May 21, 1935. G. D. KELLOGG 2,001,733

SOUND DEADENING STRUCTURE

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Fig. 1.

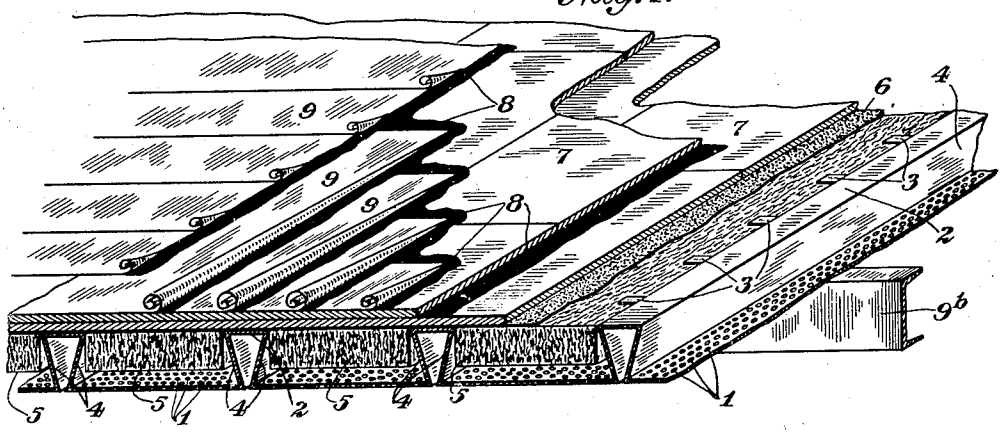


Fig. 2.

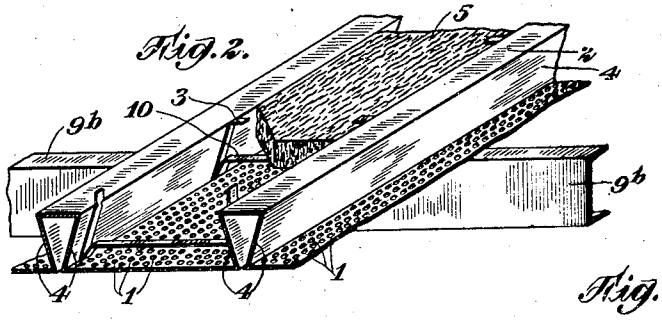


Fig. 3.

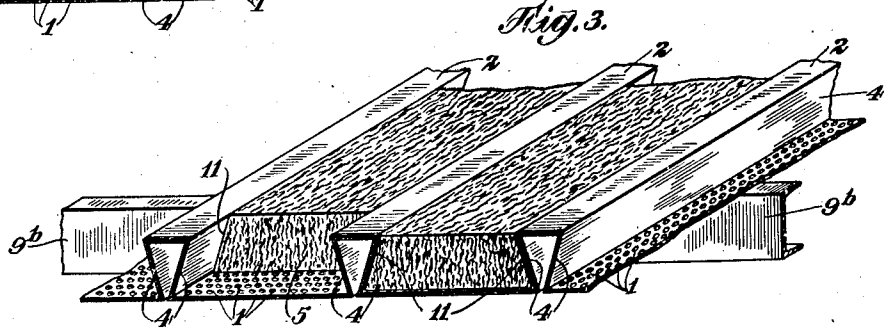
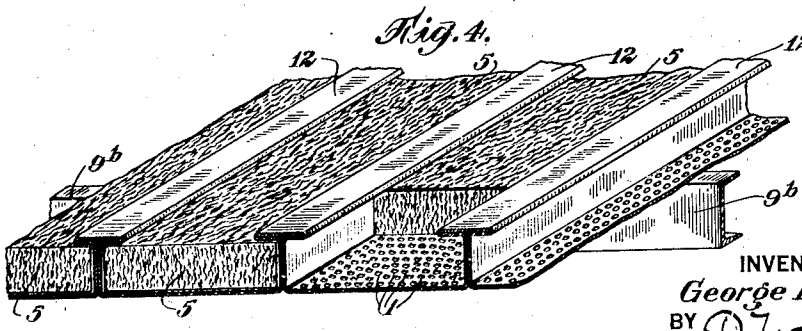


Fig. 4.



