April 20, 1937. J. PAGE ET AL 2,078,207

SOUND INSULATING CONSTRUCTION

Filed July 26, 1933 2 Sheets-Sheet 1

Fig. 1

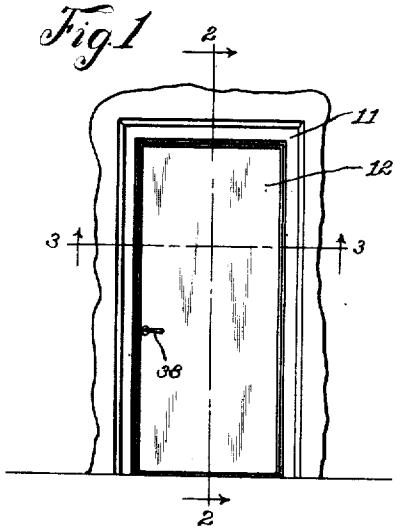


Fig. 2

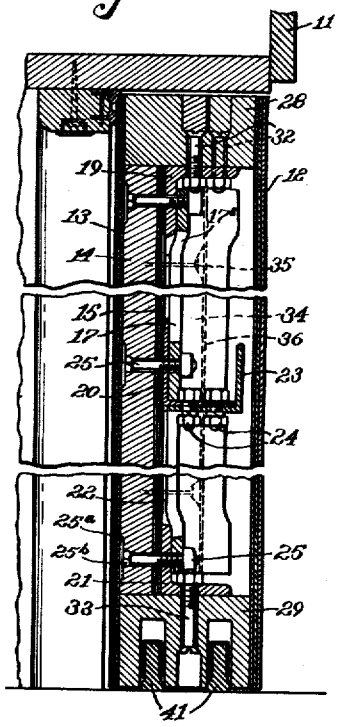
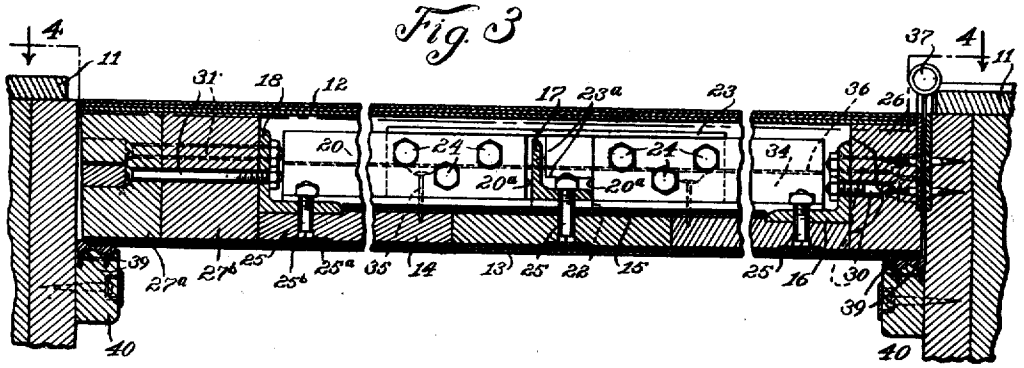


