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H. J. SABINE

2,966,954

ACOUSTICAL CORRECTION ELEMENT

Filed July 11, 1957

Fig. 2.

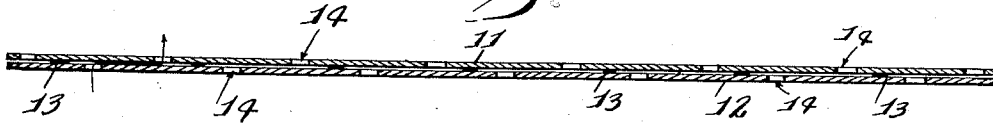


Fig. 1.

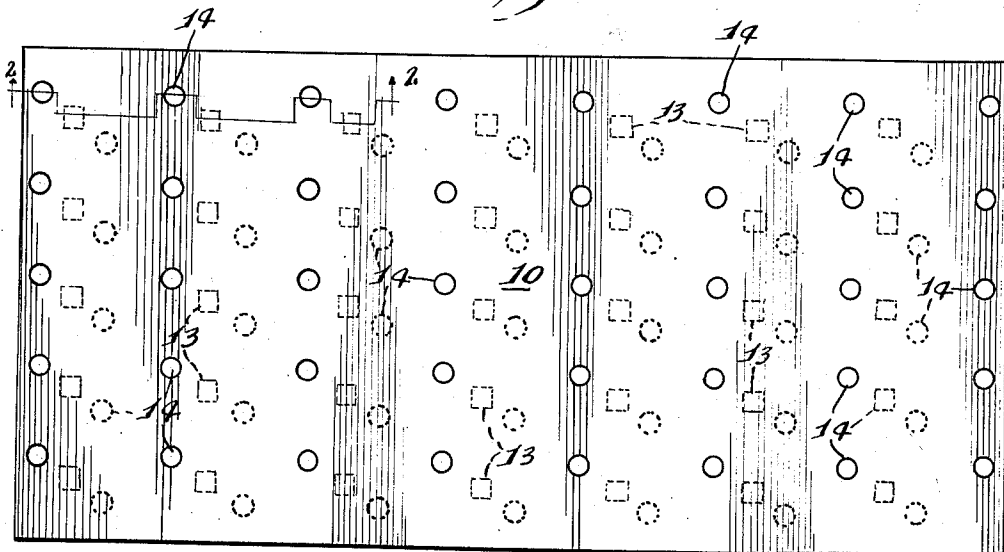


Fig. 3.

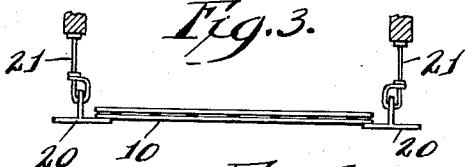


Fig. 4.

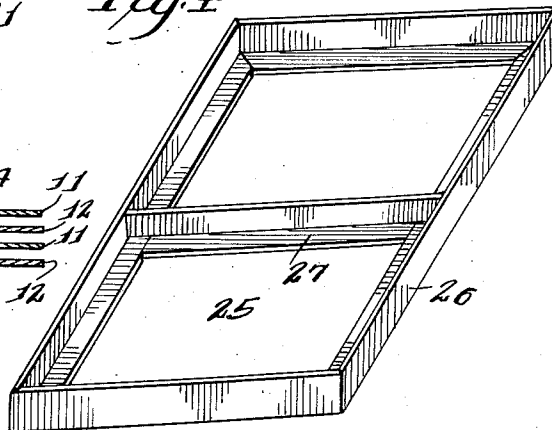


Fig. 5.

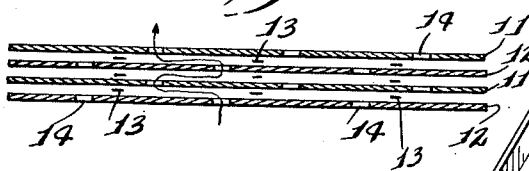
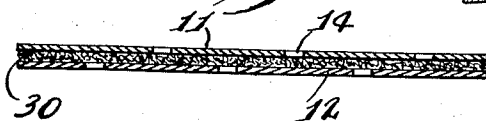


Fig. 6.



Inventor.
Hale J. Sabine.
By. *Edw. A. Hampton*
Attorney.

