

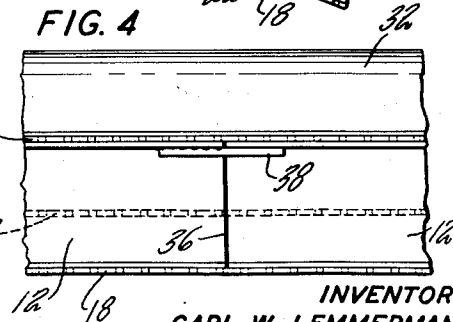
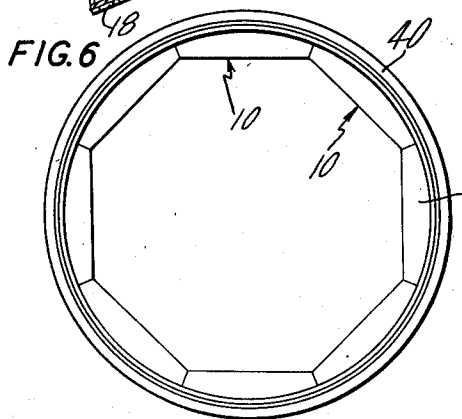
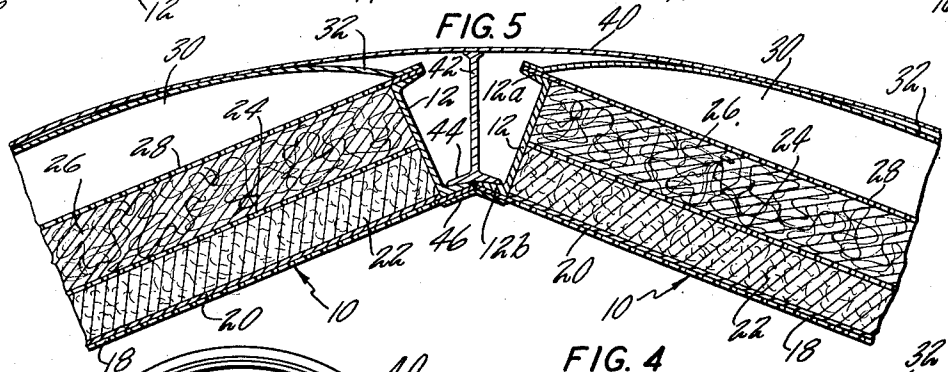
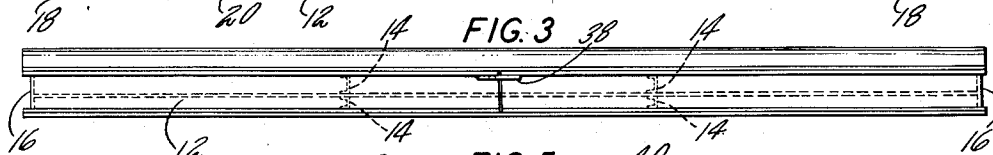
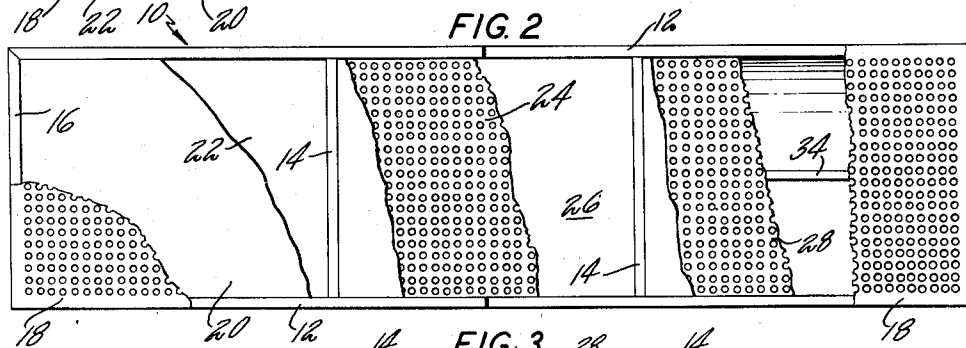
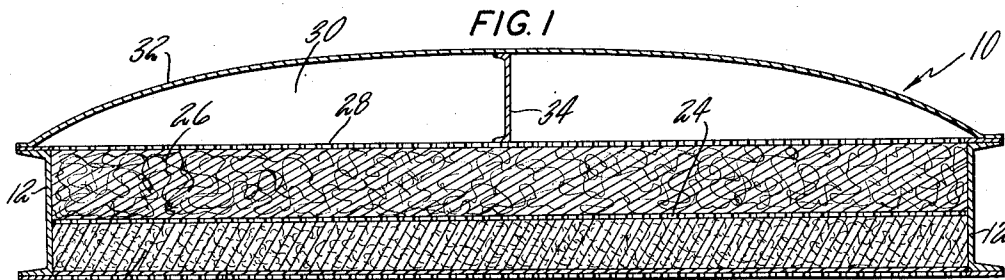
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C. W. LEMMERMAN

