

TITLE OF INVENTION: ACOUSTIC SHIELD FOR A WINDOW

FIELD

[0001] The present invention is generally directed to noise control systems, and is in particular directed to an acoustic shield for a window. While the present invention will be described with respect to its application for building windows, it is to be appreciated that the present invention is not restricted to this application, and other applications are also envisaged.

BACKGROUND

[0002] The following discussion of the background to the invention is intended to facilitate an understanding of the present invention only. It should be appreciated that the discussion is not an acknowledgement or admission that any of the material referred to was published, known or part of the common general knowledge of the person skilled in the art in any jurisdiction as at the priority date of the invention.

[0003] An increasingly common problem associated with living within an urbanised environment is the amount of external noise that can be experienced by residents living within that urban environment. Typical noise sources include traffic noise from motor vehicles, and from public transport such as trains and buses, industrial and city activities such as building construction, road works, and noise from entertainment venues. Due to site constraints, it may not always be possible to setback buildings to reduce levels. At the same, there is a need to comply with authority regulations which restricts the noise level. Residents living close to such noise producing sources will therefore need some form of noise control to minimise the amount of noise within their internal living environment.

[0004] Much of the noise enters though the exterior windows of a building, particularly when they are open to allow for natural ventilation into the internal living environment. Therefore, common noise reduction solutions include the use of rubber gaskets to seal the air gap around external windows, or through the use of double or triple glazing of external windows to provide a noise barrier. These current noise reduction solutions have the common disadvantage of being only effective when the

windows are fully closed. This then prevents natural ventilation from air passing through the window opening into the internal living environment. This can be a greater problem in hotter climates such as in Singapore in which residents benefit from such natural ventilation to provide a degree of cooling within their internal living environment. The closing of the windows will require the use of alternative cooling methods including the use of air-conditioning leading to increased electric usage.

[0005] Much of the noise within an urban environment comes from traffic noise generated by car engines and road-tyre friction, and from public transport such as buses and above ground trains. This noise typically falls within the frequency range of between 800 to 1600 hz, and it would be advantageous for any noise reduction technology to target noise within that frequency range.

[0006] It would therefore be advantageous to be able to provide noise reduction through a window when open while at the same time allowing for natural ventilation through the window.

[0007] It would also be preferably advantageous to have noise reduction that targets the frequency range of between 800 to 1600 Hz.

SUMMARY

[0008] According to an aspect of the present invention, there is provided an acoustic shield for a window, including:

one or more acoustic cavity modules locatable over at least a portion of the opening of the window, the or each module providing at least one resonance opening for reducing an overall sound pressure level of sound waves passing through the resonance opening while allowing an air flow to also pass therethrough, the acoustic cavity module including a plurality of plates aligned in a generally parallel and adjacent configuration such that a resonance cavity is defined between each pair of plates, each plate having at least one aperture, the aperture(s) of each plate together providing the resonance opening(s) of the module;

wherein the or each acoustic cavity module is designed to trap noise frequencies of between 800 to 1600Hz.

[0009] In some embodiments, the apertures of each of the plates are respectively aligned within the acoustic cavity module(s).

[0010] In some embodiments, the plates and the aperture provided within each said plate is generally rectilinear in shape.

[0011] In some embodiments, the aperture of each said plate provides an opening ratio of between 25 to 30%.

[0012] In some embodiments, at least one of the plates is at least partially formed from a porous material.

[0013] In some embodiments, at least one of the plates are provided with projections extending from at least one face thereof.

[0014] In some embodiments, at least one plate comprises a combination of portions made from porous material, and portions having projections extending therefrom.

[0015] In some embodiments, the resonance chamber provides an internal noise trap therein.

[0016] In some embodiments, the internal noise trap is provided at an internal peripheral area of the resonance cavity.

[0017] In some embodiments, the internal noise trap comprises opposing elongate tapered channels respectively provided at a corner of the peripheral area.

[0018] In some embodiments, the internal noise trap comprises an elongate rectilinear cavity extending between corners of the peripheral area.

[0019] In some embodiments, the acoustic cavity module(s) comprises three said plates.

[0020] In some embodiments, the aperture has a rectilinear shape having a dimension of 0.107m on each side thereof.