1

2,966,954

ACOUSTICAL CORRECTION ELEMENT

Hale J. Sabine, Glen Ellyn, Ill., assignor to The Celotex Corporation, Chicago, Ill., a corporation of Delaware

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6 Claims. (Cl. 181—33)

This invention is with respect to an acoustical correction element which is susceptible to utilization in various manners; that is, it is a basic sound absorbing element which may be formed to various shapes or incorporated in various constructions, and in such respect is a most versatile sound absorbing material.

Basically, the sound absorbing product hereof is an assembly, that is, it is comprised of several parts which are assembled in operative relation, in connection with which many acoustically similar but structurally different combinations may be effected.

The base element of the combination hereof is a perforated sheet material which should have sufficient stiffness to constitute substantially a plane surface when supported at points spaced about one-half inch apart. The average office letter paper would satisfy such requirement. The stiffness of the sheet, or, conversely, the spacing of supports relative to the stiffness, may be varied over a great range in connection with the utilization of the invention hereof. A vinyl resin sheet 0.015 inch thick is sufficiently thick when supported at points spaced about two inches apart. If the perforated sheet is the average one-eighth inch hardboard such will have sufficient stiffness if supported on points spaced about six to eight inches apart, and if such sheet is a one-quarter inch asbestos-cement board, such would have sufficient stiffness if supported on points spaced around twelve inches apart. Actually, the stiffness of such sheet is not too critical in that within substantially any limits such sheet, in connection with its utilization in the invention hereof, may be supported at points spaced such as to offset the lack of stiffness of the sheet.

The element or unit hereof constitutes two sheets of material each of which is perforated with a pattern of openings extending through the sheet, the two sheets mounted together in spaced relation with the perforations of the sheets in staggered relation so that the perforations in the composited element are not through perforations but, as will be seen, constitute the ends of a tortuous path through the composited element. These sheets, as referred to, are assembled in spaced relation, which relationship may be within the limits which will be hereinafter explained and described as constituting an almost endless variety thereof.

The composited element hereof, in accordance with the foregoing, is available for mounting in any convenient or desired manner in a room or elsewhere where sound is to be absorbed adjacent a ceiling or wall, or otherwise, the only limitation with respect thereto being that for sufficient sound absorption the element should be spaced at least two inches from the surface with respect to which it is mounted, which spacing preferably should be, for the most efficient absorption of sound, about eight to ten inches, at which spacing the efficiency in absorbing sound flattens out so that there is no appreciable advantage in greater spacing.

The particular object of this invention is to provide a new and novel sound absorbing element. Other objects

2

hereof are to provide such sound absorbing element which has relatively high efficiency in absorbing sound, is simple in construction, may be of light weight, may be translucent or substantially transparent and which, in its field, may be produced at a relatively low price, and finally, an element which is adaptable to many and various forms of use.

In the accompanying drawings the invention is illustrated, largely diagrammatically, as follows:

Figure 1 is a plan view of a portion of an element;

Figure 2 is an edge elevation taken on line 2—2 of Figure 1;

Figure 3 is a diagrammatic view of a manner of mounting the element;

Figure 4 is a perspective view of a different manner of mounting the element;

Figure 5 is a diagrammatic view of a modified form of the element; and Figure 6 is a schematic view of a further modified form of the element.

The base sheet comprising the element hereof may be almost any sheet material which, when composited, as will be described, will result in an element or unit which has the sufficient stiffness to serve as a satisfactory wall or ceiling surface, or the like, in accordance with the manner in which such unit is to be installed.

A preferred construction, for the purposes of description hereof, is one wherein the composited sheet materials are ordinary commercial vinyl resin sheets 0.015 inch thick, which sheets may be transparent or translucent, integrally colored as desired, or may be opaque sheets, depending upon the effect desired for the finished assembled unit. The composited or assembled element comprises two such sheets as have just been described and which in Figure 2 are identified by numerals 11 and 12. Each of these sheets is provided with a pattern of perforations, in the drawing, for the purposes of description, comprising a regular pattern of perforations $\frac{3}{16}$ -inch in diameter spaced one-half inch on the centers which will constitute approximately 11% open area. Perforations of other size, spacing and pattern may be utilized, as, for example, a regular pattern of perforations $\frac{3}{32}$ inch in diameter spaced one-fourth inch center to center. Perforations need not be circular; they may be of equivalent area or substantially equivalent area, either square, triangular, oval, or the like.