2,674,336

ACOUSTICAL PANEL

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INVENTOR
CARL W. LEMMERMAN
BY *Lindsey & Prutzman*
his ATTORNEYS

UNITED STATES PATENT OFFICE

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ACOUSTICAL PANEL

Carl W. Lemmerman, West Hartford, Conn., assignor to C. W. Lemmerman, Inc., Hartford, Conn., a corporation of Connecticut

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This invention relates to an acoustical panel and, more particularly, to a sound absorbing panel adapted to absorb sounds over a wide range of mingled frequencies and under conditions encountered at extremely high temperatures.

The sound absorbing devices of this invention, although not restricted thereto, may be particularly adapted to absorb the engine and exhaust noises of a jet engine while undergoing tests in a test cell and are adapted to withstand the high temperatures and extreme velocities of the exhaust stream.

The development of jet engines has posed a serious problem relating to muffling of exhaust sounds while the engine or aircraft is undergoing ground tests. The sound muffling difficulties are particularly acute in test cell installations, since the conventional muffler constructions utilized with the test cell for reciprocating engines are not capable of efficient operation at the high temperatures encountered in jet engine operation. It has also been found that the jet engine develops a wider range of mingled sound frequencies than do conventional reciprocating engines.

Accordingly, it is an object of the present invention to provide an acoustical panel capable of absorbing sounds throughout a wide range of frequencies and capable of operating efficiently when disposed in an exhaust stream of relatively high temperature.

Another object of this invention is to provide a sound absorbing panel which can be readily utilized in a muffler construction for the testing of jet engines or which can be utilized in constructing a baffle wall for an aircraft test cell.

A more specific object of the invention is to provide an acoustical panel for a sound absorbing muffler capable of withstanding the temperature of a stream of exhaust gases introduced into the muffler.

Other objects will be in part obvious and in part pointed out more in detail hereinafter.

The invention accordingly consists in the features of construction, combination of elements and arrangement of parts which will be exemplified in the construction hereafter set forth and the scope of the application of which will be indicated in the appended claims.

In the drawings:

Fig. 1 is a transverse sectional view through an acoustical panel constructed in accordance with this invention;

Fig. 2 is a bottom plan view on reduced scale of a panel similar to the panel of Fig. 1, with

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parts broken away to illustrate details of construction;

Fig. 3 is a side elevational view of the panel illustrated in Fig. 2;

Fig. 4 is a fragmentary side elevational view of the sound absorbing panel of Fig. 1, showing an expansion joint at the side of the frame of the panel.

Fig. 5 is a fragmentary transverse sectional view of a muffler duct incorporating a plurality of panels similar to those illustrated in Figs. 1 to 3; and

Fig. 6 is an end view of the muffler duct.