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Fig. 5.

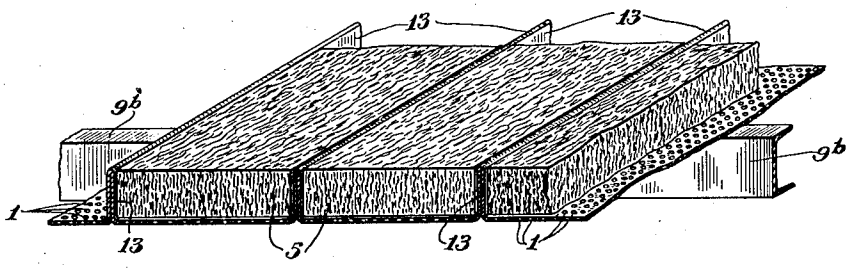


Fig. 6.

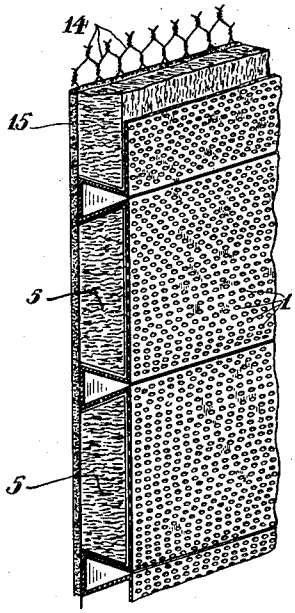


Fig. 9.

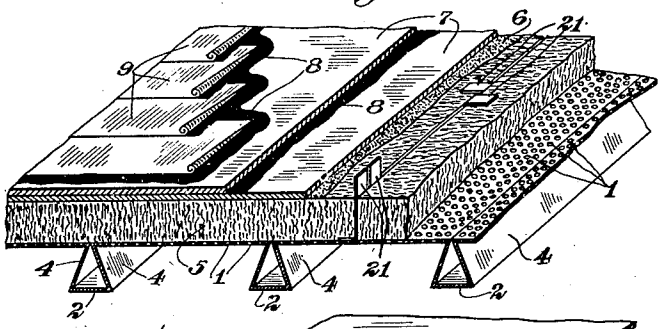


Fig. 8.

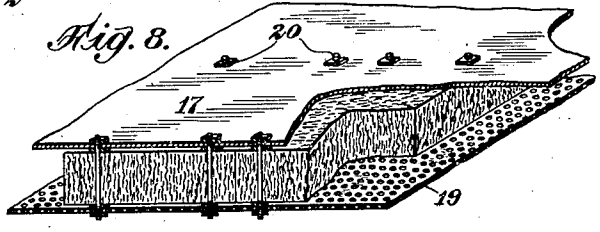
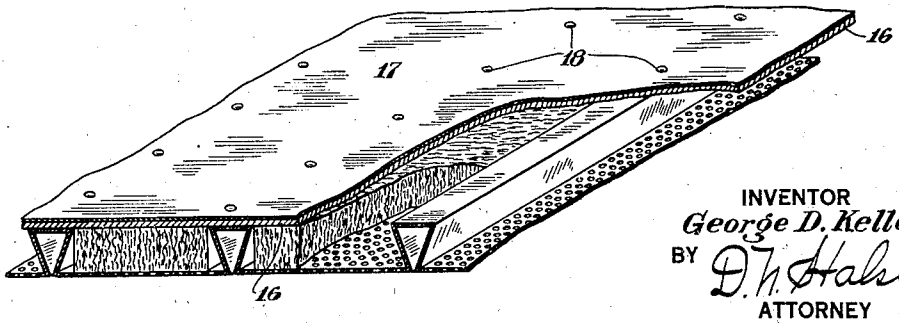


Fig. 7.



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SOUND DEADENING STRUCTURE

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Application January 2, 1932, Serial No. 584,446

8 Claims. (Cl. 189—85)

This invention relates to a structure adapted for use in a roof or side wall of a building. It pertains especially to a structure in which sound-deadening material is maintained in position over or behind a perforated metal sheeting in the form of a rigid, large unit and is protected on the outer side against the penetration of water. A preferred embodiment of the invention is a relatively inexpensive, fire-resistant roof structure comprising a perforated metal deck with upwardly extending integral beams, such as ribs, a sound-deadening material in position above the perforations, and a protecting superstructure adapted to coact with the sound-deadening material in such manner as to preserve the latter in effective condition.

