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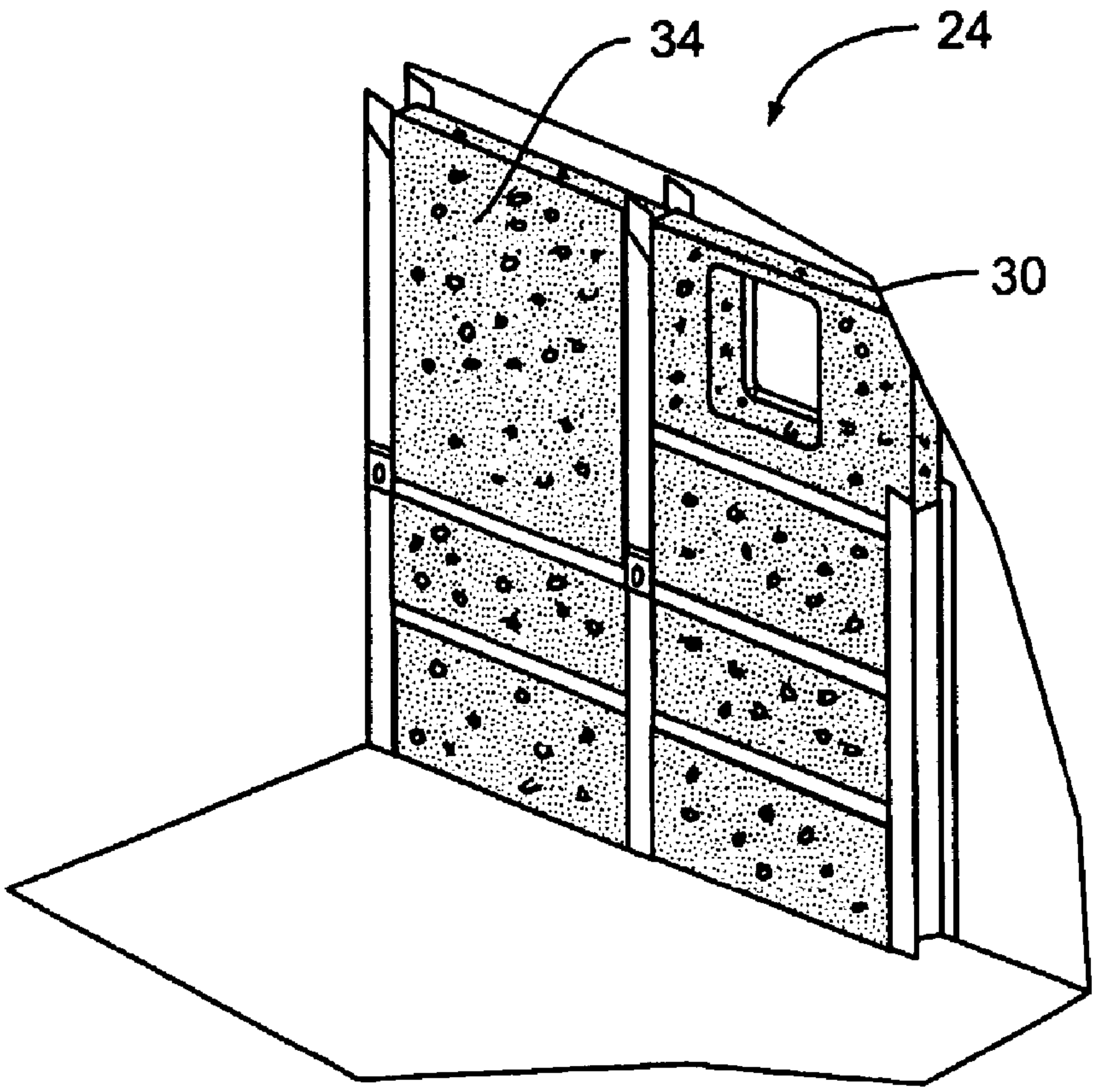
(54) Title: ACOUSTIC ABSORPTION SYSTEM FOR AN AIRCRAFT AIRFRAME



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An acoustic absorption system fills each frame void within an airframe section with a close fitting foam portion. A mass barrier layer is adhered over the foam portions and to a multitude of frame members. The mass barrier layer is a contiguous layer adhered across the multitude of frame members to seal the airframe frame voids to make use of mass-air-mass principles to reduce flanking path leakage around the foam portions.