Referring to the drawings in detail, reference numeral 10 indicates generally an acoustic panel construction in accordance with this invention to absorb sound waves directed thereagainst through a wide range of frequencies, to resist heat encountered at relatively high temperatures and to materially reduce the temperatures of a stream of gases directed against its surfaces.

The panel 10 is housed or supported by a frame structure which includes side frame members 12 secured as by welding to cross pieces 14 and to end frame members 16. The members 12 and 15 may be formed from channel stock and are preferably assembled with the flanges of the sides 12 and ends 16 directed outwardly to provide securement surfaces for connecting a plurality of panels in the manner shown in Fig. 4. The cross pieces 14 are formed of lighter channel stock and are transversely secured to side members 12 in superimposed pairs, one such member 14 on either side of a plate to be described in detail hereinafter.

A perforate cover plate 18 covers the rectangular frame of the panel 10 to provide the operating face for the panel and is secured at its marginal portions to the frame members 12 and 16 as by welding. The plate is also secured as by welding to one cross member 14 of each superimposed pair.

The cover plate 18 provides a resonator for purposes of sound attenuation and absorption. The thickness of the plate and the size and spacing of the perforations are all factors in determining the efficiency of the plate 18 as an instrument for this purpose. In practice, the cover plate 18 is exposed to sound waves of various frequencies. The lower frequency, longer sound and shock waves, engages the plate 18 and causes it to vibrate between the frame elements as a diaphragm. The higher frequency, shorter waves, pass through the perforations to the spaces beyond the plate 18.

where they are absorbed by elements to be described later.

Since in the preferred embodiment the panel 10 may be used in muffler installations for absorbing the sounds of engine exhausts, the panel must therefore be resistant to the heat encountered which, in the case of jet engines, is of relatively high range. To this end the cover plate 18 is formed of stainless steel or other material having high heat resistant characteristics.

Inwardly of the cover 18, the panel 10 is packed with layers of sound absorbing and heat resistant materials in side by side relationship. In the illustrated embodiment, the first such layer comprises a sheet 20 of asbestos fabric or fibers or the sheet 20 may be constructed of glass fibers or other similarly efficient heat resisting elements. The sheet 20 may be disposed elsewhere within the panel and will pass sound waves and, like any porous wall, will absorb some of the sound, but its main purpose is to materially reduce the temperatures of a stream of gases inwardly directed through the plate 18. The sheet 20 is sufficiently thin to vibrate with the plate 18 and provides a covering means to hold the other pack elements in place and not permit particles of the elements to project through the perforations in the plate 18.

Immediately adjacent the other surface of the sheet 20 a pack 22 of relatively dense metallic tinsel is disposed. The term "metallic tinsel" is used herein to denote tangled or interwoven strips, ribbons or wire, including flattened wire sometimes referred to in the field as "scrubble" which is resistant to compression or packing and which has a low flow resistance compared with metal filaments or fibrous material such as steel wool and similar sound-absorbing materials. The metallic tinsel such as copper, stainless steel, Monel metal or copper brass or the like serves to absorb the vibrations of the plate 18 and to dampen translational vibrations of sound waves, dissipating the sound by frictional resistance. The metallic tinsel pack 22 is heat resistant and cooperates with sheet 20 to further reduce the temperature of a stream of gases directed against the panel 10.

A perforate metal plate 24 is disposed adjacent the pack 22 at the side opposite the sheet 20. The sheet 24 is secured at its periphery to the side frames 12 and the end frames 16 and is disposed between the superimposed cross members 14 and may be welded or riveted thereto. The plate 24 is perforated for the same reasons mentioned in connection with plate 18 and here again the thickness of the plate and the size and number of perforations determine the resonating and sound absorbing qualities of the plate. The plate 24 will not be subjected to the temperatures encountered by plate 18 and may therefore be formed of galvanized steel or materials having similar heat resistant characteristics.