An object of the invention is to adapt a usual type of roof structure, including a metal deck, to sound deadening. Another object is to provide an inexpensive and relatively rigid roof or side wall, that is sound-deadening and suitably also thermal insulating and fire-resisting. A further object is to improve the sightliness of a roof containing ribbed sheet metal, known as a metal deck, by reversing, in some cases, the conventional position of the ribs, that is, by causing them to extend upwardly instead of downwardly, and thus exposing in the interior of the building the flat portion of the metal deck, with preservation of the rigidity imparted in the conventional construction by the downwardly extending reenforcing ribs. Other objects and advantages will appear from the detailed description that follows.

To provide a light-weight, fire-resistant thermal insulating roof deck of sufficient structural strength to permit application over fairly large spans in steel buildings, sheet metal has been formed with integral beams in the form of reenforcing ribs. This structure has become known as a metal deck. The ribs, pressed or drawn into the flat steel sheets, are of various sizes and shapes, depending in part upon advantages in economical application and upon the distance between the purlins to which the metal deck sheets are applied.

In general practice these metal deck sheets are made of copper-bearing steel and are applied with the ribbed side down and exposed in the interior of a building. The ribs are clipped, bolted, welded at intervals, or otherwise fastened to the steel purlins. End joints between roof deck sheets are lapped, as are also the side joints, whereby there is formed an interlocking, continuous roof construction. A roofing material may be applied on the outside, that is, to the flat steel plates, by cementing it to the surface with hot asphalt or pitch. Or, an insulated roof may be provided by first cementing and/or clipping one or more sheets of an insulating board to the flat steel deck and then applying to the upper surface of the insulating board a built-up roofing, such as asphalt-impregnated asbestos paper, the various layers of the paper being cemented to the insulating board or to each other by means of asphalt or pitch applied in hot condition.

This type of construction is in common use as a roof in many buildings where light weight steel construction and heat insulation are desirable. There is used occasionally also some kind of acoustical treatment or sound-deadening interior finish on the ceilings. The application of such acoustical treatment has involved heretofore an extra operation and expense after the roof deck and roofing have been installed. Usually there has been required the erection of scaffolding and means of supporting the sound-deadening material.

The present invention provides for the support of the sound-deadening, that is sound-absorbing material, the heat insulating material, and the protecting superposed layers of roofing material by the metal deck itself, so that, after the roofing has been installed, the deck possesses three functions or properties, namely, sound-deadening, thermal insulating, and waterproofing.

It is known that while steel sheets constitute an excellent reflecting surface for sound waves impinging against the sheets, these same sheets become quite permeable to sound if they are perforated properly. Perforations made in accordance with U. S. Patent No. 1,726,500 to Norris are satisfactory. Norris describes a sound-deadening structure adapted to be applied to the under side of a ceiling.

The present invention is illustrated by the drawings.

Figs. 1–9 show perspective views of various embodiments of the invention. The embodiment which is preferred at this time is that illustrated in Fig. 1.

In the various figures, like reference characters indicate like parts.

Thus there is illustrated a metal deck provided with perforations 1 adapted to admit incident sound and with integral beams in the form of reenforcing ribs. The deck is in the form of sections provided each with a plurality of imperforate reenforcing ribs. The ribs preferably ex-

tend upwardly in the case of a ceiling construction as illustrated in several of the figures, and outwardly in the case of a side wall construction illustrated in Fig. 6. The ribs extend in approximately parallel directions and are provided with side walls 4 and a base 2 or portion remote from the flat portion of the roof deck. In some cases the base is wider than the part of the rib joined to or adjacent to the flat portion of the roof deck. This is illustrated in Figs. 1, 2, 3, 6, 7 and 9, in which cases the ribs are hollow or approximately triangular in cross section, and illustrated also in Fig. 4, in which case the ribs are provided with flanges 12 extending from the edge of the rib remote from the flat portion of the roof deck. The ribs may have clips 3 welded to the ribs or may consist of tongues of metal punched out from the rib. These clips are adapted to engage or maintain, in position, panels 5 of sound-deadening material inserted between the said ribs, as by having the ends of the clips turned over the edge of the panels. These panels of sound-deadening material may be placed directly over or behind the perforated flat portion of the metal deck or may be maintained in spaced relationship thereto by means of spacing members 10 (shown in Fig. 2).