So far as is known at present, perforations having an area of the order of that of $\frac{3}{16}$ inch diameter, perforations and spacing in the order of one-half inch on centers to provide approximately 11% open area is the most efficient in absorbing sound, but it will be readily apparent to those skilled in the art of sound absorption or acoustical correction that specific area of the perforations and spacing is not critical, since a loss in absorbing efficiency due to variation of the area of the perforation may be offset by suitable spacing of the perforations and/or by variation of the number of perforations with resultant variation in the total open area in any given surface area.

In forming the composited product, sheets 11 and 12 are assembled in spaced relation by the inter-position of spacers 13 which may be provided in many forms. The spacing between sheets 11 and 12 is of the order of 0.005 inch.

For the purpose of illustration and description, the spacers 13 are assumed to be thin and small elements of thermoplastic material whereby, when the sheets are assembled, by suitable application of heat and controlled pressure the sheets 11 and 12 may be adhered in definite spaced relation. It will, of course, be understood that the required spacing of sheets 11 and 12 can conceivably be obtained by suitable roughening of the opposing surfaces of sheets 11 and 12, preferably as by a slight embossment which will maintain the re-

quired spacing but in connection with which, however, it must be understood that the contacting and adhering portions must be limited to such areas so that the required spacing between the contiguous faces is substantially an open space through which sound waves may travel. It would be possible to dimple one of the sheets at spaced points and then heat-bond the two sheets with controlled spot heaters so that they would be adhered or welded at spaced points with the required spacing between the contiguous faces of the sheets. Various other procedures for suitably compositing the sheets will be readily apparent to those skilled in the applicable arts.

In assembling sheets 11 and 12, as above referred to, it is to be understood that the perforations in the sheets are to be positioned in offset relation so that there is no direct through passage through the composited sheets but, however, that due to the controlled spacing between the sheets there is provided a tortuous passage for sound waves through the perforations in one sheet, then through the space between the adjacent faces of the sheets, and finally through the perforations of the other sheet.

The unit as above described, it will be readily understood, instead of being composited of vinyl resin sheets, as described, may even be of paper, although such should be a fairly stiff paper, such as cardboard, or may be hardboard, wood, plywood, aluminum, asbestos-cement, and so on.

Since the thickness of the sheets has but relatively little effect on the absorption, sheets 11 and 12 may be of substantially any practical thickness, say, from about one-thousandth of an inch to one-quarter inch, although, since in general light weight is of importance in connection with such elements, it is preferable that the composited product be comprised of relatively thin and light weight sheet material.

Elements such as have been described may be made in more or less any appropriate size or may be made in large sheets and cut to size, as is desired. Finished elements of desired size may be mounted on inverted T runners 20, such as illustrated in Figure 3, being supported on oppositely directed flanges of adjacent runner members, and such runner members 20 may be suitably supported as by supporting members 21 which are suitably connected to elements of a structure.

An alternative method of mounting the sound absorbing elements of desired size is to mount them in a suitable frame, such as 25, which comprises connected angle members 26, one leg of which is arranged horizontally and the other vertically as a closed element, which may be provided with cross reinforcing and stiffening members 27 and which, when assembled together with the sound absorbing element, may constitute units for suitable installation in spaced relation to the surface from which they are to be supported. Due to the lightness of the preferred form of the invention, as particularly described herein, a supporting frame, such as 25, may be comprised of very light weight plastic or aluminum members so that an entire and completely assembled element, frame 25 and unit 10, is of very light weight. Assuming angles 26 of frame 25 to be of a thermoplastic resin material, then elements 10 may be heat-sealed or welded to the under sides of the horizontal flanges thereof with the consequence that the supporting framework will not show and a smooth unbroken ceiling may be provided.

The inventions hereof are not limited to a two-sheet element, and it will be obvious that, if desired, the inventions as hereof described, may be incorporated in a three or four or more sheet element, as is diagrammatically illustrated in Figure 5.

As an alternative to providing a rigid spacing between sheets 11 and 12 when compositing them as an element, such may be composited by the inter-position of a very porous sheet material to which face sheets 11 and 12 may be suitably mounted. Such construction is illus-

trated in Figure 6, wherein sheets 11 and 12 are composited together with a very porous spacing sheet 30.