A second pack 26 of mineral wool or the like, less densely packed than the metallic tinsel, is disposed adjacent the surface of the plate 24 opposite the pack 22. The mineral wool pack 26 is resistant to heat, but its main purpose is to dissipate and absorb sound waves. Due to the porous nature of the mineral wool, the pack 26, as a result of frictional contact, converts much of the kinetic energy of sound waves to heat energy. The pack 26 also absorbs vibration of the plate 24 caused by sound and shock waves striking thereagainst.

A third perforate plate 28 is disposed against the pack 26 and is secured to the frame elements in the same manner as the plate 18, but on the

opposite open end of the frame. The third plate 28 is perforated for the reasons mentioned in connection with the plates 18 and 24 and the efficiency of the plate can be predetermined by examining its thickness and size and frequency of its perforations. The plate 28 may be constructed of galvanized steel or similar material.

A final resonating chamber 30 is provided adjacent the plate 28 on the side opposite the pack 26 by securing an arcuate cover 32 to the side and end frame members 12 and 16. A reinforcing rib 34 is longitudinally disposed within the panel 10 between the plate 28 and the cover 32 and is secured thereto as by welding. The resonating chamber 30 provides the last sound dissipating chamber in the panel 10 and dissipates those waves which pass through the aforescribed perforate plates and the associated chambers and packs. The chamber 32 requires no pack to absorb the sound waves which should be encountered for most contemplated installations.

It will thus be seen that the panel 10 provides three banks of multiple resonators, each bank comprising a perforate plate and the enclosed resonating space behind the plate. Each plate has a relatively large open area provided by the perforations and thereby passes the higher frequency sound waves for absorption by the associated pack. All of the sound waves passed are not absorbed by the initial pack, but some strike against the next perforate plate to vibrate it and some pass through the perforations in the plate. The packs also provide shock walls for the plates which are contacted and vibrated by the lower frequency sound waves. The band of wave frequencies which each bank or unit, comprising a plate and associated resonator, will absorb is limited by the size and number of perforations, the plate thickness, depth of the resonator and type of sound absorption pack used.

By varying the aforescribed determinants of efficiency and frequency band width for each unit or bank making up the panel 10, the overall wave band of the panel 10 may be substantially predetermined. As a typical example of a construction which has been found to dissipate sound over a relatively wide frequency band, the following dimensional units were used:

Plate 18—14 gauge stainless steel spaced 2" from plate 24 with .140" perforations on .218" center lines

Plate 24—22 gauge galvanized steel spaced 3" with .090" perforations on .125" center lines

Plate 28—20 gauge galvanized steel spaced 3" from the center line of cover member 32 with .108" perforations on .1875" center lines

Cover plate 32—16 gauge galvanized steel
Peripheral dimensions of panel—8 ft. x 3 ft.

The frequency band of the panel 10 is approximately three times the width of the band for each bank because the banks are coupled in a manner similar to coupled band pass filters utilized in other acoustical devices.

In the preferred form which incorporates the heat resistant sheet 20, the panel 10 may be used in muffler installations subjected to relatively high temperatures. For such adaptation, a series of panels 10 are mounted in side abutting relationship, as shown in Figs. 5 and 6. It is, of course, necessary that the panels remain in their fitted relation and do not warp when subjected to heat so, in accordance with this invention, heat expansion joints 36 are spaced along the side members 12.

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The joints 36 comprise slots cut in the frame member 12 to provide for expansion of those members. The spaced ends of the frame members 12 are supported at the joints 36 by means of a plate 38 welded to the under side of the top flange 12-a of one end section of the channel stock. The plate 38 extends into the other end section engaging the under side of its upper flange in sliding relationship. Thus, the frame remains rigid and cannot buckle at any of the heat expansion joints 36.

In a muffler arrangement, as previously mentioned, the panels 10 are mounted in side abutting relationship within a cylindrical duct 40. The panels 10 may also be joined in end to end relationship to provide a muffler of any desired length.