Fig. 3



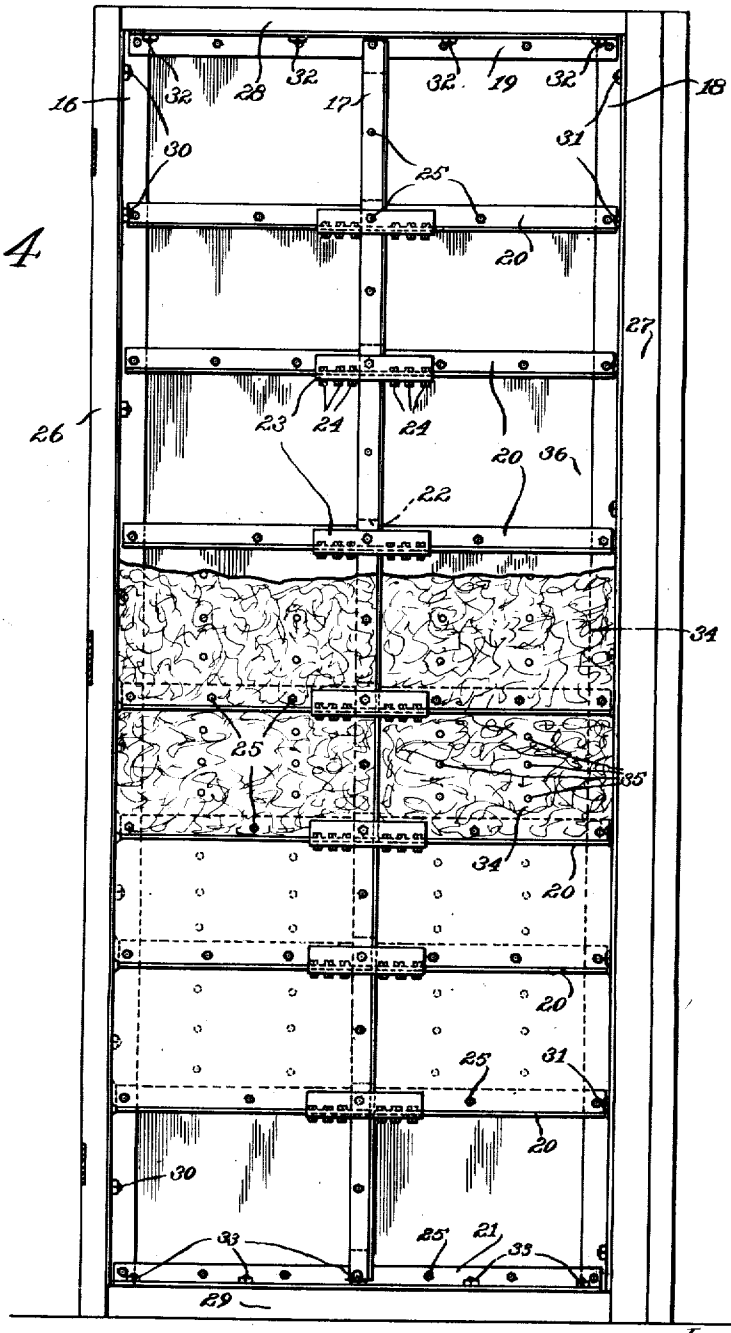
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Filed July 26, 1933 2 Sheets-Sheet 2

Fig. 4



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Patented Apr. 20, 1937

2,078,207

UNITED STATES PATENT OFFICE

2,078,207

SOUND INSULATING CONSTRUCTION

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Application July 26, 1933, Serial No. 682,194

12 Claims. (Cl. 20—35)

This invention relates to improvements in sound-insulating construction and has particular relation to a type of structure for minimizing the transmission of sound between adjacent rooms, compartments, telephone booths, and the like.

The invention has been particularly developed in connection with a sound-proof door, but is equally suitable for embodiment in fixed wall panels or sections which may be used to enclose a room or other space on all sides or any part thereof.

In the provision of so-called sound-proof structures heretofore, it has been the general practice to use one type of construction for the fixed walls and another type of construction for the doors. Difficulty has been frequently encountered, however, as a result of the doors being far less effective in sound insulation than the fixed portions of the walls, so that no matter how efficient the walls might be, a great deal of this efficiency would be destroyed by the transmission of sound through the doors. It is for this reason that the present invention has been first directed to the provision of an efficient sound-insulating door, as above indicated.

Another difficulty which has been encountered in connection with sound-insulating door constructions of the prior art has resulted from the fact that such structures, while relatively efficient in preventing the transmission of sound at some frequencies, have a very poor efficiency at certain particular frequencies. Such critical values of sound frequency occur in any construction wherein the door or other panel is of unitary construction so that the panel may vibrate as a whole. For example, sound-insulating doors built on the weight principle have a natural frequency of vibration, and sounds of that frequency, or near that frequency, will be transmitted through such doors with relatively great ease.

It has been common practice in many cases to determine the efficiency of a sound-insulating door or panel on the basis of its average sound transmission loss over the entire range of sound frequencies which may be encountered. When rated in this manner, a panel may show a relatively high theoretical efficiency by reason of the average transmission loss being increased by high values over certain portions of the frequency range, while the value at a particular frequency or frequencies may be so low as to render the panel practically useless as an insulator against sound vibrations of such frequencies.