[0021] In some embodiments, the plate is rectilinear in shape and has an external dimension of 0.254m in height and 0.184m in width.

[0022] In some embodiments, the acoustic cavity module has an overall thickness of 0.046m.

[0023] In some embodiments, the acoustic shield comprises at least one acoustic metamaterial panel locatable over at least a portion of the window opening, the acoustic metamaterial panel comprising a plurality of the acoustic cavity modules.

[0024] In some embodiments, the acoustic shield comprises a plurality of the acoustic metamaterial panels, the panels being respectively joined by one or more hinge members to allow for folding of the acoustic shield.

[0025] In some embodiments, the acoustic shield further provides a safety grille for the window.

[0026] In some embodiments, the acoustic cavity module comprises at least one engagement arrangement provided at an external surface of the acoustic cavity module for engaging on or more bars of a window safety grille.

[0027] In some embodiments, the engagement arrangement comprises a pair of U shaped resilient members secured to opposing sides of the acoustic cavity module.

[0028] Other aspects and features will become apparent to those of ordinary skill in the art upon review of the following description of specific embodiments in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] In the figures, which illustrate, by way of example only, embodiments of the present invention,

[0030] [Figure 1] is respectively a front view of an acoustic metamaterial panel, and a perspective view of an acoustic cavity module according to the present disclosure;

[0031] [Figure 2] is a graph showing the predicted and experimental data performance of the acoustic cavity module shown in Fig. 1 in trapping noise frequencies;

[0032] [Figure 3] are photographs of the experimental setup used to test the performance of the acoustic metamaterial panel of Fig. 1;

[0033] [Figure 4] is a graph showing the additional noise reduction measured of the acoustic test panel using the test setup as shown in Fig. 3 when compared to a window opening of similar area;

[0034] [Figure 5] shows an embodiment of an acoustic window shield according to the present disclosure mounted on a window;

[0035] [Figures 6a to 6c] respectively show the acoustic window shield of [Fig. 5] in a fully retracted, partially extended and fully extended position;

[0036] [Figures 7] respectively show further embodiments of an acoustic window shield according to the present disclosure;

[0037] [Figure 8] shows another embodiment of an acoustic window shield according to the present disclosure;

[0038] [Figure 9a and 9b] shows an embodiment of the acoustic cavity modules according to the present disclosure installed within an existing window grille;

[0039] [Figure 10a to 10c] respectively show alternative plates configurations for an acoustic cavity module according to the present disclosure; and

[0040] [Figure 11] show alternative embodiments of noise traps for the acoustic cavity modules according to the present disclosure.

DETAILED DESCRIPTION

[0041] Throughout this document, unless otherwise indicated to the contrary, the terms “comprising”, “consisting of”, “having” and the like, are to be construed as non-exhaustive, or in other words, as meaning “including, but not limited to”.

[0042] Furthermore, throughout the specification, unless the context requires otherwise, the word “include” or variations such as “includes” or “including” will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

[0043] The acoustic window shield 1 according to the present disclosure may be used to reduce the overall sound pressure level of the noise entering though an open window while at the same time allowing for airflow therethrough to provide natural ventilation though that window. This can be achieved by the acoustic window shield 1 utilising an acoustic metamaterial panel 3 in its construction as shown in [Fig. 1], the panel allowing for both noise reduction and airflow therethrough.

[0044] The acoustic metamaterial panel 3 utilises resonant principles, i.e. Helmholtz resonators to achieve this objective. The panel 3 is formed of one or more acoustic cavity modules 5 that can be assembled together or can be fabricated integrally as part of the panel 3. Nine such modules 5 are included in the panel 3 shown in Fig. 1. Experimental tests were conducted on a panel 3 having the configuration shown in Fig. 1, with the panel 3 having an overall height of 0.762m and width of 0.552m. Each acoustic cavity module 5 was formed from three plates 7 made from optical-grade acrylic material, and aligned in a generally parallel and adjacent configuration, with each pair of plates 7 defining a resonance cavity therebetween. The plates may be spaced an equal distance apart. Each plate 7 was provided with a generally rectilinear shaped aperture 9 of 0.107m x 0.107m square holes in the middle. The apertures were sized to thereby provide an opening ratio of between 25 to 30% relative to the size of each plate 7 in the modules 5 used in the test. The apertures of each plate 7 were at least substantially aligned with the aperture 9 of the adjacent plates 7 to thereby together form a resonance opening 8 for the module 5. Each module 5 had a height of 0.254m, width of 0.184m, and overall thickness of 0.046m.

