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***E01F 8/00*** (2006.01) ***E04B 1/82*** (2006.01)

(56) Documents Cited:
**CN 203559362 U**
**CN 104860633 A**
**US 4899498 A**
**US 4529174 A**
**US 4402384 A**
**KR 1020150056126**
**KR 1020140023139**

(58) Field of Search:
INT CL **E01F**
Other: **EPODOC, TXTA, WPI**

(54) Title of the Invention: **Barrier System**
Abstract Title: **Barrier for reducing traffic noise**

(57) The barrier comprises a series of repeating units U, each unit having two vertical panels connected along a vertical side edge 5 and with front faces 1 angled towards each other, the panels standing in a zig zag arrangement. Each panel may have a front board, a back board, a top plate, a base kicker plate, a panel to panel connection portion, and internal stiffeners 50 oriented vertically. The panel to panel connection portion may be a column which connects the panels to a foundation 70, 72, 74. The panels may comprise a composite material including a magnesium oxide binder and a fibre net. The barrier may have photovoltaic panels or solar chimney sections. Also claimed is a composite material board comprising a magnesium oxide cement and a glass or nylon net. The board may have an inner core of MgO and perlite cement, a fiberglass layer, and an MgO outer cover.

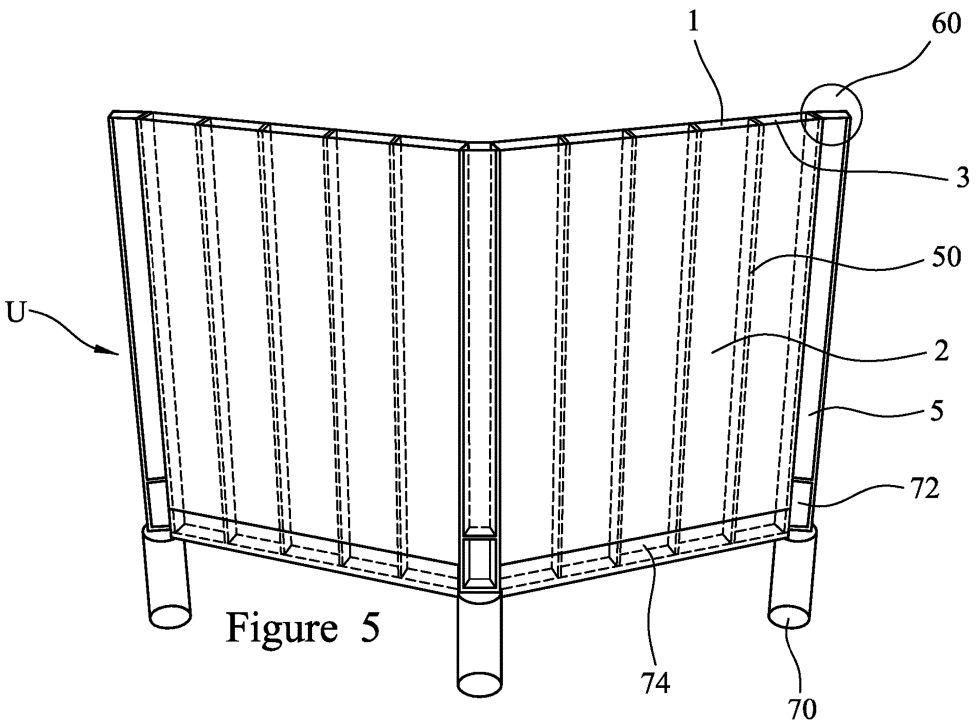


Figure 5

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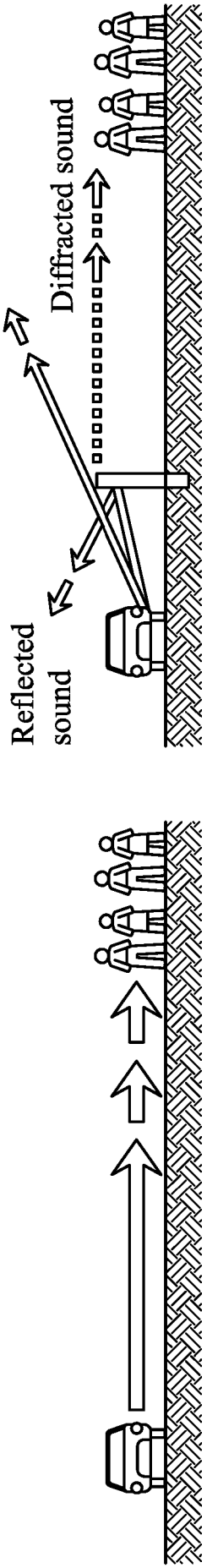