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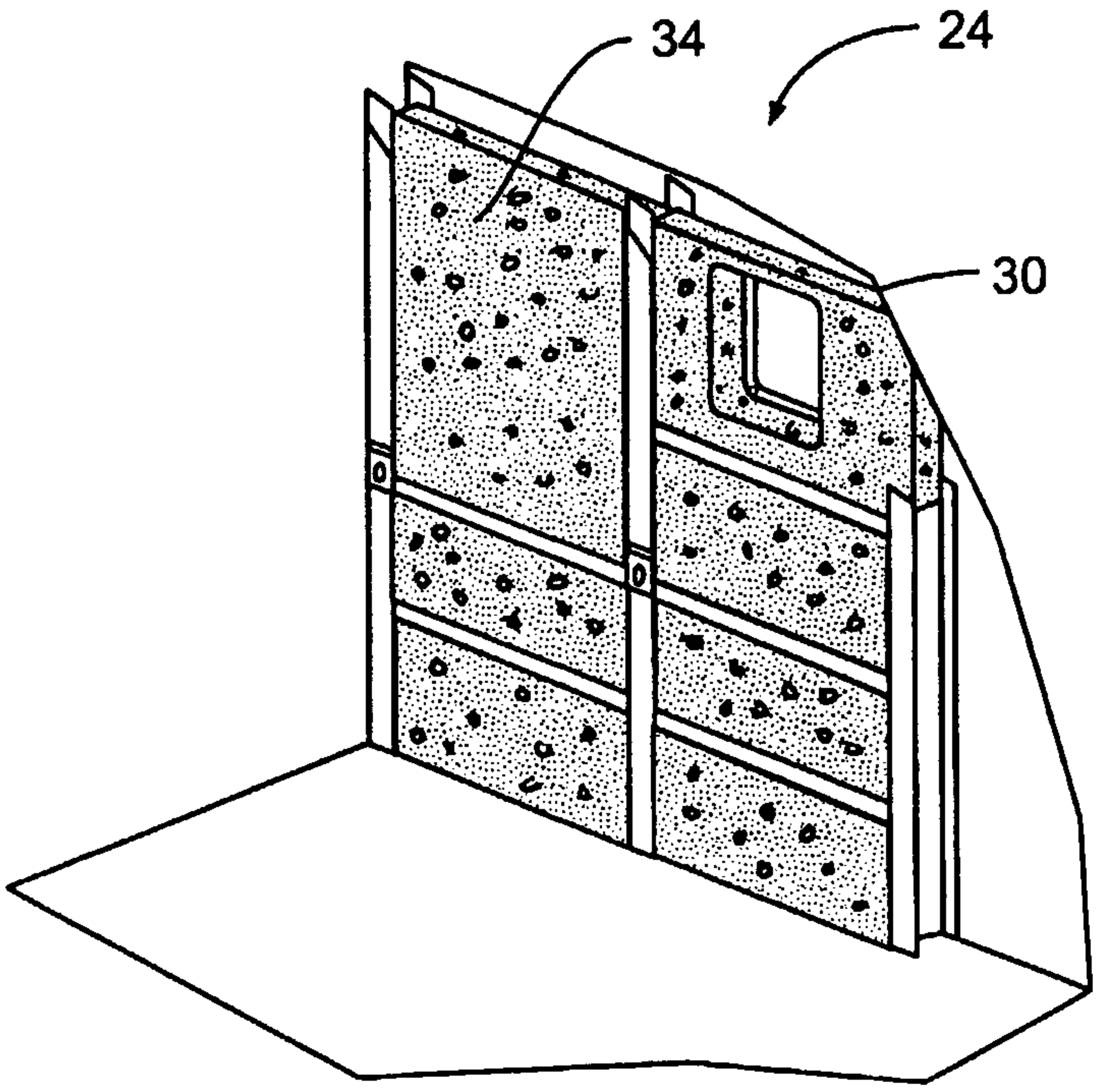
(54) **Title:** ACOUSTIC ABSORPTION SYSTEM FOR AN AIRCRAFT AIRFRAME



(57) Abstract: An acoustic absorption system fills each frame void within an airframe section with a close fitting foam portion. A mass barrier layer is adhered over the foam portions and to a multitude of frame members. The mass barrier layer is a contiguous layer adhered across the multitude of frame members to seal the airframe frame voids to make use of mass-air-mass principles to reduce flanking path leakage around the foam portions.

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ACOUSTIC ABSORPTION SYSTEM FOR AN AIRCRAFT AIRFRAME

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a noise reduction treatment for an aircraft cabin, and more particularly to a lightweight acoustic absorption system which is mounted within an airframe subcomponent to reduce aircraft interior noise levels.

[0002] Noise develops in an aircraft cabin from several sources. The most common sources are internally or externally mounted moving components, such as a transmission, engine or rotor system. Another source of cabin noise is airflow over various aircraft fuselage components. These components generate vibrations in the aircraft that propagate through the airframe and radiate into the cabin.

[0003] Noise may be a particular problem in rotary wing aircraft cabins since the rotor and transmission systems produce a significant amount of vibration directly into the airframe structure. This problem may be more pronounces in rotary wing aircraft than in fixed wing aircraft inasmuch as the dynamic components on a rotary wing aircraft are typically mounted directly above the cabin.

[0004] The main noise problem in helicopter cabins is mid to high frequency gear whine noise from the main transmission. This results in cabin noise vibrations typically from about 350 Hz through 4,000 Hz. In contrast, noise vibrations from the main and tail rotor sources are in the 20 Hz to 125 Hz range and are attenuated by up to 40+ dB by the response of the human ear.

[0005] Aircraft cabin interiors are generally designed to maintain aircraft interior noise below a certain level predetermined by competitive pressures in the marketplace. For example, executive transport rotary wing aircraft typically provide a design average noise level limit with the environmental control system (fans, vent air and cooling/heating system) turned off of approximately 75 dB SIL4. The SIL4 (Speech Interference Level 4) noise measurement metric is the arithmetic average of the sound pressure levels in the 500, 1000, 2000 and 4000 Hz octave bands. It rates steady noise according to interference with conversation between two people.

[0006] Various known acoustic absorption systems have been provided to reduce noise levels within the cabin to below desired SIL4 values. One known acoustic absorption system hangs bags stuffed with loose acoustic batting between frame members of the airframe as a primary determinant of aircraft interior noise levels is the response of the airframe to vibration excitation. Disadvantageously, such batting is relatively heavy in weight and provides minimal noise attenuation within rotary wing aircraft due to inherent flanking path leakage around the batting coupled with the complex frequency structure and the intense amplitudes of the aircraft transmission gear noise signatures.

[0007] Accordingly, it is desirable to provide an effective lightweight acoustic absorption system which may be installed within an airframe for reducing noise within an aircraft cabin.

SUMMARY OF THE INVENTION

[0008] An acoustic absorption system according to the present invention fills voids between airframe frame members within an airframe section with a close fitting foam portion. The foam portions are each interference or "force" fit into the voids to completely fill each of the frame voids. A mass barrier layer is adhered over the foam portions and to the multitude of frame members. The mass barrier layer is a contiguous layer adhered across the multitude of frame members to seal the airframe frame member voids to make use of mass-air-mass principles which reduce flanking path leakage around the foam portions.

[0009] The present invention therefore provides an effective lightweight acoustic absorption system which may be installed within an airframe for reducing noise within an aircraft cabin.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The various features and advantages of this invention will become apparent to those skilled in the art from the following detailed description of the currently preferred embodiment. The drawings that accompany the detailed description can be briefly described as follows:

[0011] Figure 1 is a general perspective view an exemplary rotary wing aircraft embodiment for use with the present invention;

[0012] Figure 2 is a plan view of an airframe section for use with an acoustic absorption system of the present invention;

[0013] Figure 3 is a plan view of an airframe section with foam portions which completely fill in frame voids within the airframe panel;

[0014] Figure 4 is a plan view of an airframe section with a mass barrier layer adhered over the foam portions and the airframe panel;

[0015] Figure 5 is a sectional view of the airframe section of Figure 4 taken along ht line 5-5 in Figure 4;

[0016] Figure 6A is a graphical representation of the acoustic reductions provided by an acoustic absorption system according to the present invention adjacent a window opening; and

[0017] Figure 6B is a graphical representation of the acoustic reductions provided by an acoustic absorption system throughout the airframe section according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0018] Figure 1 schematically illustrates a rotary-wing aircraft 10 having a main rotor assembly 12. The aircraft 10 includes an airframe 14 having an extending tail 16 which mounts an anti-torque rotor 18. The main rotor assembly 12 is driven through a transmission (illustrated schematically at 20) by one or more engines 22. Although a particular helicopter configuration is illustrated in the disclosed embodiment, other machines such as turbo-props, tilt-rotor and tilt-wing aircraft will also benefit from the present invention.