[0045] The acoustic cavity modules 5 were designed to trap noise frequencies of between 800 to 1600Hz based on Helmholtz resonator principles. This is the frequency range within which much of the urban noise from traffic and public transport is commonly generated. [Fig. 2] is a graph showing both the design prediction and the actual experimental data for each module 5. That graph plotted the transmission loss (dB) over a frequency range of between 600 to 1800 Hz showing that the experimental data generally followed the design prediction with the transmission loss being most pronounced with the 800 to 1600 Hz frequency range.

[0046] [Fig. 3] shows the actual experimental set-up used to test the acoustic metamaterial panel 3 shown in [Fig. 1]. The panel 3 was formed from a 3 X 3 array of module 5, and was mounted on front of a test window structure 11. The tests found that the panel 3 performed between 6 to 8 dB better then when compared with the window structure 11 when tested without the panel 3 mounted thereon. The tests used broadband white noise and traffic recording, and the test results were compared with a window opening of the same area (i.e. sum of all the square opening) plotted in the graph shown in [Fig. 4] which plots the additional noise reduction (dB) across a frequency range of between 100 to 3150Hz. That graph shows a significant noise reduction performance within the 800 to 1600Hz frequency range, the same frequency range of the noise that the acoustic cavity modules 5 were designed to trap. The measured noise reduction was on average between 6 to 8 dB.

[0047] It is to be appreciated that the abovenoted dimensions relate to the panel 3 and modules 5 used in the experimental setup, and that the panel 3 and modules 5 that may be used in practice will not be restricted to these dimensions. Furthermore, the number and placement of the acoustic cavity modules 5 used within each panel 3, and the configuration of each of the modules 5 can also vary in practice. For example, while each module 5 is described as having three plates 7, it is also envisaged that more than three or even only two plates 7 be used. Furthermore, the rectilinear apertures 9 within each plate 7 may also vary in dimension and shape from adjacent plates 7 and may not necessarily be aligned. The opening ratio for each plate 7 may therefore also vary between adjacent plates 7. Furthermore, while the modules 5 are described to be made of acrylic material, it is also envisaged that the modules 5, and therefore the panel 3 be made from alternative materials such as

glass for example. The dimensions and design of the acoustic metamaterial panel may be varied and optimised to thereby trap noise frequencies at different frequency ranges.

[0048] An embodiment of the acoustic window shield 1 according to the present disclosure utilises one or more of these acoustic metamaterial panels 3 as shown in [Figs. 5 and 6a to 6c]. Each panel 3 may be formed from a number of acoustic cavity modules 5 that are shown aligned in a vertical array in each panel 3 in [Figs. 5 and 6a to 6c]. The acoustic window shield 1 is shown with four such panels 3 in an installed position in front of a window 15 having window panes 17 to allow the window 15 to be opened. The panels 3 may be respectively connected to one or both adjacent panels 3 with hinges 19 to enable concertina folding of the acoustic window shield 1. The entire acoustic shield 1 can be connected to the frame 16 of the window 15 using a set of hinges 16. It is also envisaged that other attachment means such as strong magnets or adhesive could be used to secure the acoustic window shield 1 to the window 15. Rubber gaskets 20 can also be provided between each and/or around the periphery of each panel 3 to minimise any noise leak from an air gap around each panel 3. Guide tracks 21 for guiding roller wheels 23 mounted on brackets adjacent each hinge joint of the shield 1 can assist in both supporting and guiding the concertina opening and closing of the acoustic shield 1. [Figs. 6a to 6c] respectively show the acoustic window shield 1 in a fully retracted, partially extended and fully extended positions in front of the window opening 18.

[0049] The acoustic window shield 1 when in the fully extended position will provide significant noise reduction though that window while at the same time allowing for air to pass therethrough to provide natural ventilation into the internal living environment. The acoustic window shield 1 can be largely made from optically transparent material thereby allowing natural light to pass therethrough, and not significantly restricting the view through the window. The acoustic window shield 1 when fully extended to cover the entire window opening can also act as a safety grille for the window.