Figure 1

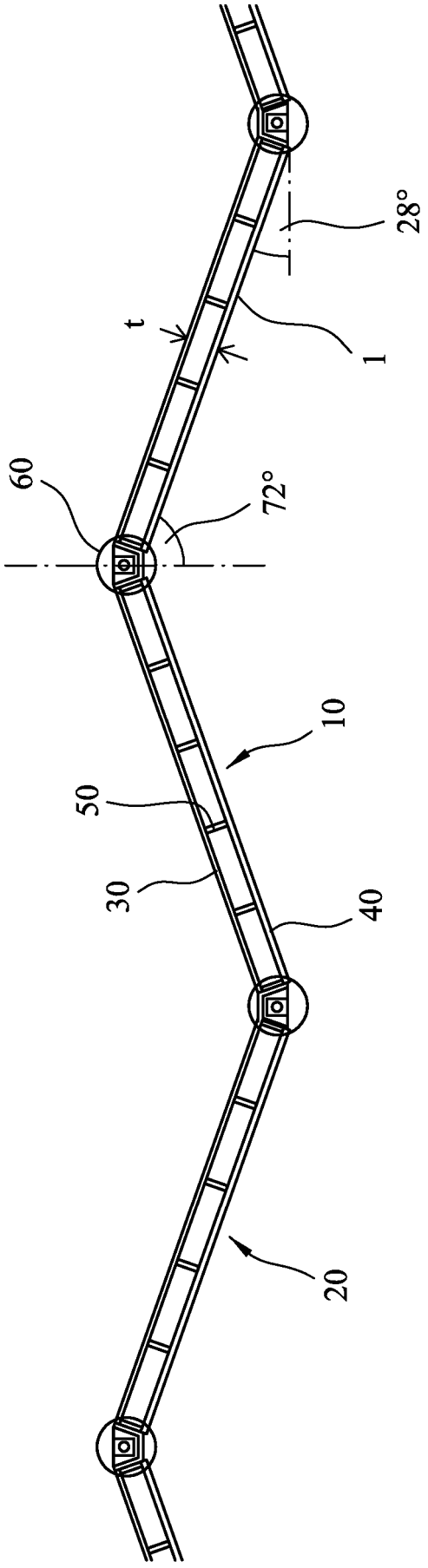


Figure 4

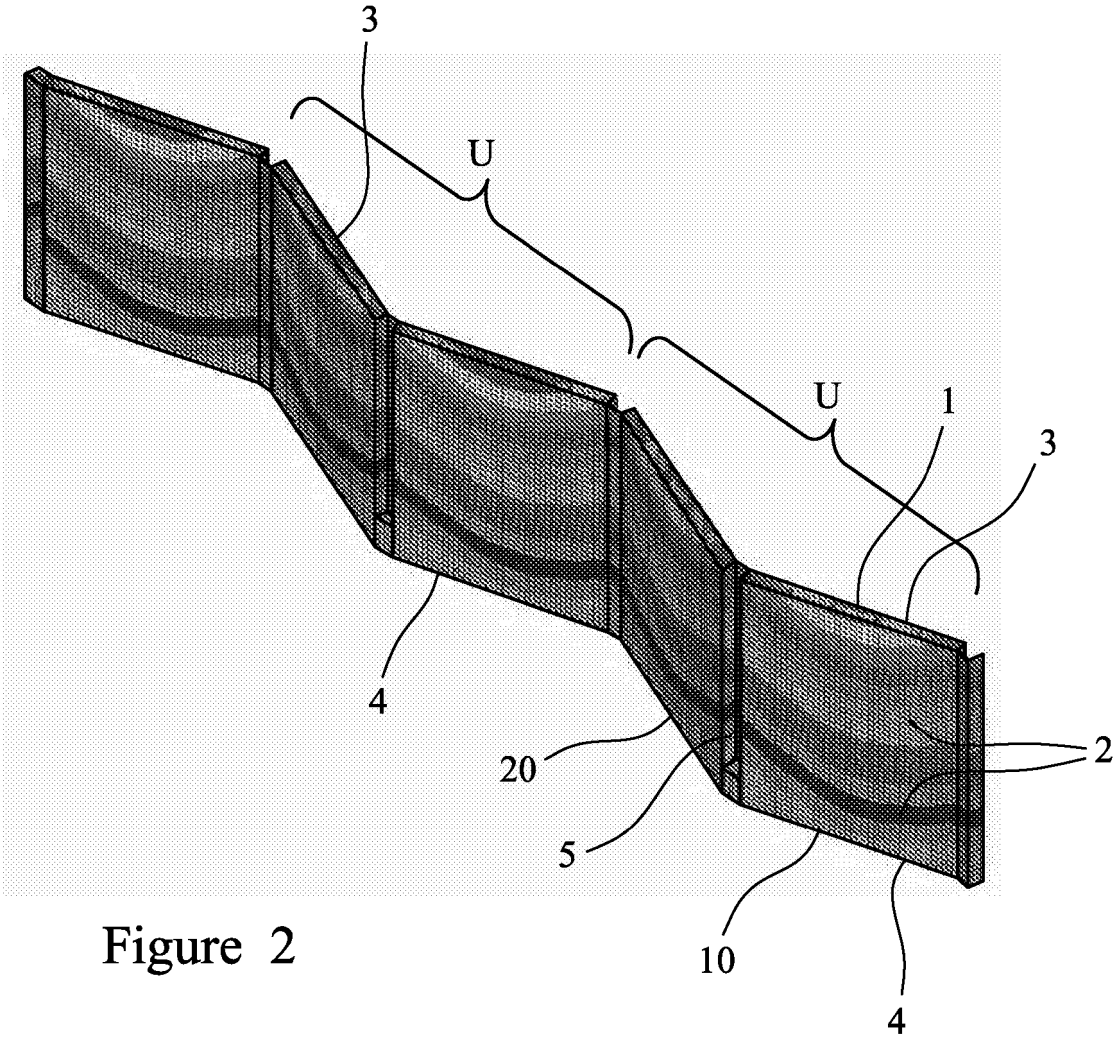


Figure 2