In the development of the present invention, attention has been given not only to the obtaining of a high efficiency on the above-described basis of rating, but to the elimination of poor results at any particular frequency or frequencies. In this connection another method of rating the sound-insulating value of doors and walls has been taken into consideration. This method is based upon the so-called minimum loudness reduction value of the door or wall. It is a more rigorous method of evaluating sound insulation and in some respects gives a truer value of the actual efficiency of the construction. It is now well understood that a given amount of sound energy has a varying apparent loudness to the human ear, depending upon the frequency. The minimum loudness reduction rating is arrived at by weighting the transmission loss at each frequency, according to the response of the human ear at that frequency. The minimum loudness reduction is the lowest reduction valve over the range of frequencies of sounds normally encountered.

By providing a construction in which a relatively high minimum loudness reduction is obtained, the structure will be highly effective as an insulator against sounds of any particular frequency, as well as sounds of mixed frequencies, and will not be characterized by a low insulating value at any particular point in the frequency range.

The primary object of the present invention, therefore, is to provide a construction which will be highly effective in sound insulation over the entire range of sound frequencies which may be encountered.

A further object of the invention is to provide a construction which may be readily built in the form of doors, wall panels, or other structures, at a minimum of expense, and at the same time producing a pleasing appearance without excessive bulk or weight.

The above-indicated objects are accomplished, in general, by the construction of a door or other building element as a composite structure embodying two spaced panels of widely different natural frequencies of vibration. One of the panels is made as rigid as possible, while the other panel is made with the maximum obtainable flexibility within practical limits. The two panels are separated by an internal air space of substantial thickness whereby a cushioning action is obtained in the transmission of vibrations from one panel to the other. Within this space a layer of sound-absorbing material is preferably,

although not necessarily, disposed to increase the cushioning action of the air space.

The use of two separated panels of widely different natural frequencies has been found to provide a degree of sound insulation over the entire range of audible frequencies normally encountered, which has hitherto been considered unattainable. This result is achieved by reason of the fact that, while a sound of a given audible frequency impinging upon one of the panels may cause that panel to vibrate to some extent at or near its natural audible frequency or frequencies, such audible frequency or frequencies are widely different from any natural audible frequency of the other panel and will not cause the latter to vibrate to any appreciable extent, even if transmitted thereto from the panel upon which the sound first impinged. This condition occurs regardless of which of the two panels the sound is initially incident upon, and therefore the composite structure provides an effective insulation against transmission of sounds of any frequencies in either direction.

The invention will be more fully understood, and other objects and advantages thereof will become apparent, from a consideration of the detailed description of a particular embodiment of the invention, as appearing hereinafter, taken in conjunction with the accompanying drawings forming a part hereof and illustrating such embodiment. In these drawings:

Figure 1 is a fragmentary elevational view of a portion of a wall in a room having therein a door embodying the invention, and indicating the section lines on which subsequent views are taken;

Fig. 2 is a broken vertical sectional view taken on the plane indicated by the line 2—2 in Fig. 1;

Fig. 3 is a broken horizontal sectional view taken on the plane indicated by the line 3—3 in Fig. 1; and

Fig. 4 is an elevational view showing the interior construction of the door, taken on the planes indicated by the line 4—4 in Fig. 3 and having certain of the parts broken away to give a better illustration of the entire construction.

Referring to the drawings, Fig. 1 shows a door set in a frame or casing 11 and presenting to view one side thereof, comprising a panel 12. Upon reference to Figs. 2 and 3, it will be seen that the panel 12 consists of a relatively thin sheet of plywood or the like, covering the entire area of the door on one side. The opposite surface of the door is constituted by a composite wood veneer sheet 13 secured to the outer surface of a relatively thick wood panel 14 and projecting beyond the edges of the latter to extend over the entire area of the door on that side.

The panel 14 preferably consists of a plurality of strips or boards of Balsa wood or other material having similar desired characteristics, glued together in edge-to-edge relation to prevent warping. The essential characteristics of this panel are relatively great stiffness in comparison to the panel 12, and low magnitude of response to impinging sound vibrations, particularly in the lower audible frequency range. Balsa wood has been found to be highly satisfactory for these purposes, although other woods or materials having the desired characteristics may also be used. The panel 14 is preferably veneered on its inner surface, as by the multiple layers of veneer 15, having the same dimensions as the panel 14.