The panels 10 are secured in abutted relation within the duct 40 by means of a plurality of elongated T-shaped beam-like members 42 secured at the stem end to the inner surface of the duct 40. The members 42 have angularly related head flanges 44 which engage the inner surfaces of the bottom flanges 12-b on the side frames 12 of two abutting panels 10. A securing plate 46, having angularly related sides as shown in Fig. 5, may be either permanently or detachably connected in spaced relationship to the head flanges 44 of the T-shaped member 42 for purposes of engaging the side edges of the cover plates 18 of the adjacent panels mounted within the duct 40. Preferably, the engagement of the edge flanges of the side channel members 12 between each head flange 44 and the securing plate 46 is such as to permit limited sliding movement of the panels 10 relative to each other and the T-shaped members 42.

The duct 40 is provided with one T-shaped member 42 between each adjacent pair of panels 10 and the spaces between the T-members 42 and the side channel members 12 on the panels 10 are preferably filled with mineral wool to prevent the ready transmission of heat and sound waves through said spaces. The curved cover 32 which defines the resonating chamber 30 in each panel 10 conforms generally to the contour of the inner surface of the duct 40 and is disposed in sliding engagement with said inner surface of the duct, thus cooperating to position the panels 10 within the duct.

The duct 40 may be of any desired configuration, that is, the duct 40 may be provided with elbow sections to direct the exhaust stream at an angle so that the duct may terminate at any desired location. The elbow sections and exit sections of the duct 40 may be provided with panels 10 in side and end abutting relationship, whereby the entire muffler is lined with acoustical panels capable of absorbing and dissipating the sound produced by the exhaust of a jet engine. A metallic end cover ring 48 conforming to the contours of the joined panels is secured within the duct 40 to present a complete annular wall at the end of the muffler.

The panels 10 may be used to line walls such as an aircraft test cell for sound proofing the cell and for such installations the panels 10 need not incorporate the asbestos sheet 20, as it is unlikely that the panels will be subjected to the temperatures encountered in the aforementioned muffler installations. For adapting the panels 10 for use in flat walls, the side and end frame members 12 and 16 may be abutted in in-line condition, that is, with the flanges of the frame members abutting. When so joined, the panels will provide a flat perforate wall capable of be-

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ing painted in the manner that conventional acoustical wall panels are painted.

As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the language used in the following claims is intended to cover all of the generic and specific features of the invention herein described and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

I claim as my invention:

1. An accoustical panel comprising a plurality of perforate plates in stacked parallel relationship, a layer of sound dissipating packing disposed between each pair of said plates, each layer being formed of unwoven material and being of substantially greater thickness than the plates, and an arcuate imperforate cover member having marginal portions engaged by one of said plates and a body portion in spaced relationship thereto to define a resonating chamber.

2. An accoustical panel comprising a plurality of perforate plates in stacked parallel relationship, a layer of relatively densely packed metallic tinsel disposed between a pair of said plates, a layer of unwoven mineral wool disposed between another pair of said plates, and an imperforate cover member cooperating with the perforate plate farthest removed from said tinsel to define a resonating chamber.

3. An accoustical panel comprising three perforate plates in spaced parallel relation, a layer of metallic tinsel disposed between the first and second plates, a layer of mineral wool disposed between the second and third plates, and an imperforate arcuate cover member having marginal portions adjacent said third plate and its body portion in spaced relation thereto, said layer of metallic tinsel and mineral wool being relatively thick compared to the perforate plates.

4. An accoustical panel comprising means defining an open ended frame structure, a first perforate plate covering one open end of the frame, a second perforate plate inwardly disposed in spaced relation to said first perforate plate, a layer of metallic tinsel disposed between said first and second perforate plates, a third perforate plate covering the other end of the frame, a layer of unwoven mineral wool disposed between said second and third perforate plates, and an imperforate arcuate cover member having marginal portions adjacent said third perforate plate and a body portion in spaced relation thereto.