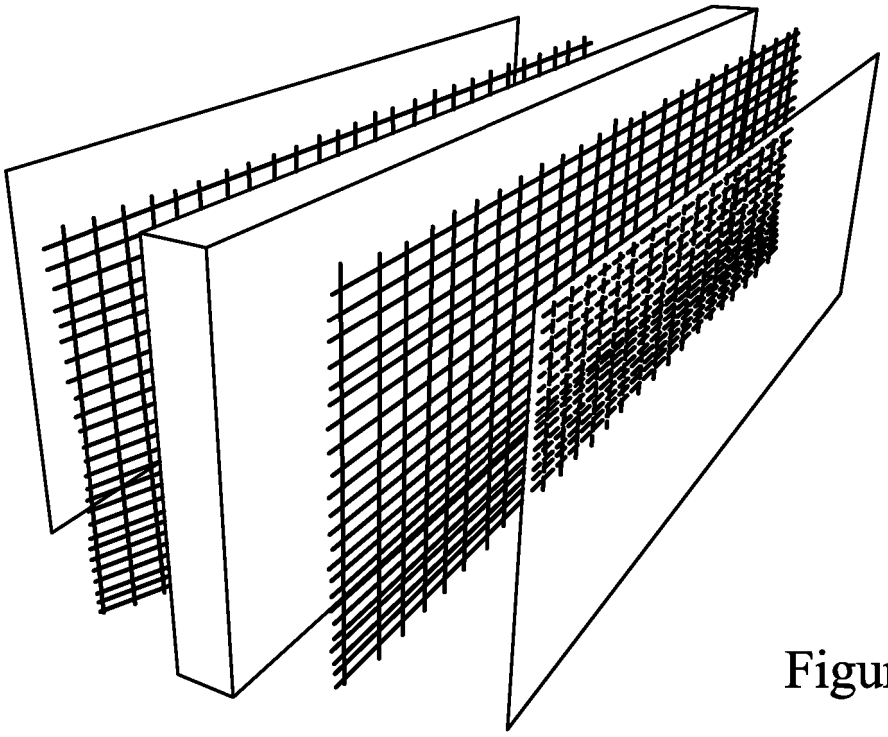

Figure 3

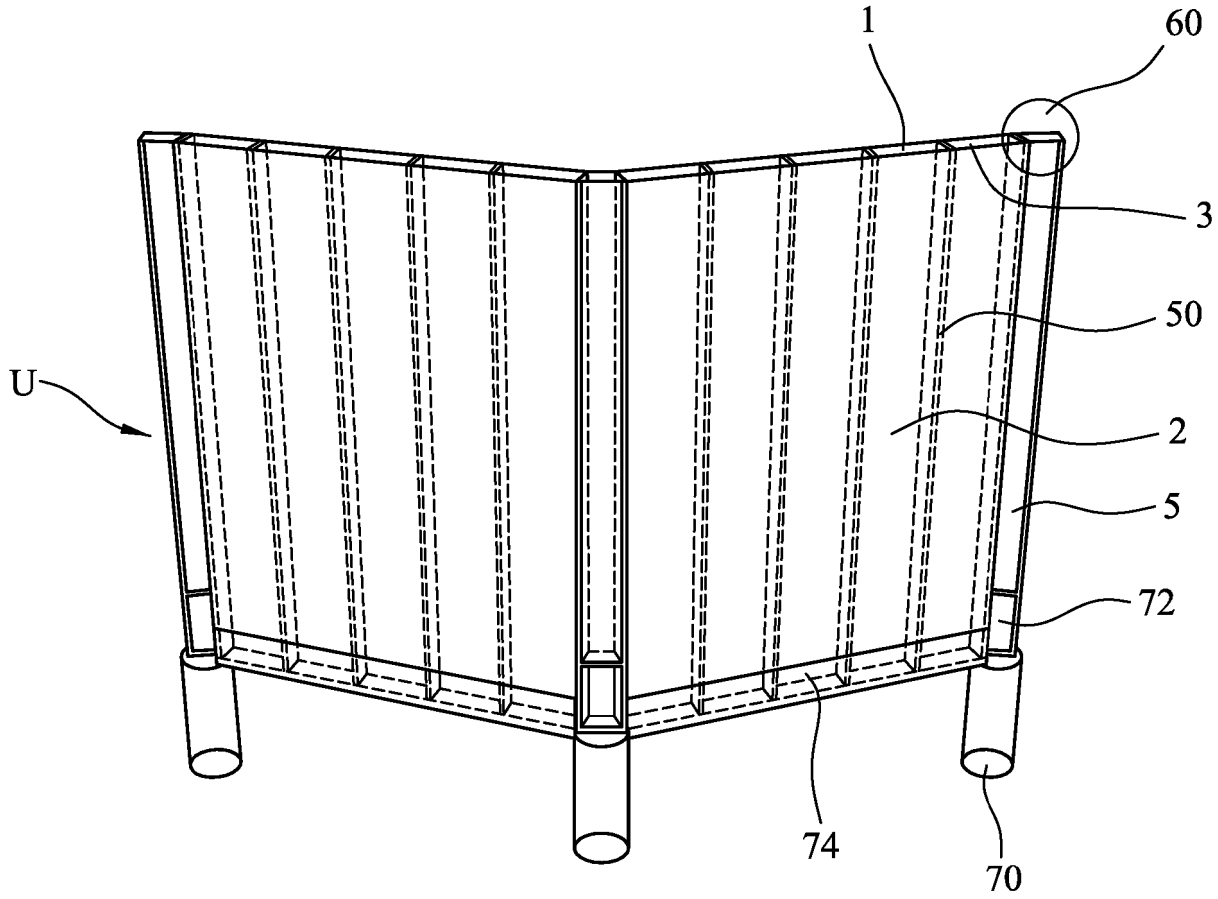


Figure 5

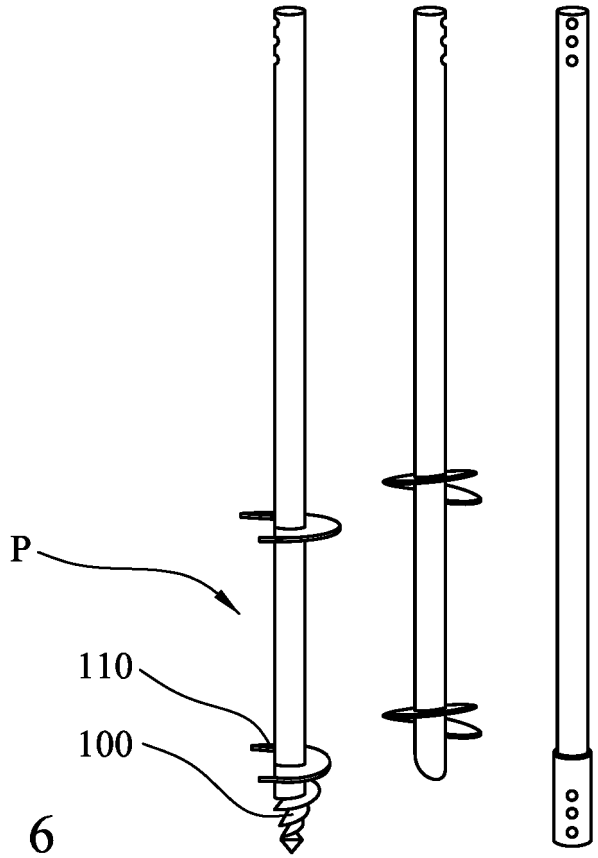