In order to make the composite panel 13, 14, 15, hereinafter referred to as the panel 14, as rigid as possible, the same is provided with a reenforcing framework suitably constituted by a plurality of structural iron members of high rigidity, such as angle irons. A suitable arrangement of such reenforcement is best illustrated in Fig. 4 and consists of vertically-disposed angle irons 16, 17, and 18 and horizontally disposed angle irons 19, 20, and 21, the members 19 and 21 being disposed at the top and bottom, respectively, of the panel 14 and there being a plurality of the members 20 disposed at spaced intervals intermediate the top and bottom of the panel.

The angle irons 16 and 18 are disposed adjacent the hereinafter-mentioned stiles of the door at the vertical edges thereof and are, therefore, designated as the stile angles. The angle irons 19 and 21 are similarly disposed adjacent the hereinafter-mentioned top and bottom rails of the door and for this reason are designated as the top and bottom rail angles. The angle iron 17 is designated as the central stiffener angle and the plurality of angle irons 20 are referred to as transverse stiffener angles.

Each of said angle irons is disposed with one flange thereof lying in a plane parallel to the panel 14 and with the other flange thereof projecting from the surface of said panel covered by the veneer 15 toward the resilient panel 12 of the door. As shown in Fig. 3, the inside surface of the panel 14 is formed with rabbeted grooves along the vertical edges thereof to receive the base flanges of the stile angles 16 and 18. The depth of these grooves is such that exposed surfaces of these flanges are flush with the exposed surface of the inside veneer covering 15 of the panel. The rail angles 19 and 21 and the transverse stiffener angles 20 overlap these flanges and extend across the entire veneered surface 15 with their base flanges in contact therewith.

Each of the angle irons 20 is formed with a slot 20*a* in its projecting flange, so that the central stiffener angle 17 may be inserted therein, as best shown in Fig. 3. Between the transverse angle irons the central stiffener angle 17 is spaced from the veneered surface 15 by shims 22 which are preferably made of wood. These shims are of the same thickness as the base flanges of the transverse stiffener angles 20 so that they provide the same spacing of the angle iron 17 from the exposed veneered surface 15.

The top and bottom rail angles 19 and 21 are preferably of heavier stock than the intermediate transverse angle irons 20, and for this reason the vertical stiffener member 17 is crimped, as indicated at 17*a*, so that the ends thereof lie flush on the exposed surface of the base flanges of said rail angles.

In order to reenforce the transverse stiffener angles around the slots 20*a* in the projecting flanges thereof, splice members 23 in the form of short sections of angle iron are provided. Each of these splice members is formed with an L-shaped slot 23*a* in one flange thereof to fit around the stiffener angle member 17, and this slotted flange is placed adjacent the projecting flange of the corresponding stiffener member 20 and secured thereto by means of bolts 24. The other flange of each of these stiffening splice members extends in a plane parallel to the base flange of the stiffening angle irons 20, but is located beyond the edges of the projecting flanges of the members 17 and 20, as shown.

Each of the said several stiffening angle irons is firmly secured to the panel 14 by means of bolts 25. These bolts are provided with large flat heads 25*a* located in counter-sunk recesses in the outer

surface of the core portion of the panel 14 and are inserted in suitably spaced holes through the panel prior to application of the outer veneer covering 13. The shanks of the bolts 25 are formed with short square portions 25b of slightly enlarged diameter, adjacent the heads of the bolts, whereby the bolts are securely held against turning in the holes in the panel 14. As best shown in Fig. 4, a considerable number of the bolts 25 are used, so that the reenforcing framework is secured to the panel 14 at frequent intervals. Certain of these bolts are located at points where two of the various angle irons overlap and the bolts thus located therefore serve to secure both such angle irons to the panel at those points.

The stile angle members 18 and 18 are so located that the outwardly-presented surfaces of the projecting flanges thereof are flush with the edges of the core member of the panel 14, and the rail angle members 19 and 21 are similarly located with respect to the top and bottom edges of the core of the panel. The door construction includes a hinge stile 26, a lock stile 27, and top and bottom rails 28 and 29, respectively. These members are made of suitable wood, the lock stile 27 being of composite structure including portions 27a and 27b, as shown, although it will be understood that this feature is optional and not essential to or connected with the invention.