[0019] Referring to Figure 2, an airframe section 24 within a cabin of the rotary wing aircraft includes a multitude of frame members 26 which support an outer skin 28. The airframe section 24 is the outer structure of the aircraft 10 and may include one or more window area 30. The window areas 30 are typically located through the outer skin 28 between the multitude of frame members 26. The multitude of frame members 26 are typically arranged in a rectilinear pattern, however, any arrangement may be used with the present invention. The multitude of frame members 26 defines a multiple of frame voids 32. The frame voids 32 are effectively spaces adjacent the outer skin 28 for a depth defined by the frame members 26.

[0020] Referring to Figure 3, an acoustic absorption system 31 according to the present invention fills each of the frame voids 32 with a foam portion 34. The foam portion 34 is preferably a Polyimide Foam, Solimide, such as Degussa AG Solimide® TA-301 Polyimide Foam which is a lightweight foam that had both fire-resistant and posse's acoustical properties. Solimide foam commonly used in military applications and is also known as MIL-T-24708.

[0021] The foam portions 34 are each interference or "force" fit into the frame voids 32. That is, the foam portions 34 are shaped to completely fill each of the frame voids 32. Most preferably, each foam portion 34 is shaped to be larger than the particular void, then force fit into the void 32 between the multitude of frame members 26 which surround that void 32. Applicant has determined that interference or "force" fit into the frame voids 32 provides significant unexpected advantages over conventional aircraft noise insulation.

[0022] Referring to Figure 4, once each of the frame voids 32 are filled with foam portions 34, a mass barrier layer 36 is adhered over the foam portions 34 and to the multitude of frame members 26. The mass barrier layer 36 is preferably a single layer of virgin (high grade) vinyl which is mass loaded with barium sulfate powder, or similar dense material to increase its mass, and has a thickness of approximately 1/16 to 1/4 inches such as DURASONIC manufactured by Duracoat Corp. of Riverside, CA, U.S.A. While vinyl is the preferred material because of its limpness, high inherent damping and relatively high density, the mass barrier layer 36 can be made from a variety of alternate materials, such as silicone or rubber sheet material. The materials used are selected on the basis of limpness, lowest stiffness, high relative surface density, resistance to fire, low levels of toxic fume emission when exposed to flame, expense, etc.

[0023] The mass barrier layer 36 is a contiguous layer adhered across the multitude of frame members 26 to seal the airframe frame voids 32 to make use of mass-air-mass principles which reduce flanking path leakage around the foam portions 34 (Figure 5). The foam portions 34 mounted about the window areas 30 operate as a termination locators for attachment of the mass barrier layer 36.

[0024] Referring to Figures 6A and 6B, the effect of the acoustic absorption system 31 made in accordance with the present invention is illustrated in graphic format. Proof of concept testing was performed on an airframe section installed between Reverberation and Anechoic Chambers. The airframe section was subjected to noise and vibration excitation towards reproducing the conditions encountered during flight and measurements were made to determine the levels of noise radiating into the cabin area from the bare frame. When the airframe section was provided with the acoustic absorption system 31 about the window openings alone, testing (Figure 6A) has indicated that the present invention has provided an average noise level reduction on approximately 8 dBA reduction in the amount of leakage around the window area 30. When the entire airframe section was provided with the acoustic absorption system 31 testing (Figure 6B) has indicated that the present invention has provided an average noise level reduction on approximately 7.3 dBA from a mass barrier later equipped airframe section with minimal weight increase.

[0025] Although particular step sequences are shown, described, and claimed, it should be understood that steps may be performed in any order, separated or combined unless otherwise indicated and will still benefit from the present invention.

[0026] The foregoing description is exemplary rather than defined by the limitations within. Many modifications and variations of the present invention are possible in light of the above teachings. The preferred embodiments of this invention have been disclosed, however, one of ordinary skill in the art would recognize that certain modifications would come within the scope of this invention. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described. For that reason the following claims should be studied to determine the true scope and content of this invention.

CLAIMS

What is claimed is:

1. An acoustic absorption system for an airframe section comprising:

a foam portion which fills a void between a multitude of airframe frame members; and

a mass barrier layer mounted to said multitude of airframe frame members to at least partially enclose said foam portion.

2. The acoustic absorption system as recited in claim 1, wherein said foam portion includes polyimide foam.

3. The acoustic absorption system as recited in claim 1, wherein said mass barrier portion includes a vinyl which is mass loaded with a barium sulfate powder.

4. The acoustic absorption system as recited in claim 1, wherein said foam portion completely fill said void.

5. The acoustic absorption system as recited in claim 1, wherein said foam portion provides an interference fit within said void.

6. The acoustic absorption system as recited in claim 1, wherein said foam portion provides an interference fit between a multitude of frame members.

7. An airframe section comprising:

an airframe component having a multitude of frame members which define a void;

a foam portion which provides an interference fit with said multitude of frame members; and

a mass barrier layer mounted to said multitude of frame members.

8. The airframe section as recited in claim 7, wherein said foam portion includes polyimide foam.

9. The airframe section as recited in claim 7, wherein said mass barrier layer includes a vinyl which is mass loaded with a barium sulfate powder.

10. The airframe section as recited in claim 7, wherein said foam portion completely fill said void.

11. The airframe section as recited in claim 7, wherein said airframe component includes a window area, said foam portion surrounding said window area.

12. The airframe section as recited in claim 7, wherein said mass barrier layer is a contiguous layer which covers a multitude of said foam portions.

13. The airframe section as recited in claim 7, wherein said mass barrier layer is adhered to said foam portion and said multitude of frame members.