Figure 6

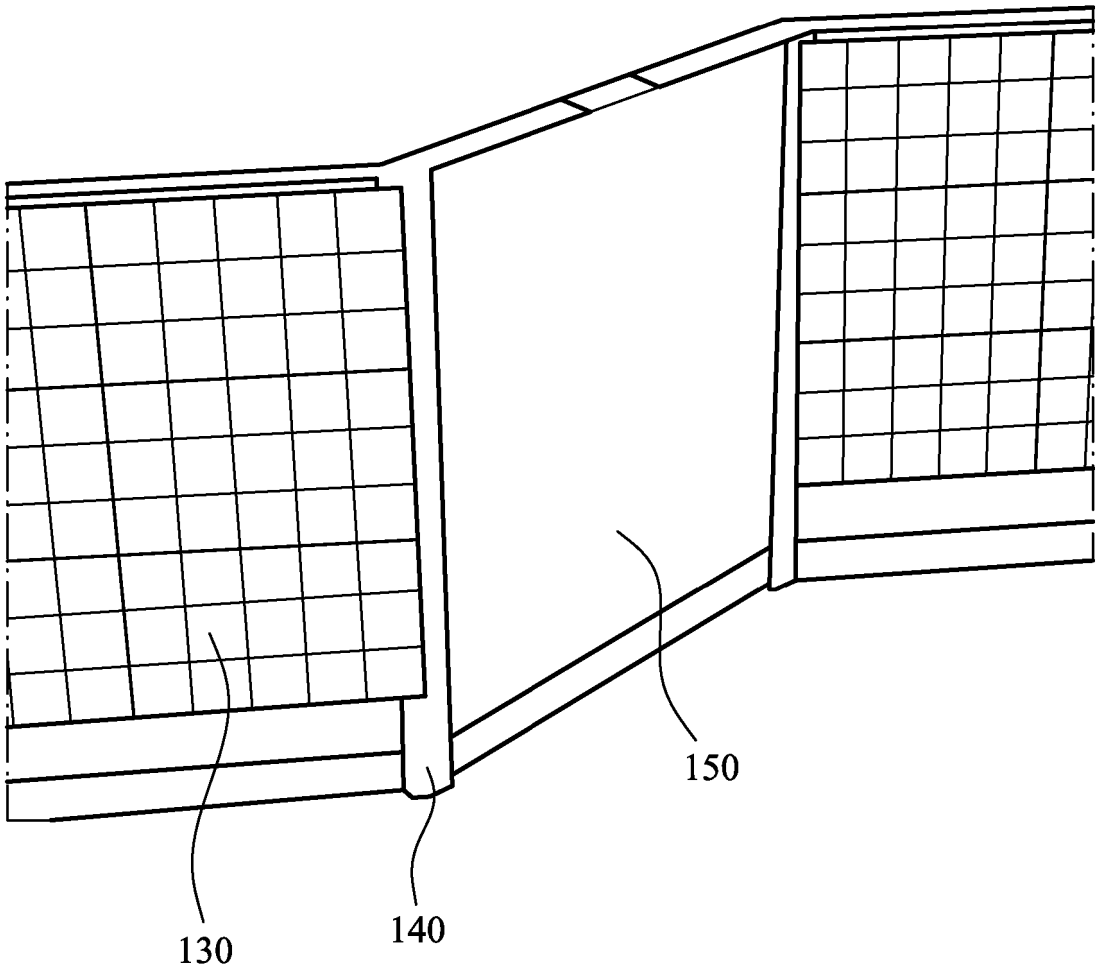


Figure 7

# BARRIER SYSTEM

The present invention relates to a barrier to reduce noise produced by traffic, the invention also relates to a barrier with environmental features providing renewable energy.

