore M. Prudden, Hingham Center, Mass.

Application May 21, 1935, Serial No. 22,586

13 Claims. (Cl. 154—44)

This invention relates to acoustical or sound absorbing and insulating material adapted to be applied in confronting relation with the inner surface of the wall of a room to absorb sound present in the room and preferably also to insulate the room from the transmission of sound through the wall.

The invention is particularly applicable to closed automobile bodies to quiet the interior of the body against noises incident to the operation of the automobile.

One of the objects of the present invention is an acoustical material that is characterized by being effective to absorb sound and at the same time is cheap.

A further object of the invention is the provision of an acoustical material that is flexible so that it can readily be conformed and applied to the curved wall of an automobile top or side.

Another object is the provision of an improved acoustical structure characterized by having an outer surface of such nature that it reflects as little sound as practicable and is relatively sound permeable so that sound can pass readily into the interior of the structure, the inner construction of the structure being such that sound that passes therein is absorbed preferably by vibratory sheets resonant to the sound.

A specific object of the invention is a sound absorbing structure formed of an open porous outer sheet of loosely arranged or felted fibres, and particularly jute fibres, needled onto a kraft supporting sheet and disposed closely in front of resonant sheets preferably of tissue paper and glassine, all sheets being loosely attached together at relatively widely spaced intervals.

A yet further object is the combination of the structure above described with a second fibre sheet needled onto a supporting kraft sheet disposed behind the paper sheets, the supporting and paper sheets preferably having different weights so that they are resonant to different sound frequencies.

Another object is the duplication of either one of the structures above described on opposite sides of and carried by a supporting and relatively non-vibratory panel wherein both structures are exposed to sound, thereby increasing the surface area of the structures exposed to the sound and improving the effectiveness of the material.

A further object is generally to improve the construction and effectiveness of acoustical materials.

Fig. 1 is a perspective view of a portion of the acoustical material embodying the present invention, a portion of the material being broken away to illustrate the various layers thereof.

Fig. 2 is an enlarged sectional detail of the structure of Fig. 1 attached to a supporting wall which may, for instance, be a roof of an automobile.

Fig. 3 is an enlarged section illustrating the use of a part only of the total layers of material of Fig. 1.

Fig. 4 is a view similar to Fig. 2 but illustrating a modified construction of the acoustical material wherein similar layers of sound permeable material are disposed on opposite sides of a relatively sound impenetrable sheet.

Fig. 5 is a sectional detail illustrating a modified arrangement wherein the innermost fibre sheet of Fig. 2 is secured to the supporting surface by the fibre tufts.

Fig. 6 is a sectional detail illustrating the manner in which the needling process secures the fibre and paper sheets together.

The acoustical material embodying the present invention is a flexible mat or blanket that can be attached to any suitable surface and conformed with the configuration thereof. The acoustical material comprises an outermost sheet **10** that is as little sound reflecting as practicable and is relatively sound permeable, and inner sheets **12** and **14** that are resonant to the sound and are capable of vibrating, the resonant sheets, however, being so arranged that the vibrations are damped to absorb the energy of vibration and thereby to absorb the sound.

The outermost sheet **10** preferably comprises a relatively thick layer **16**, say one-fourth inch in thickness, of loosely arranged or felted fibres, and particularly jute fibres which form an open or readily sound permeable sheet readily penetrated by the sound impinging thereagainst and reflecting very little sound from the surface.

The jute fibre sheet is carried by a supporting or backing sheet **18** of paper, preferably a kraft sheet, and is attached to said sheet by a needling process wherein needles are driven through the fibre and paper sheets at suitably spaced intervals, say one-half inch or so apart, thereby perforating or breaking through the supporting sheet **16** as at **20**, see especially Fig. 6, and forcing fibres through the perforations to overlie and outstand from the back face of the supporting sheet in the form of nubs **22**. These nubs anchor the fibre and paper sheets together like a rivet and the perforations render the paper sheet sound permeable to a considerable degree.

The resonant sheet **12** confronts the back or nubbed face of the supporting sheet **18** and preferably is a glassine sheet.

The glassine sheet is lighter than the combined fibre and supporting sheets.

The resonant sheet **14** that confronts the glassine sheet **12** is lighter than the glassine sheet and preferably is a ten ounce tissue sheet.