14. An airframe section comprising:

an airframe component having a multitude of frame members which define a void;

an outer skin mounted to said multitude of frame members, said outer skin defining a window area therethrough;

a foam portion mounted about said window area; and

a mass barrier layer mounted to said foam portion.

15. The airframe section as recited in claim 14, wherein said mass barrier layer is adhered to said foam portion and said multitude of frame members.

16. The airframe section as recited in claim 14, wherein said foam portion provides an interference fit with said multitude of frame members.

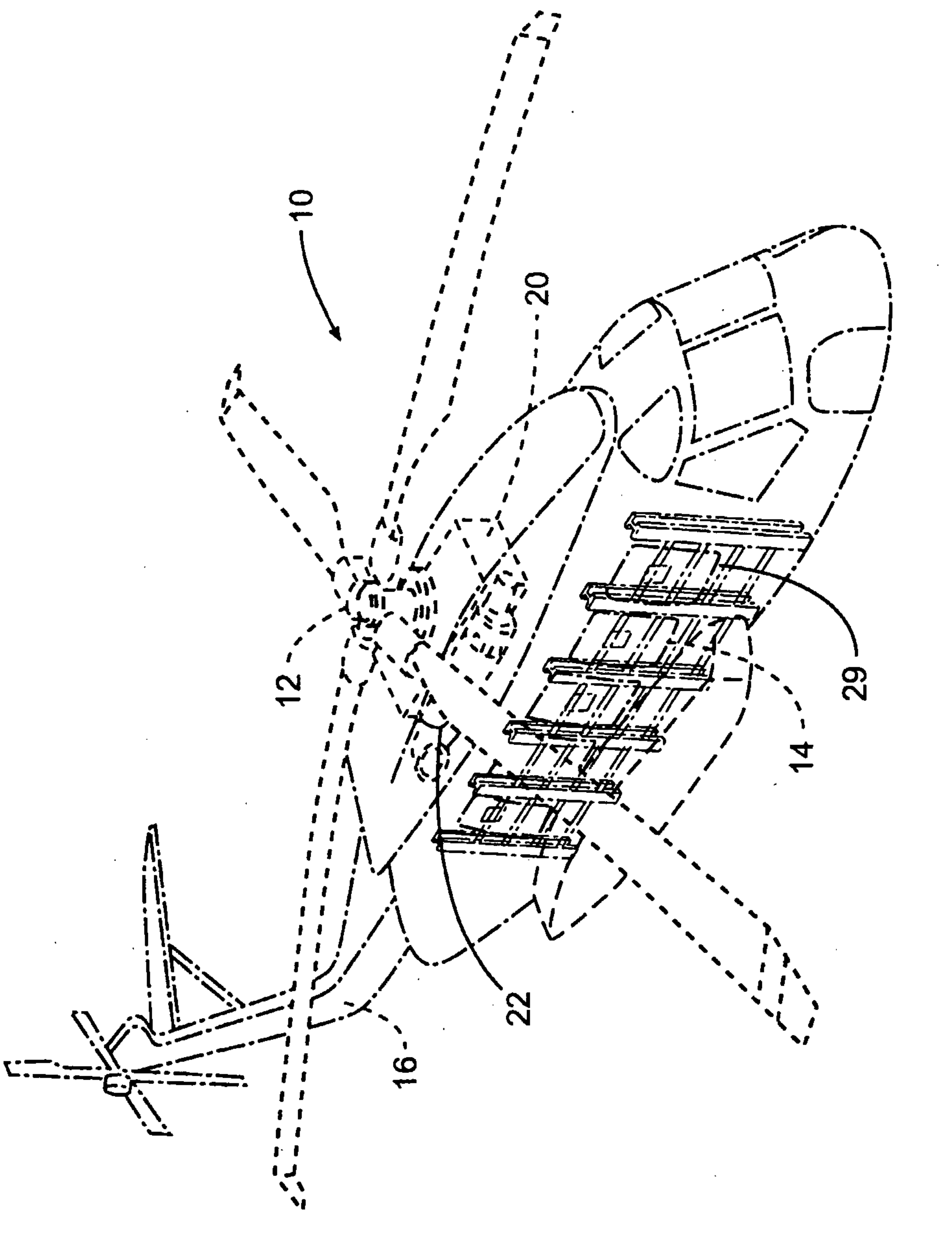


FIG. 1

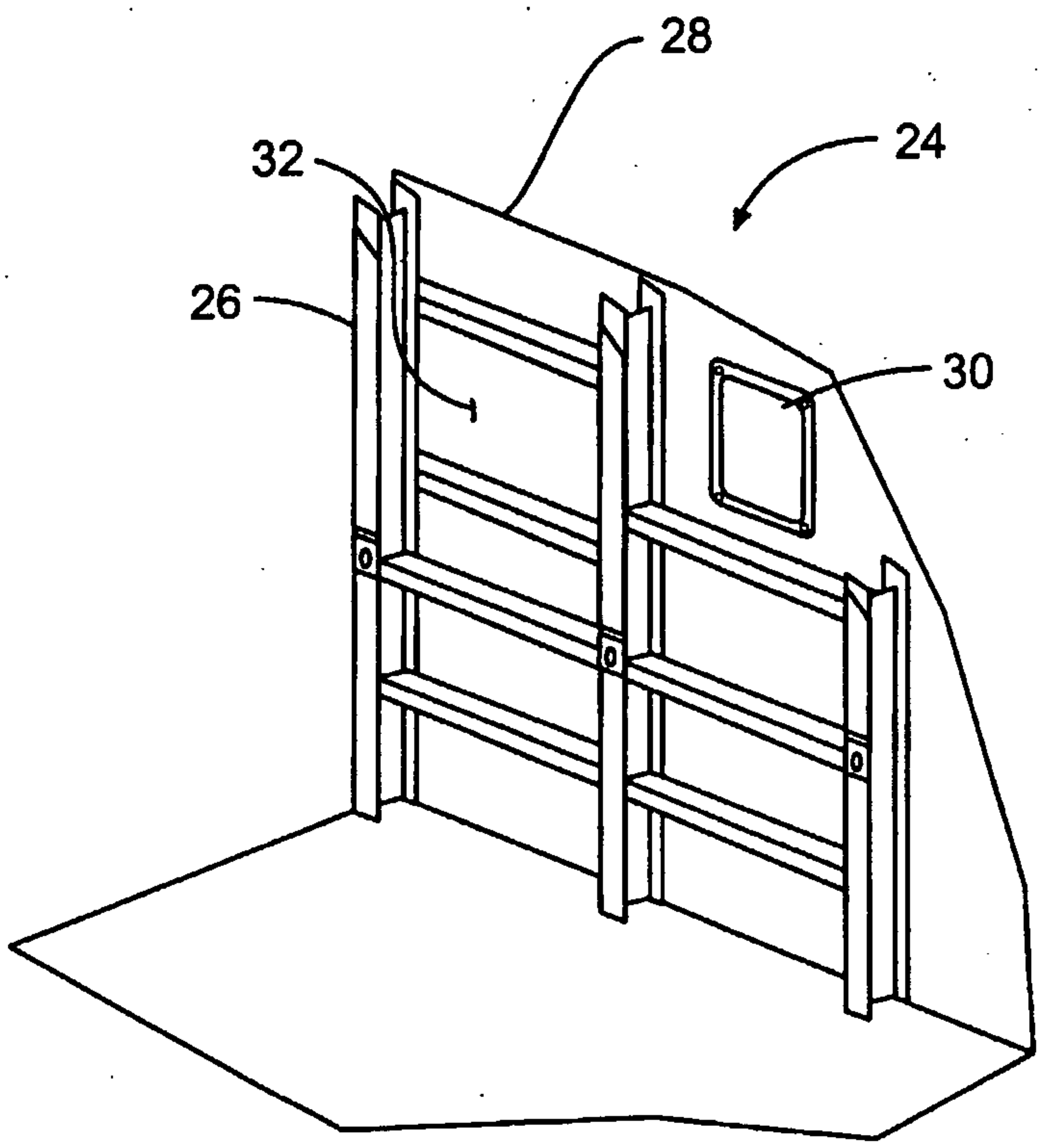


FIG. 2

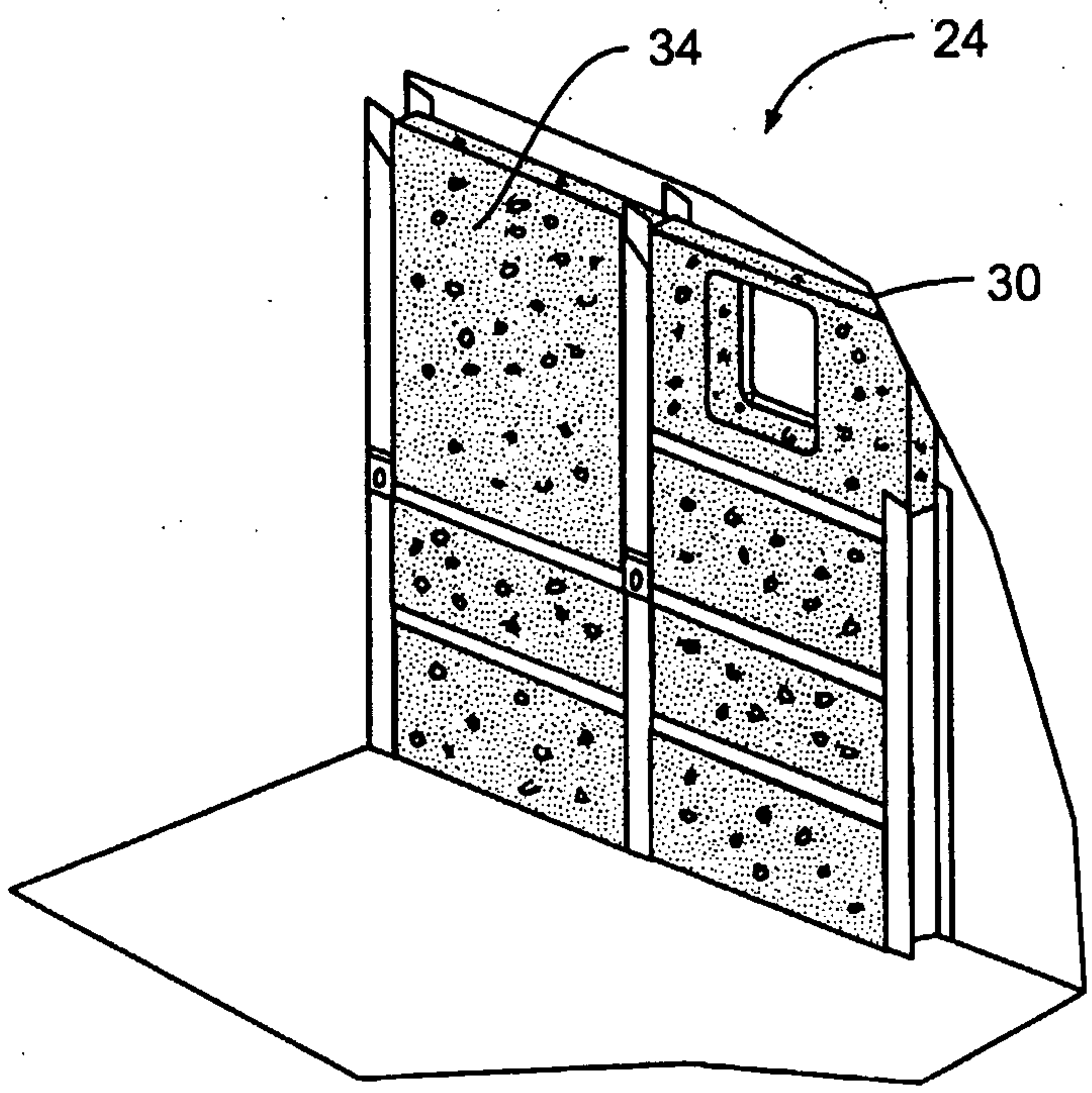


FIG. 3

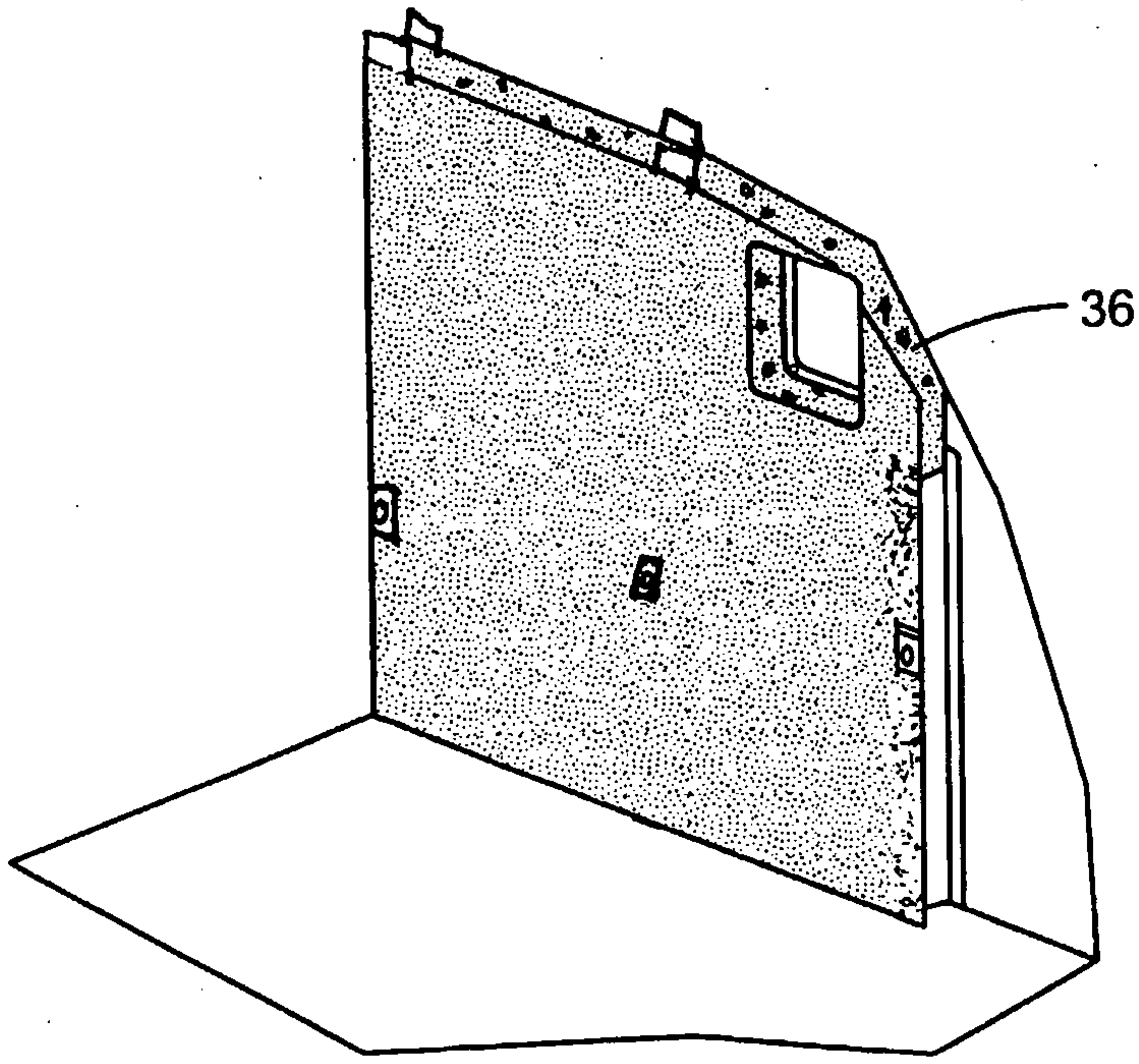


FIG. 4

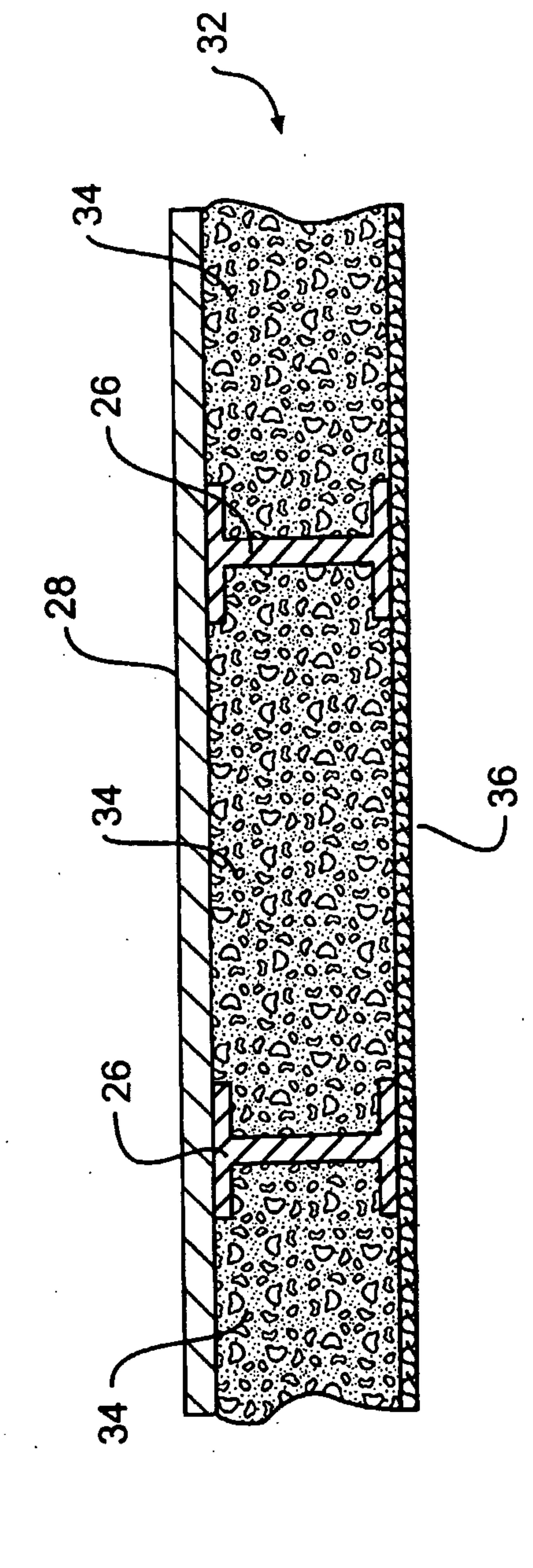