5. An accoustical panel for installations subjected to high temperature comprising a frame structure, a first perforate plate covering the frame and secured thereto at its marginal portions, a sheet of incombustible fabric disposed adjacent the inner surface of said first plate, a layer of heat resistant metallic tinsel disposed adjacent said fabric, a second perforate plate disposed adjacent said tinsel, a layer of mineral wool disposed adjacent said second perforate plate, a third perforate plate disposed adjacent said wool, closing said frame and secured thereto at its marginal portions, and an imperforate arcuate cover member secured to said frame with

its body in spaced relation to said third perforate plate.

6. A sound panel for installations subjected to high temperatures comprising a frame structure having open ends, a first perforate plate covering one open end of said frame and secured thereto at its marginal portions, an asbestos sheet disposed adjacent the inner surface of said plate, a layer of copper tinsel disposed inwardly of said sheet, a second perforate plate adjacent said tinsel secured to the frame, a layer of mineral wool disposed inwardly of said second perforate plate, a third perforate plate closing the open end of the frame and secured thereto at its marginal portions, an imperforate arcuate cover member secured to said frame with its body in spaced relation to said third perforate plate, and reinforcing means transversely disposed in said frame and secured thereto.

7. An acoustic panel comprising an open ended frame structure, three perforate plates disposed in the frame in spaced parallel relationship cooperating with the frame to define a pair of resonating chambers in side-by-side relationship, the outermost plates closing the ends of said frame, a layer of fine copper tinsel disposed in the first of said resonating chambers, a layer of mineral wool in the second of said resonating chambers, reinforcing means transversely secured to said frame in each of said resonating chambers, an imperforate arcuate cover member secured to said frame having a body portion in spaced relationship to one of said perforate plates to define a third resonating chamber therewith in side-by-side relationship to the second resonating chamber, and reinforcing means secured to said frame in said third resonating chamber.

8. An acoustical panel capable of dissipating sounds over a relatively wide band of mingled frequencies comprising a plurality of perforate plates in stacked parallel relationship, a relatively thick layer of sound dissipating packing disposed between each pair of said plates, and an imperforate arcuate cover member having marginal portions engaged by one of said plates, said plates being formed of sheet metal of varying thicknesses, and having perforations of predetermined size and spacing varying from plate to plate whereby each plate and associated packing element as a unit is capable of dissipating sound waves of frequencies within a predetermined band differing from the band of each other plate and associated packing element.

9. In a sound muffler for attenuating the sound of an engine exhaust stream, a duct forming a passageway for the exhaust stream, and a lining for said duct comprising an acoustical panel in the duct having a plurality of relatively rigid perforated metal plates arranged in spaced apart parallel relationship disposed with an outer plate in contact with and parallel to the flow of the exhaust stream through the duct, a relatively thick layer of unwoven inorganic fibrous material between said plates, and a layer of metallic tinsel for protecting the layer of fibrous material disposed along the interior surface of the said outer plate.

10. An acoustical panel for use in sound-absorbing ducts and the like and capable of withstanding the extreme velocity and temperature conditions encountered in the exhaust stream of a jet engine and effective for attenuating sound varying over a wide frequency range comprising a rectangular frame, front and back cover plates

on said frame comprising flat and rigid metallic plates of relatively heavy gage for withstanding said velocity and temperature conditions, both of said plates having spaced apart perforations therein for the passage of sound waves there-through, and a filler between said plates capable of withstanding said velocity and temperature conditions and attenuating sound comprising a relatively thick layer of metallic tinsel adjacent the front cover plate and a relatively thick layer of unwoven inorganic fibrous material behind the layer of tinsel.

11. A duct as defined in claim 9, in which said acoustical panel lining is spaced from the duct wall to form a resonating chamber therebetween.