[0050] [Figs. 7a to 8] show further embodiments of an acoustic shield 30 according to the present disclosure. Each of these embodiments are configured as a plurality of connected panels 31 to form a foldable acoustic shield 30, with four panels

31 being used for the acoustic shield 30 respectively shown in [figs. 7a and 7b]. The embodiment of the acoustic shield shown in [figs. 5 to 6c] uses acoustic metamaterial panels 3 formed from an array of acoustic cavity modules 5. The embodiments of the acoustic shield 1 shown in [figs. 7a to 8] use a single acoustic cavity module 33, with each panel 31 having an outer frame 32 for supporting the acoustic cavity module 33. Each module 33 comprises a plurality of single plates 35, each plate 35 providing a single layer of material. A single long aperture 37 is provided in each plate 33 of the embodiment shown in [fig. 7a], while a plurality of apertures 39 positioned in an aligned vertical row are provided in each single plate 35 of the acoustic cavity module 33 of the embodiment shown in [fig. 7b].

[0051] [Fig. 8] shows in more detail the embodiment of the acoustic shield 30 shown in [fig. 7a] showing that each connected panel 31 supports a plurality of plates 35 located parallel and adjacent each other supported by the outer frame 32, with a single elongate aperture 37 provided through each plate 33, the apertures 37 being aligned to provide a passage for air ventilation therethrough.

[0052] [Fig. 9a and 9b] show an embodiment of an acoustic shield 40 according to the present disclosure comprising one or more acoustic cavity modules 52 that are adapted to be installed in the grille opening 51 of an existing window grille 50 as shown in [fig. 9a]. The configuration of the acoustic cavity module 52 is shown in more detail in [fig. 9b] which shows that the module 52 comprises an outer box shaped frame 53 within which is accommodated a plurality of rectilinear shaped plates 54 in a parallel and adjacent configuration, with three plates 54 shown in [fig. 9b]. Each plate 54 also has a central rectilinear aperture 55, with the aperture 55 of each plate 54 being aligned. Quick engagement arrangement 56 in the form of U-shaped resilient members 56 can be secured to opposing sides of the frame 53 for respectively engaging a grille bar 57 of the safety grille 50. The acoustic cavity module 52 therefore has a similar internal configuration to the acoustic cavity modules 5 shown in [figs. 1 and 3]. This provides a convenient way to convert an existing window grille 50 into an acoustic shield 40 according to the present disclosure by pushing or pulling one or more acoustic cavity modules into the grille openings 51 of an existing grille 50 as shown in [fig. 9a]. This modular arrangement also allows the level of noise reduction and ventilation to be controlled by varying the

number and placement of the acoustic cavity modules 52 installed within the grille 50. The acoustic cavity modules 52 can also be easily removed when not required.

[0053] The configuration of the plates 7,54 used within the acoustic cavity modules 5,52 can also be varied as shown in [figs. 10a to 10c] in order to further improve the noise reduction that can be achieved. [Fig. 10a] shows a plate 60 that is similar in configuration to the plates 7,54 used in the previously described acoustic cavity module 5,52. However a porous material is used in place of the smooth material used in the earlier described modules 5,52. The porous material can act to absorb some of the incoming noise. The plate 62 shown in [fig. 10b] includes a series of protrusions 63 arranged in a waffle like line configuration on one side of the plate 62. It is also envisaged that protrusions of other shapes, and different arrangements of the protections could be used. These protrusions act to deflect noise inside the acoustic cavity module 7,52 thereby reducing noise by lengthening the travel path of the noise. [Fig. 10c] shows a plate 64 combining both porous zones 65 and protrusions 66 on the plate 64 to thereby provide a combination of noise absorption and deflection within the acoustic cavity module 5,52.

[0054] The interior configuration of the acoustic cavity module 5,52 may also or alternatively be adapted to further trap and dissipate noise therein. [Fig. 11] shows alternative noise trap configurations 71, 73 provided within at least one internal peripheral area of the resonance cavities 70 defined between the plates 7,35 within the acoustic cavity module 5,52. One trap configuration 71 comprises opposing elongate tapered channels provided at each corner of the peripheral area of the resonance cavity 70 to form the noise trap. The other configuration 73 comprises an elongate rectilinear cavity extending along the peripheral area of the resonance cavity 70, and between corners of the peripheral area of the resonance cavity 70. It is to be appreciated alternative noise trap configurations are also envisaged in addition to those shown in [fig. 11].