In order to maintain the sound-deadening material in effective condition and also to make the roof structure thermal insulating and watertight, the metal deck and the panels of sound-deadening material are protected by superposed layers of thermal insulating and waterproofing material. These thermal insulating and waterproofing layers are illustrated in Figs. 1 and 9 and may be used in association with any of the subcombinations or modifications illustrated in Figs. 2–5. Such protective material is suitably supported, directly or indirectly, upon the upstanding ribs, whereby the structure is adapted to withstand substantial loading, even when the sound-deadening material between the ribs is relatively weak. These layers of protective material in preferred form are shown in detail in Figs. 1 and 9 with modifications illustrated in Figs. 7 and 8. Any of these protective materials may be used in association with any of the subcombinations shown in Figs. 2–5.

From Fig. 1 it will be seen that the roof deck with inserted sound-deadening material may be covered with thermal insulating material 7, suitably in the form of light weight boards of cane or wood fibers applied in a thickness of two layers with broken joints.

The lower layer is adhered to the reenforcing ribs of the metal deck and to the sound-deadening material between the ribs by securing means 6, which may consist of a thin layer of Portland cement, asphalt applied in hot condition, or other adhesive material. The second or upper layer of insulating material is adhered to the lower layer by a coating 8 which may be asphalt or pitch, applied in hot condition, or other adhesive. The whole is then covered by a so-called built-up roofing consisting of a number of layers of asphalt-impregnated asbestos paper, rag felt impregnated with tar, or equivalent material 9 adhered to each other or to the underlying insulating board layers by the adhesive material 8.

The metal deck is supported on a substructure of which there is shown only one purlin 9—b. The metal deck may be secured to the purlins or supporting members in any conventional manner, as by welding at intervals, bolts, rivets, or clips of suitable design.

In cases where the ribs have sides 4 converging in the direction of the flat portion of the metal deck, as illustrated in the hollow rib construction of Fig. 3, for example, the sound-deadening material may be wedged in or dovetailed in between the sloping sides of the ribs. With rigid sound-deadening panels with beveled edges 11, this wedging in or dovetailing adds rigidity to the structure. However, this dovetailing is usually unnecessary and a more convenient method of inserting the panels is preferred. For convenient insertion the panel may have width no greater than that of the most narrow part of the opening between two adjacent ribs, as illustrated in Figs. 1 and 8.

Ribs with flanges 12 extending from the edge of the rib remote from the flat portion of the roof deck are illustrated in Fig. 4.

A roof construction in which the reenforcing ribs of the metal deck have relatively straight sides and no wide portion are illustrated at 13 in Fig. 5.

The adaptation of the structure of the present invention to a side wall of a building is illustrated in Fig. 6. Here the outer surface of the structure may be finished by the application of a layer of finishing material, as, for example, a Portland cement layer 15 secured to the expanded metal or chicken wire netting 14 which, in turn, is secured to the ribs of a metal deck similar to that used in construction of a roof. Modifications in which the outer protecting layers are substituted by other material, as, for example, by metal sheeting are illustrated in Figs. 7 and 8. In Fig. 7 there is shown a sound-deadening and thermal insulating structure in which sound-deadening material is in position between the ribs in a perforated metal deck, a layer of thermal insulating material 16 is placed over the sound-deadening material and the ribs, and an imperforate sheet 17 of structural material, suitably steel, is placed over the insulating material. The imperforate sheet may be attached to the rest of the structure in any conventional manner, as, for example, by case-hardened self-tapping screws 18 which may be driven through the sheet and into the ribs. The use of the layer of thermal insulating material between the ribs and the outer imperforate sheeting insures a spaced relationship between the ribs and the outer sheeting and minimizes the transfer of heat from one to the other.