Motorways link and connect cities across the United Kingdom, they are also common in other countries. These large roads are important transport arteries and take business and leisure traffic. The location and construction of this type of road with multiple lanes on both sides of the carriageway for traffic, uniform road surface and a straight direction without significant curves or corners enables high speed travel, subject to congestion or volume of traffic which can slow the overall speed of travel. The volume of traffic and speed of travel on the road surface along with the wind and turbulent air flow generated has the effect of generating significant road traffic noise.

Traffic noise is recognised as a serious public health problem by the World Health Organization, and a European study estimated the social cost of road traffic noise to be €40 billion per annum (0.4 per cent of total GDP) across Europe. It is suggested that regular exposure to traffic noise over 55 dB is potentially dangerous to health. The most adverse effects of traffic noise is simply annoyance, but there is substantial evidence that traffic noise disturbs sleep patterns, affects cognitive functioning and contributes to certain cardiovascular diseases, for instance through raised blood pressure.
Therefore, it is desirable to reduce traffic noise and mitigation by introducing noise insulation and barriers. Barriers are being increasingly recognised as a requirement for new or altered roads and developments.

According to a first aspect of the present invention there is provided a traffic noise barrier for reducing traffic noise arranged as a series of repeating units; each unit comprising at least

two panels, each panel comprising a front face, a rear face, an upper edge, a lower edge and side edges, wherein the panels are arranged substantially vertically and connected one to another along a vertical side edge with the front faces angled towards each other, whereby the repeating units comprise panels positioned to stand in a zig zag arrangement. The zig zag is made with two or more units together and by this arrangement the noise and other pollution caused by traffic can be reduced.

Preferably, the traffic noise barrier comprises at last two units of panels. The resulting zig-zag shape provides acoustic advantages and improved structural behaviour over conventional shaped barriers. It is known that, assuming the barriers to be located behind a suitable road and vehicle restraint system (crash barrier) then the most significant force on the barrier will be wind. The structure of a conventional barrier is such that in order to resist wind loads the barrier has to operate as a cantilever structure. This means they are required to have good bending resistance and heavy foundations to resist the wind induced moments. The zigzag shape resists wind loads differently and more efficiently by mobilising in-plane membrane behaviour, and transmitting forces to the foundations directly in either tension or compression.

In an embodiment, each panel of the traffic barrier comprises a front board, a back board, a top plate, a base kicker plate, a panel to panel connection portion and one or more internal stiffener portions orientated vertically and arranged to extend between the front board and the back board. Advantageously, as the panels themselves are not required to resist bending, at least globally, they do not need wind posts for lateral support. In an embodiment the panel connection portion is located at a vertical side edge and comprises a column arranged to connect the panel to a barrier foundation using mechanical fixings. Heavy foundations are not required leading to structural advantages and simplicity over existing barriers. In turn this means a reduced timescale for construction, and a concomitant decrease in costs.

In the barrier outlined here each unit is connected to the next, in a non- cantilever arrangement, due to the reduced forces experienced on the barrier face. It is considered novel to form a barrier or fence of this kind in a zig zag shape and makes efficient use of the extra width of land that is often available along most highways. The zig zag construction does not lend itself to a fence or traditional barrier that marks a land boundary, nor is there the space to accommodate a zig zag width along a boundary line so is seldom used for any kind of barrier or boundary fencing system.

In an embodiment the angle between the respective front faces of the panels in the zig zag formation is in the range from 90 degrees to 179 degrees, in particular 144 degrees. The length of the panels in an embodiment is in the range from 1 to 5 m, in the embodiment described here the length of the surface against the road is 3m. This is the length of the face presented to the traffic noise. The particular set up arrived at in this example reduces noise by a combination sound reflection and diffraction.