Representative suitable spacing sheet 30 is a porous sheet material such as Dexter filter paper, a 10-pound basis sheet which, from its appearance, is an air-laid fiber sheet resin-bonded to provide wet strength. This paper is approximately .002-inch thick and has an air porosity of approximately 75, such air porosity being the cubic feet of air which will pass through one square foot of the sheet per minute at 0.5 inch water pressure. An alternative spacing sheet 30 is an Owens-Corning glass-fiber sheet which is apparently an air-laid glass fiber sheet bonded with a suitable resin and which is 0.026-inch thick and has a weight of 0.0405 gram per square inch. This spacing sheet 30 must be of sufficient porosity that sound waves will relatively, freely, travel therethrough, and while representative such sheets have just above been described, it will, of course, be understood that other generally similar sheet materials may be employed provided they have internal inter-connected porosity and are of such construction as to have air porosity of the order of that above referred to but with permissible variation of air porosity of between approximately 50 to 150.

It will be understood, of course, that a composited product of a construction as illustrated in Figure 6 may have facing sheets 11 and 12 similar to the facing sheets described in connection with Figures 1 and 2, and that such product may be erected or applied in substantially the same manner as is the product illustrated in those figures.

The inventions hereof having been disclosed in detail, I claim:

1. An acoustical correction element comprising spaced sheets, each sheet thereof perforated with a generally like pattern of perforations in substantially regular arrangement and spacing, the area of such perforations of the order of that of $\frac{3}{32}$ to $\frac{1}{16}$ " diameter circles, the arrangement and spacing of the perforations providing passages through the sheet of the order of 11% of the area thereof substantially uniformly dispersed over the sheet, means spacing the sheets a distance not more than about 0.005" and securing the sheets in assembled relation with the perforations of one of the sheets offset substantially medially relative the perforations of another sheet.

2. An acoustical correction element comprising spaced sheets and means securing the sheets in spaced assembled relation, each such sheet having a generally like pattern of perforations the total area of which is of the order of about 11% of the effective area of the sheet, the center to center spacing of the perforations of the order of between about $\frac{1}{4}$ to $\frac{1}{2}$ " and in substantially regular arrangement, the means securing the sheets in spaced assembled relation being of limited area allowing relatively free fluid flow passage between the sheets spaced thereby, spacing the sheets approximately 0.005-inch and securing the sheets in offset relation whereby substantially all of fluid flowing through two adjacent such assembled sheets must follow a tortuous pattern.

3. A sound absorbing element comprising at least two sheets of material, each sheet having a substantially uniformly dispersed overall pattern of perforations extending therethrough and means securing the sheets in spaced assembled relation, spaced in the order of 0.005-inch and with perforations of one of the sheets displaced with respect to perforations of the other sheet by about one-half the spacing of the perforations of a sheet whereby there are provided tortuous passages extending from one outer face to the other outer face of the composite.

4. A light transmitting sound absorbing element comprising an assembly of sheets of light transmitting material of a thickness of between about 0.01 inch and 0.1 inch and means spacing assembled sheets thereof about 0.005 inch, each said sheet perforated with a substantial-

5

ly regular pattern of perforations of an area substantially equal to the area of circles of about $\frac{3}{32}$ to $\frac{3}{16}$ " in diameter and comprising about 11% of the active area of the sheet, the sheets comprising the composited element positioned whereby the perforations of one sheet are offset substantially medially relative the perforations of an adjacent sheet providing substantially "Z" shape passages from the outer face of one sheet to the outer face of an adjacent composited sheet.

5. A sound absorbing structure comprising a wall surface and sound absorbing elements mounted relative thereto, spaced therefrom by in excess of about two inches, the sound absorbing elements comprising sheet material assembled with spacing means whereby the average spacing of contiguous faces is of the order of 0.005 inch, each sheet perforated with openings having an area of the order of the area of circles of between about $\frac{3}{32}$ to $\frac{3}{16}$ " diameter in substantially uniform pattern comprising about 11% open area, perforations of one sheet offset substantially medially relative the perforations of an adjacent sheet, a mounting means comprising spaced supporting members receiving and supporting opposite edges of the sound absorbing elements.

6. A sound absorbing element comprising spaced

6

sheets of a thickness of about 0.001 to 0.25 inch, each perforated by a substantially regular pattern of perforations providing about 11% open area, the sheets mounted with the perforations thereof substantially out of register and with spacers therebetween, spacing their contiguous faces by not in excess of 0.005 inch.

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