The weights and characteristics of the several sheets **18**, **12** and **14** are suitably chosen for the particular sounds to be absorbed, and will be varied to function best for different specific conditions. For use in the interior of automobile bodies good results are obtained when the supporting sheet **18** is a twenty-five pound kraft sheet although a lighter weight sheet could be used if it were not deficient in mechanical strength after being needled. The sheet **14** is a ten ounce tissue sheet.

The structure comprising the several sheets as above described can be mounted upon a wall as illustrated in Fig. 3 and is effective to absorb sound. In using the structure a backing sheet **24** is disposed behind the tissue sheet **14**. All sheets are loosely connected together at relatively spaced intervals of, say, eight inches, more or less, by suitable means as the lines of stitching **26**, the stitching loops being loose so that the various sheets are not drawn tightly together.

The backing sheet **24** preferably is a heavy relatively sound impenetrable sheet, as compared with the other paper sheets of the structure and may be a ninety pound kraft sheet. The backing sheet is attached to all underlying portions of the face of a wall **28** by glue or other means. With this arrangement, where the wall is the ceiling of a room or the roof of an automobile body, all the other sheets hang draped from the lines of stitching as illustrated in Fig. 3. The sheets **12** and **14** are to some extent in loose contact with each other and to some extent hang free from contact with each other. The fibre sheet hangs below the other sheets and some of the nubs **22** that project rearwardly from the backing sheet can loosely engage the face of the draped glassine sheet.

With this arrangement sound readily penetrates the fibre sheet and causes the sheets **12** and **14** to vibrate resonantly, their vibrations being suitably dampened by their internal friction and frictional contact with one another so that the sound is absorbed. While the sheets **12** and **14** are relatively imporous and hence relatively sound impermeable as compared with the fibre sheet and its perforated supporting sheet, the sound impinging thereupon causes them to vibrate resonantly and absorb a certain amount or part of the sound and transmit another part of the sound. The sound transmitted by the innermost tissue sheet is largely reflected by the backing sheet and is acted upon and largely absorbed by the resonant sheets.

The fibre sheet and its supporting sheet are also resonant and can vibrate and thus absorb sound; the fibre loading the supporting sheet so that it is resonant to relatively low frequencies as compared with the glassine and tissue sheets.

It will be noted that the sheets are arranged in the structure in the order of their weights, the lighest weight sheet, which is resonant to the highest frequencies being innermost, this arrangement being found most effective.

The effectiveness of the structure above described and as illustrated in Fig. 3 can be considerably improved by adding to it a second layer or sheet of jute fibre **30** needled to a supporting sheet **32**, preferably a kraft paper sheet, that is heavier than the first supporting sheet **18** as, for instance, a seventy pound kraft sheet. The second fiber layer is disposed as illustrated in Figs. 1 and 2, with the fibre face confronting the tissue sheet and all sheets loosely connected together as before by stitching **34**. The sound absorbing efficiency of this construction, while not double that of the structure of Fig. 3, is sufficiently increased thereover to warrant the use of the second fibre layer and for many purposes is the preferred structure.

The structure of Figs. 1 and 2 can be glued directly to the face of a supporting wall **36** as illustrated in Fig. 5. In this case glue may be applied to the wall and the absorbing structure applied thereto so that the fibre nubs **22***a* alone are attached to the glue, the supporting sheet **32** being spaced from the wall by the nubs. This construction permits the supporting sheet to vibrate in response to the sound by the yielding character of the nubs.

When the wall construction or the nature of the installation is such that it is not desirable to employ this method of attachment, the structure can be attached to the wall by large headed tacks **38**, as in Fig. 2, the tacks being preferably relatively widely spaced so that the sheets of the structure hang downwardly or are draped between the tacks in the manner explained in connection with Fig. 3. With such installation it is sometimes desirable for mechanical reasons to interpose a backing sheet **40** between the structure and the wall and to stitch the structure to the backing sheet. The backing sheet can be a ninety pound kraft paper sheet.

It will be understood that where the sound absorbing structure is applied to a vertical wall, the various sheets of the structure will not hang draped as in Figs. 2 and 3 but will, nevertheless, be loose and free to act as described.