[0055] While the acoustic shield has been described for use with windows, it is not restricted to this application and could be used in other applications requiring both noise reduction and natural ventilation functions.

[0056] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as is commonly understood by a skilled person to which the subject matter herein belongs.

[0057] It should be appreciated by the person skilled in the art that the above invention is not limited to the embodiment described. It is to be appreciated that modifications and improvements may be made without departing from the scope of the present invention.

[0058] It should be further appreciated by the person skilled in the art that one or more of the above modifications or improvements, not being mutually exclusive, may be further combined to form yet further embodiments of the present invention.

CLAIMS:

1. An acoustic shield for a window, including:

one or more acoustic cavity modules locatable over at least a portion of the opening of the window, the or each module providing at least one resonance opening for reducing an overall sound pressure level of sound waves passing through the resonance opening while allowing an air flow to also pass therethrough, the acoustic cavity module including a plurality of plates aligned in a generally parallel and adjacent configuration such that a resonance cavity is defined between each pair of plates, each plate having at least one aperture, the aperture(s) of each plate together providing the resonance opening(s) of the module;

wherein the or each acoustic cavity module is designed to trap noise frequencies of between 800 to 1600Hz.

2. An acoustic shield for a window according to claim 1, wherein the apertures of each of the plates are respectively aligned within the acoustic cavity module(s).
3. An acoustic shield for a window according to claim 1 or 2, wherein the plates and the aperture provided within each said plate is generally rectilinear in shape.
4. An acoustic shield for a window according to any one of the preceding claims, wherein the aperture of each said plate provides an opening ratio of between 25 to 30%.
5. An acoustic shield for a window according to any one of the preceding claims, wherein at least one of the plates is at least partially formed from a porous material.
6. An acoustic shield for a window according to any one of the preceding claims, wherein at least one of the plates are provided with projections extending from at least one face thereof.
7. An acoustic shield for a window according to any one of claims 1 to 4, wherein

at least one plate comprises a combination of portions made from porous material, and portions having projections extending therefrom.

8. An acoustic shield for a window according to any one of the preceding claims, wherein the resonance chamber provides an internal noise trap therein.
9. An acoustic shield for a window according to claim 8, wherein the internal noise trap is provided at an internal peripheral area of the resonance cavity.
10. An acoustic shield for a window according to claim 9, wherein the internal noise trap comprises opposing elongate tapered channels respectively provided at a corner of the peripheral area.
11. An acoustic shield for a window according to claim 9, wherein the internal noise trap comprises an elongate rectilinear cavity extending between corners of the peripheral area.
12. An acoustic shield for a window according to any one of the preceding claims, wherein the acoustic cavity module(s) comprises three said plates.
13. An acoustic shield for a window according to claim 12, wherein the aperture has a rectilinear shape having a dimension of 0.107m on each side thereof.
14. An acoustic shield for a window according to claim 13, wherein the plate is rectilinear in shape and has an external dimension of 0.254m in height and 0.184m in width.
15. An acoustic shield for a window according to claim 14, wherein the acoustic cavity module has an overall thickness of 0.046m.
16. An acoustic shield for a window according to any one of the preceding claims, comprising at least one acoustic metamaterial panel locatable over at least a portion of the window opening, the acoustic metamaterial panel comprising a plurality of the acoustic cavity modules.
17. An acoustic shield for a window according to claim 16, comprising a plurality of the acoustic metamaterial panels, the panels being respectively joined by one or more hinge members to allow for folding of the acoustic shield.

18. An acoustic shield for a window according to claim 16 or 17, wherein the acoustic shield further provides a safety grille for the window.
19. An acoustic shield for a window according to any one of claims 1 to 16, wherein the acoustic cavity module comprises at least one engagement arrangement provided at an external surface of the acoustic cavity module for engaging on or more bars of a window safety grille.
20. An acoustic shield for a window according to claim 19, wherein the engagement arrangement comprises a pair of U shaped resilient members secured to opposing sides of the acoustic cavity module.