FIG. 5

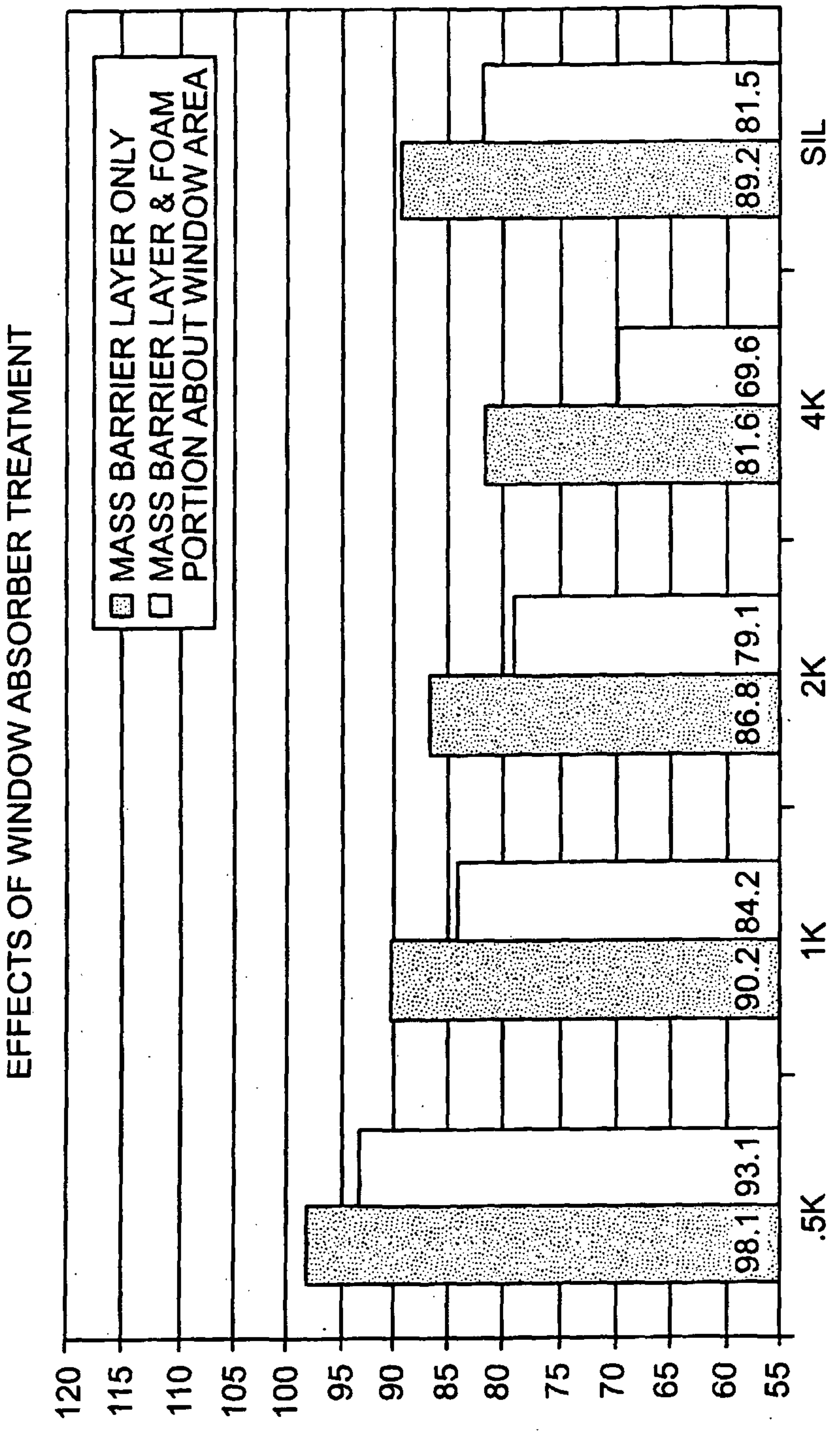

EFFECTS OF WINDOW ABSORBER TREATMENT
MASS BARRIER LAYER ONLY
MASS BARRIER LAYER & FOAM PORTION ABOUT WINDOW AREA
120
115
110
105
100
95
90
85
80
75
70
65
60
55
98.1
93.1
90.2
84.2
86.8
79.1
81.6
69.6
89.2
81.5
.5K
1K
2K
4K
SIL