While the invention has been described as applied to a sound-deadening construction comprising a ribbed and perforated metal sheet, the ribs may be substituted by other spacing members, as, for example, by the bolts or studs 20, illustrated in Fig. 8. The studs shown have nuts on each side of the plain perforated sheet 19 and also of the imperforate water-tight sheet 20. These nuts and the studs maintain the two sheets in spaced relationship and, if desired, maintain also the imperforate sheet 17 in spaced relationship to the sound-deadening material placed between this sheet and the perforated sheet 19. It will be understood that a construction of this type is ordinarily not as rigid or desirable in other regards as one in which there are reenforcing ribs, such, for example, as the somewhat similar structure illustrated in Fig. 7.

The upwardly extending ribs prevent crushing of a sound-deadening material by a load on top of the roof. However, if it is known that a given roof will never carry a load greater than the sound-deadening material can withstand without crushing, in the absence of the load-

carrying ribs, then the position of the metal deck may be reversed, as in the roof construction shown in Fig. 9. Here the reenforcing ribs extend downwardly. Over the perforated flat portions of the metal deck are placed the panels of sound-deadening material, secured to the metal deck as by the clips 21. These clips may consist of bands of metal spot-welded or otherwise attached to the metal deck, at one end, and split and bent over panels of sound-deadening material, at the other end. Over the sound-deadening material is placed and adhered protective material, suitably the same structure as illustrated in Fig. 1 and comprising the elements numbered 6, 7, 8, and 9. The construction shown in Fig. 9 may be used also in a side wall of a building, in which case the ribs extend inwardly and the protecting material, outside the sound-deadening material, may comprise the elements 14 and 15 (Fig. 6) or other water-tight protective material.

The method of making structures or assemblies of the types illustrated should require little or no explanation other than what has been given in connection with the description of the drawings. The metal deck is provided in standard form and perforated, as with $\frac{5}{16}$ inch diameter holes on ¾ inch centers or in other manner described in the above mentioned patent to Norris. When this perforated metal deck has been installed in the roof of a building, panels, felts, or other form of sound-deadening material, but preferably rigid or semi-rigid panels, are placed over the perforations and, if there are upwardly extending ribs, between the ribs. The panels are maintained in position in any of several different manners. Thus the panels may be maintained in position by clips consisting of thin strips of metal secured to the ribs or to flat portions of the roof deck and bent over the inserted sound-deadening material, as illustrated in Figs. 1 and 2. Or, the panels may be engaged by tongues provided in the ribs by punching out during the fabrication of the roof deck. The tongues may have points turned at right angles to the rest of the tongue and may be adapted to be inserted, at the point, into panels of sound-deadening material in position between the ribs. The application of the protective material, such as the insulating board and the built-up roofing, may be made in a usual manner, as has been described. If the panels are to be dovetailed between the ribs, then the panels should be inserted at the end of a section of the rock deck and slipped along to the position desired. While the ceiling structure is supported suitably on steel purlins, the side wall construction may be supported on studding, either metal or wood, but preferably metal where fireproof construction is desired. By having the studding relatively strong for the width of the studding, the side wall may be supported by the studding without covering a sufficient area of the sound-deadening construction to render unsatisfactory the sound-deadening properties of the side walls. The structures illustrated in Figs. 7 and 8, in which the sound-deadening material is enclosed on the upper or outer side by sheet metal, such as sheet steel, are designed to be assembled preferably during the construction of a building rather than preassembled and installed as a unit.