For increased efficiency without the use of additional fibrous material, the two fibre sheets may be arranged on opposite sides of a heavy supporting sheet or plate **42** located in front of the wall **28** as in Fig. 4 disposing the structure so that the sound has access to both fibre faces in any suitable manner as around the edges of the supporting sheet. By placing the fibre sheets on opposite sides of the supporting sheet **42** so that sound reaches the back fibre sheet from the back of the sheet **42** the combined efficiency of the two sheets is double that of a single sheet and much larger than that of two fibre sheets placed together. The efficiency is still further improved if glassine and tissure sheets **12** and **14** are associated with both fibre sheets in the manner heretofore explained.

The kraft backing sheet of Fig. 3 and also the supporting sheet of Fig. 5 that confronts the wall is largely sound reflecting and reflects back to the wall sound that tends to penetrate the structure or panel from the wall side, thereby insulating the enclosure from entrance of sound through the wall.

The sound absorbing structure as herein described is particularly adapted for the absorption of sound incident to the operation of an automobile, which sound in the main has a range in frequency of from 128 to 1024 cycles per second, to which frequencies the sheets of the construction are vibratorily responsive.

I claim:

1. A flexible sound absorbing blanket comprising a stack of resonant paper sheets of different weights, the outermost sheet carrying a layer of loosely arranged fibres that provide a surface of low sound reflecting property, and means loosely connecting said sheets together at spaced intervals only.

2. A sound absorbing structure comprising a series of loosely positioned vibratorily responsive sheets, the outer sheet carrying a layer of loosely arranged fibres.

3. A sound absorbing structure comprising a series of loosely positioned vibratorily responsive sheets, the outer sheet carrying a layer of loosely arranged fibres on its outer face only, the fibre layer being attached at spaced intervals to its associated sheet.

4. A sound absorbing structure comprising a series of loosely-positioned vibratorily responsive sheets, the outer sheet carrying a layer of loosely arranged fibres on its outer face only some of which fibres extend through the sheet.

5. A sound absorbing structure comprising a series of vibratorily responsive sheets, the outer sheet carrying on its outer face a layer of loosely arranged fibres, said outer sheet being broken through at intervals and fibres of said layer being forced through broken parts of said outer sheet thereby securing said sheet and layer together, and means loosely connecting said sheets only at widely spaced intervals.

6. A sound absorbing panel comprising a paper sheet having a layer of loosely arranged fibres on its outer face and needled to the sheet, a second sheet behind said paper sheet, a tissue paper sheet associated with said second sheet, and means connecting said sheets loosely together only at relatively wide intervals.

7. A sound absorbing panel comprising a pair of paper-backed sheets of loosely arranged fibres needled to the backing sheets, loose resonant paper sheets interposed between the fibre face of one and the backing sheet of the other of said pair of sheets, and means loosely connecting said sheets at spaced intervals.

8. A sound absorbing panel adapted to overlie and be secured to a wall, said panel having spaced flexible panel-supporting nubs that are adapted to confront and be secured to said wall, said nubs constituting the sole attaching means for said panel.

9. A sound absorbing panel adapted to overlie and be secured to a wall, said panel comprising in part a rearmost paper sheet having a sheet of loosely arranged fibres needled thereto so that fibres project through said paper sheet at intervals, said projecting fibres constituting the sole means for attaching the panel to said wall.

10. A sound absorbing construction comprising a series of paper sheets, the outermost sheet having a layer of loosely arranged fibres thereon, the sheets being of such weight as to be vibratorily responsive to sounds within the frequencies of 128 to 1024 cycles per second.

11. A sound absorbing structure comprising an outer sheet characterized by being readily sound permeable and by reflecting little sound, and adjacent relatively sound impermeable sheets of such weight and elasticity as to be resonant to sound between the frequencies of 128 to 1024 cycles per second.

12. A sound absorbing panel comprising a paper sheet, a layer of loosely arranged fibres carried by and disposed on the outer face of said sheet, associated relatively light and heavy paper sheets disposed immediately behind said first paper sheet and confronting the fibre free face of said first sheet, and means connecting said sheets loosely together at relatively wide intervals.

13. A sound absorbing panel comprising a pair of paper-backed sheets of loosely arranged fibres, resonant paper sheets interposed between the fibre face of one and the fibre-free face of the backing sheet of the other of said pair of fibre sheets, and means loosely connecting all sheets at spaced intervals.

THEODORE M. PRUDDEN.