The door stiles and rails are arranged around the periphery of the core of the panel 14, with the inner surfaces of said members abutting against the corresponding edges of said panel core and also against the outwardly-presented surfaces of the corresponding projecting angle iron flanges. These stiles and rails are glued to the portions of the veneer covering 13 which extend beyond the edges of the panel core 14 to the extreme edges of the door, and may also be glued to the edges of the core portion of the panel. They are securely fastened in the positions thus established by means of suitable bolts 30, 31, 32, and 33, which are placed at frequent intervals along the length of each of said members.

The heads of these bolts are located in counterbored recesses in each of the wood stiles and rails and are subsequently covered by wood plugs inserted in said recesses to present a finished exterior surface, as is customary. These bolts extend through aligned holes in the projecting flanges of each of the corresponding stile and rail angle members and are drawn up tight, to provide a rigid construction. The thin panel 12 is glued to the surfaces of the stile and rail members opposite those which abut against the veneered surface 13, and completes the external construction of the door itself.

Prior to the application of the thin panel 12, however, the inside surface of the panel 14 (constituted by the veneer covering 15) is preferably, although not necessarily, covered by pads of sound-absorbing or vibration-damping material 34, consisting of acoustical felt or other suitable material of similar characteristics. These pads are cut to the proper size to fit in each of the rectangular spaces between adjacent angle irons and may be suitably secured to the panel 14 as by nails 35. The exposed surfaces of these pads are preferably covered with a layer of paper 36 which is cut in pieces of the same size as the pads and suitably attached to the edges of the latter.

The addition of the pads adds damping to the cushioning effect of the air space within the door under certain conditions, and the addition of the flexible membrane covering of paper or the like has been found to provide a still further increase in the damping action in some cases.

When the above-described construction is embodied in a door, as in the particular embodiment of the invention herein shown and described, the same is hung on suitable hinges 37 in the usual manner. Since the construction does not involve unusually great weight, hinges and other hardware of ordinary design and size may be utilized. Any desired type of knob or handle 38 may be provided and associated with any desired type of latching and locking mechanism. It is preferable that a latch of the type which forces the door tightly into its closed position be utilized, but since such latches are well known and constitute no part of the present invention, this detail is not illustrated herein.

Gaskets 39 are preferably carried by door stops 40 along both sides and the top of the door to prevent the passage of sound past these edges when the door is closed, and the bottom is preferably sealed in closed position by members 41 of a so-called trigger bottom construction. These members are automatically actuated by suitable mechanism upon closing of the door and are thereby caused to move downwardly and to press against the floor or threshold when the door is tightly closed, thus providing the desired sealing action at the bottom of the door. This construction likewise forms no part of the present invention and, being well understood in the art, is not shown or described in greater detail herein.

From the foregoing description, it will be seen that the present invention resides in a door or other wall panel or the like, which is of composite structure, comprising one panel of an extremely rigid nature and another panel of a very flexible nature. The two panels are separated by an air space of substantial thickness which provides a cushioning action to impede the passage of sound through the structure, and to this cushioning action may be added a damping effect in some cases by the addition of pads of sound-absorbing felt or the like and further by the covering of the exposed surfaces of such pads by membranes of paper or other flexible material. The most important and fundamental principle which is involved in the construction is the provision of the two panels having a wide difference in natural frequency of vibration and the separation of these panels in such manner that vibration of either one will be transmitted to the other to a minimum degree. Thus, the passage of any sound which may cause one of the panels to vibrate will be substantially completely prevented by the other panel, which has no natural period of vibration at or near the same frequency or frequencies.

While only one particular embodiment of the invention has been specifically shown and described herein, it will be apparent to those skilled in the art that various changes and modifications in the details of construction, arrangement of parts and general application of the invention may be made without departing from the spirit and scope of the invention, as set forth in the appended claims.