The properties of the structures made in accordance with the invention are such as to adapt them generally for use where relatively inexpensive and rigid sound-deadening, fireproof construction of ceiling and/or side walls is desired. A typical construction was found to be light in weight and effective as a sound deadener as well as a thermal insulator. This construction was made of hollow rib, copper-bearing steel fabricated into units 18⅛ inches wide and of length depending upon the purlin spacing, which may be 5½ to 8½ feet. The metal deck had hollow ribs of approximately triangular cross section 1½ inches deep by 1 inch wide, spaced on 6 inch centers. The metal sheeting was perforated with a multiplicity of holes, each of diameter $\frac{3}{32}$ inch, on approximately $\frac{5}{16}$ inch centers. This perforated metal roof deck was placed on steel purlins. Semi-rigid panels of standard type 1¼ inches thick, comprising nodulated rock wool and an asphalt binder so used as to maintain the porosity and permeability to sound of the finished block, were inserted above the perforations and between the ribs. The panels were fastened in place by clips and the whole was then covered by two layers, each ½ inch thick, of insulating wood fiber board and protected from water by the application, over the upper layer of insulating board, of several layers of asphalt-impregnated asbestos paper. The insulating board and the superposed water-tight layers of roofing paper were adhered to each other or to the ribs of the roof deck and the sound-deadening material by means of mopping with hot asphalt. The finished roof, excluding the supporting substructure but including the metal roof deck, weighed approximately 6.7 pounds per square foot, absorbed more than 60 per cent of incident sound of approximately 500 cycles frequency, and was calculated to give a thermal transmittance of less than 0.160 B. t. u. per square foot, per hour, per degree Fahrenheit difference in temperature between the inside and the outside surfaces, at a wind velocity of 15 miles per hour over the exterior surface. It has been calculated also that this roof construction is more effective as a thermal insulator than 20 inches of solid concrete.

In view of the fact that sound-deadening material loses its effectiveness when the pores therein are closed by water and in view of the fact that a metal roof deck, unless protected by an outer thermal insulating coating, may cause condensation of moisture in the form of dew below the metal roof deck, under certain conditions of temperature and humidity, the importance of the outer thermal insulating and protecting material may be readily appreciated. This outer layer, by decreasing the difference of temperature between the metal roof deck and the air below and adjacent thereto, minimizes the condensation of moisture as dew, which might otherwise form within the pores of the permeable sound-deadening material, and thereby coacts with the sound-deadening material to maintain it in effective or dry condition. Likewise the built-up roofing or water-tight material placed above the thermal insulation on top of the metal roof deck serves to maintain this insulation also in effective or dry condition by excluding liquid water therefrom.

While the invention has been described particularly as applied to the construction of a ceiling or to a side wall, it should be understood that other uses may be made of this sound-deadening structure. The inverted and perforated metal deck filled with sound-deadening material may be used to span the under side of girders, trusses, and the like, to form a sound-deadening

and heat insulating medium in certain types of firred ceiling construction.

The details which have been given are for the purpose of illustration rather than limitation of the invention. Thus the sound-deadening material may consist of many materials other than the rock wool which has been mentioned. The sound-deadening material may comprise, for example, asbestos fiber in porous and permeable form, cane fiber board with a multiplicity of holes sunk therein to give a product sold for acoustical purposes, felts of various kinds adapted to deaden or absorb sound, or permeable and porous ceramic tile. While loose felts may be used, rigid or semi-rigid sound-deadening material in the form of preformed units or panels is particularly desirable in the structures of the present invention.

The term "sound-deadening" is used herein to include what is frequently called "sound-absorption." The sound-deadening material used should be relatively effective, by which is meant that the sound-deadening material should deaden or absorb more than 40 per cent and suitably 50 to 90 per cent or more of incident sound of approximately 500 cycles frequency.

The superposed protective material consisting of insulating board protected from rain by asphalt-impregnated roofing paper has been described. Other thermal insulating materials may be used, as, for example, sheets of vegetable cork, compositions comprising asbestos, mineral wool, or other effective thermal insulating material. However, particularly satisfactory results have been obtained when the thermal insulating material has considerable rigidity. This rigidity of the protective material serves to increase the rigidity of the whole structure so that a man may walk over a typical roof constructed in accordance with the present invention.

It will be understood that the term "rock wool" as used herein represents a product of melting and blowing an argillaceous limestone. While other mineral wool, such as slag wool, may be used in place of rock wool, the rock wool is preferred, in part, because of the greater stability of the latter when exposed to air.

Some of the binding materials used in the sound-deadening panels are affected by water and particularly by alternate wetting and drying out of the panel. This is particularly true when various glue or modified starch binders are used. For this reason also the action of the protective layers of the thermal insulating and waterproofing materials in excluding water from the sound-deadening materials is desirable.