12. An acoustical panel capable of withstanding the extreme velocity and temperature conditions encountered in the exhaust stream of a jet engine and capable of dissipating sounds over a relatively wide band of mingled frequencies, comprising a front sheet metal plate for facing the exhaust stream and at least two additional flat sheet metal plates rearwardly thereof in spaced-apart parallel relationship, said sheet metal plates being perforated throughout and at least one of said plates being of different gage, a porous filler of sinuously arranged inorganic material which is pervious to sound but resistant to gas flow disposed between the front plate and the next adjacent rear plate, and a layer of acoustically absorbent unwoven inorganic fibrous material between the two rear sheet metal plates.

13. An acoustical panel capable of withstanding the extreme velocity and temperature conditions encountered in the exhaust stream of a jet engine and capable of dissipating sounds over a relatively wide band of mingled frequencies, comprising a front sheet metal plate for facing the exhaust stream and at least two additional flat sheet metal plates rearwardly thereof in spaced-apart parallel relationship, said sheet metal plates being perforated throughout and at least one of said plates having perforations of different size, a porous filler of sinuously arranged inorganic material which is pervious to sound but resistant to gas flow disposed between the front plate and the next adjacent rear plate, and a layer of acoustically absorbent unwoven inorganic fibrous material between the two rear sheet metal plates.

14. An acoustical panel capable of withstanding the extreme velocity and temperature conditions encountered in the exhaust stream of a jet engine and capable of dissipating sounds over a relatively wide band of mingled frequencies, comprising a front sheet metal plate for facing the exhaust stream and at least two additional flat sheet metal plates rearwardly thereof in spaced-apart parallel relationship, said sheet metal plates being formed of sheet metal of varying thicknesses and having perforations of predetermined size and spacing varying from plate to plate, a porous filler of sinuously arranged inorganic material which is pervious to sound but resistant to gas flow disposed between the front plate and the next adjacent rear plate, and a layer of acoustically absorbent unwoven inorganic fibrous material between the two rear sheet metal plates.

15. An acoustical panel capable of withstanding the extreme velocity and temperature conditions encountered in the exhaust stream of a jet engine and capable of dissipating sounds over a relatively wide band of mingled frequencies, comprising a front sheet metal plate for facing

the exhaust stream and at least two additional flat sheet metal plates rearwardly thereof in spaced-apart parallel relationship, said sheet metal plates being perforated throughout, a porous filler of sinuously arranged inorganic material which is pervious to sound but resistant to gas flow disposed between the front plate and the next adjacent rear plate, a layer of acoustically absorbent unwoven inorganic fibrous material between the two rear sheet metal plates, and an imperforate rear cover member spaced from the rearmost perforated plate and cooperating therewith to form a resonating chamber therebetween.

16. In a sound muffler for attenuating the sound of an exhaust stream, a duct forming a passageway for the exhaust stream, and a lining for said duct comprising an acoustical panel adjacent the periphery of the duct having an outer sheet metal plate in contact with and parallel to the flow of the exhaust stream through the duct and at least two additional flat sheet metal plates rearwardly thereof in spaced-apart parallel relationship, said sheet metal plates being formed of sheet metal of varying thicknesses having perforations of predetermined size and spacing varying from plate to plate, a porous filler of sinuously arranged inorganic material which is pervious to sound but resistant to gas flow disposed between the outer plate and the next adjacent rear plate and a layer of acoustically absorbent unwoven inorganic fibrous material between the two rear sheet metal plates.

17. An acoustical panel capable of withstanding the extreme velocity and temperature conditions encountered in the exhaust stream of a jet

engine and capable of dissipating sounds over a wide band of mingled frequencies comprising parallel front and rear cover plates formed of sheet metal of relatively heavy gage and perforated throughout, a relatively thick layer of acoustically absorbent unwoven inorganic fibrous material disposed at the inner face of the rear cover plate, a perforate retaining wall for the said layer spaced from and parallel to the rear cover plate, and a porous layer of sinuously arranged inorganic material pervious to sound but having high resistance to gas flow disposed between the front cover plate and said retaining wall including a glass fiber sheet.

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