What is new and is desired to secure by Letters Patent, therefore, is:

1. A sound-insulating construction comprising a panel of high rigidity, a panel of high flexibility in comparison to said first panel, means supporting said panels in spaced, parallel rela-

tion, and a layer of vibration-damping material covering the inside surface of the rigid panel but only partly filling the space between said panels.

2. A sound-insulating construction comprising a panel of high rigidity, a panel of high flexibility in comparison to said first panel, means supporting said panels in spaced, parallel relation, a layer of vibration-damping material covering the inside surface of the rigid panel but only partly filling the space between said panels, and a flexible membrane extending over the exposed surface of said vibration-damping material.

3. A sound-insulating construction comprising a panel of high rigidity, a panel of high flexibility in comparison to said first panel, means supporting said panels in spaced, parallel relation, a layer of vibration-damping material covering the inside surface of the rigid panel but only partly filling the space between said panels, and a flexible membrane extending over the exposed surface of said vibration-damping material and secured thereto.

4. A sound-insulating construction comprising only two spaced, parallel impervious panels rigidly supported at their peripheries and reenforcing means secured to the inner surface of one of said panels and rendering the same highly rigid, the other of said panels being relatively flexible and so mounted as to be free to vibrate over its entire unsupported surface.

5. A sound-insulating construction comprising spaced, parallel impervious panels rigidly secured to a supporting framework at their peripheries and structural iron reenforcing members secured to the inner surface of one of said panels and rendering the same highly rigid, the other of said panels being relatively flexible and so mounted as to be free to vibrate over its entire unsupported surface.

6. A sound-insulating construction comprising spaced, parallel panels and a plurality of angle-iron members secured at frequent intervals to the inner surface of one of said panels in intersecting relation to each other to render said panel highly rigid, the other of said panels being relatively flexible and so mounted as to be free to vibrate over its entire unsupported surface.

7. A sound-insulating construction comprising spaced, parallel panels, a plurality of angle-iron members secured at frequent intervals to the inner surface of one of said panels in intersecting relation to each other to render said panel highly rigid, the other of said panels being relatively flexible, and rail and stile members supporting said panels in said spaced relation and secured to the reenforcing members along the corresponding edges of the rigid panel.

8. A sound-insulating door construction comprising spaced, parallel panels, a plurality of angle-iron members secured at frequent intervals to the inner surface of one of said panels in intersecting relation to each other to render said panel highly rigid, the other of said panels being relatively flexible, rail and stile members supporting said panels in said spaced relation and secured to the reenforcing members along the corresponding edges of the rigid panel, a casing for the door, and means for sealing the edges of the door in the casing to prevent the passage of sound around said edges.

9. A sound-proof door comprising a frame, and impervious panels rigidly supported thereby, one of said panels being relatively thick and rigid and hence resonant only to sounds of high audible frequency, the other panel being thin and flexible and hence resonant only to sounds of low audible frequency, each panel having one side exposed to the spaces divided by the door, said flexible panel being free to vibrate over its entire unsupported surface.

10. A second-proof door comprising a frame, and impervious panels rigidly supported thereby, one of said panels being relatively thick and rigid and hence resonant only to sounds of high audible frequency, the other panel being thin and flexible and hence resonant only to sounds of low audible frequency, each panel having one side exposed to the spaces divided by the door, and a layer of sound-absorbing material between said panels and in contact with the rigid panel, said thin panel being free to vibrate over substantially its entire unsupported surface.

11. A sound-proof door construction comprising a rigid frame having impervious panels rigidly secured thereto, one of said panels being substantially rigid and inflexible, and the other being of a highly flexible nature and free to vibrate over its entire unsupported surface.

12. A sound-proof door construction comprising a rigid frame, a rigid impervious panel rigidly secured within the frame substantially flush with one surface thereof, and a relatively thin and flexible impervious panel rigidly secured to the marginal portions of said frame on the side opposite to that where the rigid panel is secured, said thin panel being free to vibrate over substantially its entire unsupported surface.

JOHN PAGE.
GEORGE W. BAKER.

CERTIFICATE OF CORRECTION.

Patent No. 2,078,207. April 20, 1937.

JOHN PAGE, ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, second column, line 27, claim 10, for second-proof" read sound-proof; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 29th day of June, A. D. 1937.

Henry Van Arsdale

(Seal) Acting Commissioner of Patents.