The multiplicity of perforations adapted to admit incident sound, with which the metal deck is provided, communicate with the pores in the sound-deadening material maintained in position above the perforations. This permits the entrance of incient sound through the perforations and into the pores of the sound deadener. The imperforate ribs, on the other hand, prevent or minimize lateral circulation of air through sound absorbing material disposed between the ribs.

Reference has been made to the use of imperforate metal sheeting, as illustrated in Figs. 7 and 8, for placement over the back of the sound-deadening material, that is, the surface remote from the perforated sheeting. The term "imperforate" excludes sheeting provided with a multiplicity of perforations adapted to admit sound, but does not exclude sheets perforated to receive rivets or bolts, for example, or in such a manner as not to adapt the sheet to admit readily sound which is incident upon the sheet.

The structures of the present invention are to be distinguished from a conventional acoustical ceiling which requires protection by an independent roof structure. According to my invention the acoustical ceiling and the roof are combined in one structure.

Since many variations from the illustrative details given may be made without departing from the scope of the invention, it is intended that the invention should be limited only by the terms of the claims interpreted as broadly as consistent with novelty over the prior art.

What I claim is:

1. A sound-deadening roof comprising in combination a supporting sub-structure, a metal deck in the form of sections provided each with a plurality of imperforate integral beams, flat portions of said deck, intermediate the beams, provided with a multiplicity of perforations adapted to admit incident sound, relatively effective sound-deadening material maintained in position above the perforations and between the beams, and a layer of thermal insulating material placed above the sound-deadening material and adapted to maintain the sound-deadening material in effective condition.

2. A sound-deadening roof comprising in combination a supporting substructure, a metal deck in the form of sections provided each with a plurality of imperforate integral beams, flat portions of said deck, intermediate the beams, provided with a multiplicity of perforations adapted to admit incident sound, relatively effective sound-deadening material maintained in position above the perforations, and layers of thermal insulating and water-tight materials placed above the sound-deadening material and adapted to maintain the sound-deadening material in effective condition.

3. A sound-deadening roof including in combination a supporting substructure, a metal deck comprising upwardly extending integral beams and flat portions provided with a multiplicity of perforations adapted to admit incident sound, relatively effective sound-deadening material placed above said perforations and between the beams, and superposed protective material supported upon the said beams and adapted to maintain the sound-deadening material in effective condition.

4. A sound-deadening roof including in combination a supporting substructure, a metal deck comprising integral beams and flat portions provided with a multiplicity of perforations adapted to admit incident sound, relatively effective sound-deadening material in the form of rigid panels placed above said perforations, superposed protective material adapted to maintain the sound-deadening material in effective condition, and means for spacing the sound-deadening material from the perforated portions of the said deck.

5. A sound-deadening roof including in combination a supporting substructure, a metal deck comprising upwardly extending integral beams and flat portions provided with a multiplicity of perforations adapted to admit incident sound, relatively effective sound-deadening material in the form of rigid panels placed above said perforations, and superposed metal sheeting, said superposed metal sheeting being maintained in spaced relationship to the beams of the perfo-

rated roof deck, whereby the thermal transmission to the said beams is minimized.

6. A sound-deadening roof comprising in combination a supporting substructure, a metal deck in the form of sections having each a plurality of imperforate integral beams and flat portions of said deck, intermediate the beams, provided with a multiplicity of perforations adapted to admit incident sound, and sound-deadening material maintained in position above the perforations.

7. A sound-deadening roof comprising in combination a supporting substructure, a metal deck in the form of sections having each a plurality of imperforate upwardly extending integral beams and flat portions of said deck, intermediate the beams, provided with a multiplicity of perforations adapted to admit incident sound, and sound-deadening material maintained in position above the perforations and between the beams, whereby lateral circulation of air through the sound-deadening material is minimized.

8. A sound-deadening roof comprising in combination a supporting substructure, a metal deck in the form of sections having each a plurality of imperforate integral beams and flat portions of the said deck, intermediate the ribs, provided with a multiplicity of perforations adapted to admit incident sound, relatively effective sound deadening material maintained in position above the perforations, and a protective material disposed above the sound-deadening material and adapted to maintain the sound-deadening material in effective condition.

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