FIG. 6A

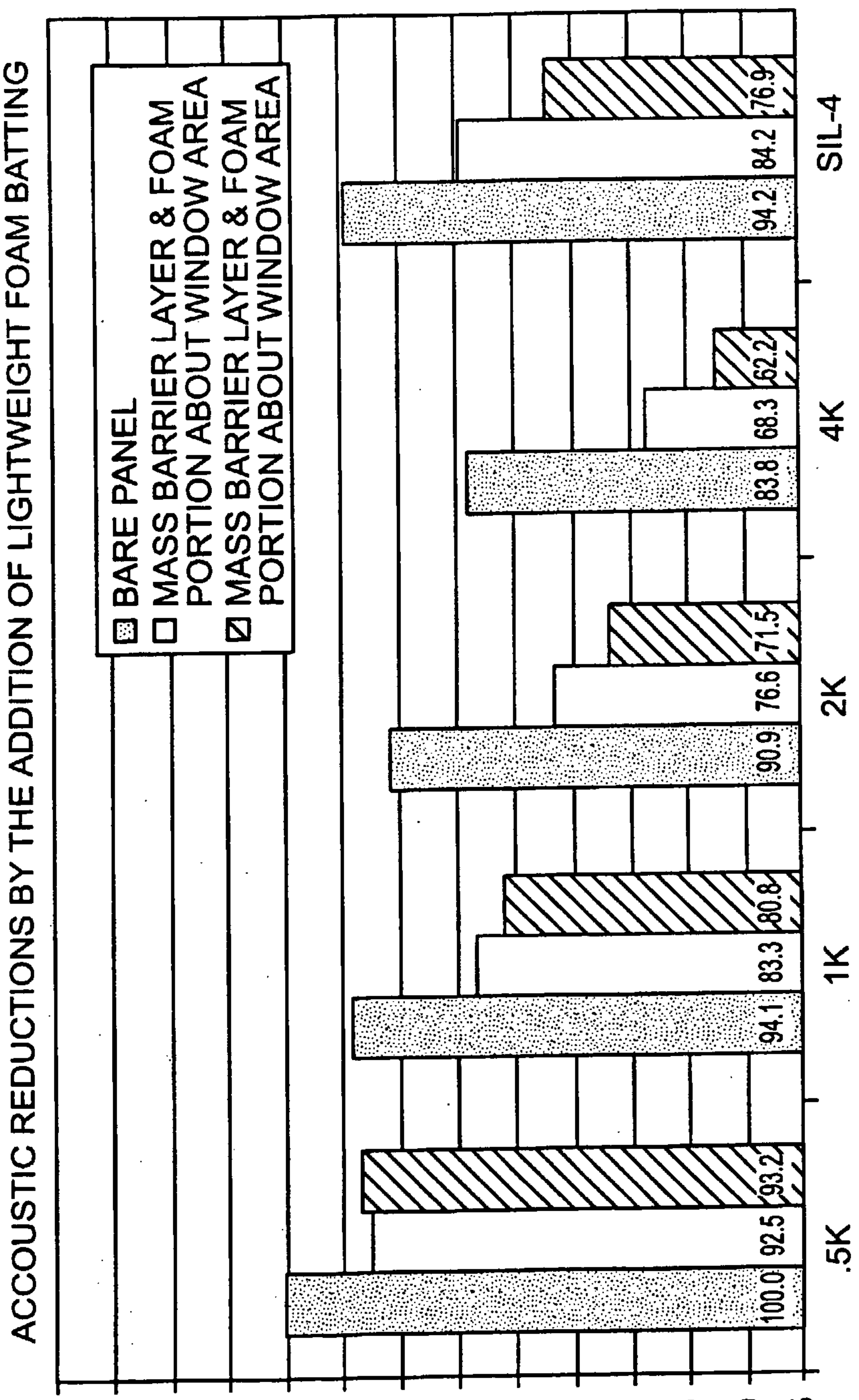
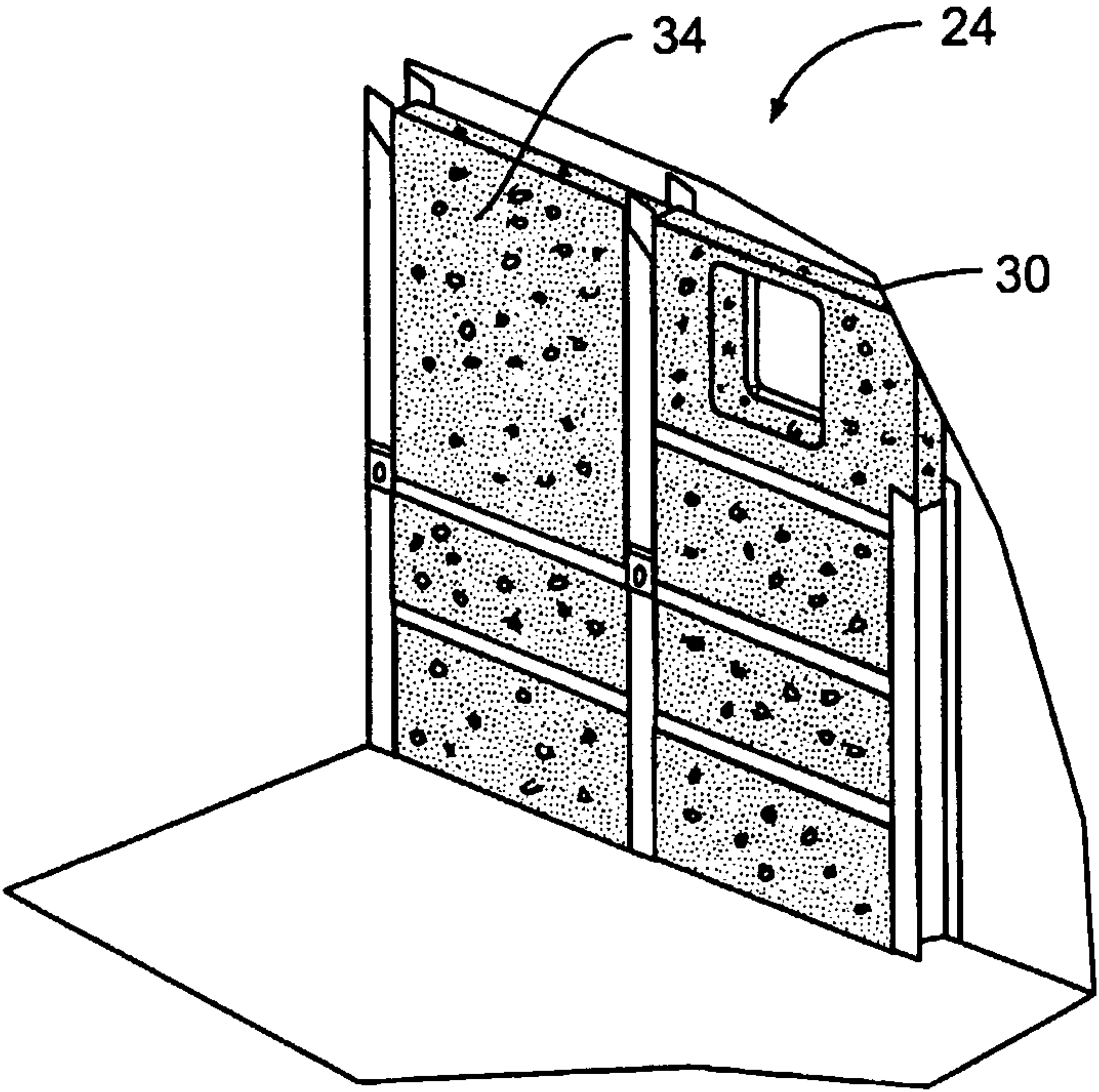

ACCOUSTIC REDUCTIONS BY THE ADDITION OF LIGHTWEIGHT FOAM BATTING
BARE PANEL
MASS BARRIER LAYER & FOAM PORTION ABOUT WINDOW AREA
MASS BARRIER LAYER & FOAM PORTION ABOUT WINDOW AREA
120
115
110
105
100
95
90
85
80
75
70
65
60
55
100.0
92.5
93.2
94.1
83.3
80.8
90.9
76.6
71.5
83.8
68.3
62.2
94.2
84.2
76.9
.5K
1K
2K
4K
SIL-4

FIG. 6B


34
24
30