In an embodiment the board or panel comprises a composite material including Magnesium Oxide (MgO) cement for the boards. MgO boards whilst having good engineering properties currently have poor take up in engineered applications. In the embodiment described the composite material of the barrier comprises a MgO binder and a fibre net. The structure of the MgO board has advantages over other existing barrier materials such as wood. The advance is in the material as well as the structural arrangement.

A MgO board is made from a composite material using MgO cement as the binder and a fibre net in both surface layers to provide tensile strength. The fibres are typically glass or nylon, although the constituent products can be varied. The amount of MgO cement, fillers and fibre reinforcement can be altered along with the board thickness in order that a required strength is achieved by the engineering and altering of the composite properties.

MgO boards have good tensile properties, can be shaped, coloured and textured according to user requirements and generate significantly less carbon dioxide during manufacture than conventional calcium cement which could be used to form a similar barrier. Typically, current cement production produces around 800 kg $CO_2$/tonne, whereas MgO ranges from -100 kg to 300 kg $CO_2$/tonne.

Other advantageous properties of MgO boards are that they are very robust and durable, resistant to fire, water, freeze/thaw cycles and have good impact resistance. The panels are stable with respect to thermal actions and also have an excellent resistance to chemical and insect attack. Their density and stiffness gives them good sound insulation properties. MgO does not rot, warp, split, shrink unlike wood can be prone to doing in a barrier construction. MgO boards also have good tensile properties which mean that the material can be readily glued and bonded, for instance to make panels to comprise a traffic noise barrier as described here. The fabrication of panels and boxes can be without mechanical fixings.

In an embodiment the barrier comprising two panel units extends for a length of at least 100m. This is a length typically required along a section of highway that might be bordering a residential or commercial setting where noise reduction could be required.

Further in the embodiment described the traffic noise barrier may comprise foundation elements. The benefit of using the MgO material for construction of portions of the barrier is that smaller, prefabricated foundation structures can be used such as helical steel piles. It has been suggested that the concrete foundations for conventional barriers would need to be 1.8m deep. This requires costly and time consuming site work. For the present traffic noise barrier there is the possibility of designing foundations to resist purely axial loads. Advantageously the foundation elements of this new traffic barrier can improve on the cost effectiveness of a barrier system by significantly reducing the time required for installation.

In a preferred embodiment the traffic noise barrier further comprises one or more photovoltaic (PV) panels also known as PV modules. This provides a renewable energy functionality in the barrier to generate power while reducing traffic noise. The reflective and diffusive effect of the PV modules used in the barrier may also provide additional shielding and noise reduction effects. In an embodiment the traffic nose barrier further comprises one or more solar chimney sections provided to assist with the dispersal of vehicle emissions from the side of the highway and improve the air quality in and around the highway environment.

The panels within the repeating units of the barrier that have the best solar exposure would be chosen to be fitted with PV modules and to become PV panels and in an embodiment a panel is arranged at an angle away from the vertical, and angled upwardly in the range from 5 degrees to 25 degrees. The angle is one tested for the optimum exposure to solar energy.

A particular preferred construction for a traffic noise barrier is a composite material board comprising a net and a binder, wherein the binder is MgO cement and the net is glass or nylon. A composite material board of a traffic barrier of the described embodiment further comprises an inner core of MgO and perlite cement, a layer of fiberglass and an outer cover of MgO.

The invention will now be described by way of example with reference to the following Figures in which:

Figure 1 is a side view of a basic barrier system according to the prior art;

Figure 2 is an overhead perspective view of a barrier according to an aspect of the invention;

Figure 3 is an exploded view of an MgO board component of the barrier of Figure 2.

Figure 4 is a plan view of a portion of the barrier of Figure 2 according to an aspect of the invention;

Figure 5 is a side view of one unit of panels of the barrier of Figure 2 according to an aspect of the invention;

Figure 6 is a side view of construction components and a method of construction for the barrier of Figure 2; and

Figure 7 is a perspective view of a section of barrier according to a further preferred aspect of the present invention including solar photovoltaic panels and a thermal chimney.

It is known to block sound from traffic or from construction or from other significantly loud event with a barrier or wall as shown in Figure 1.

Referring to Figures 2, 3 and 4, a traffic noise barrier for reducing traffic noise is provided. The barrier comprises a series of repeating units, U. Each of the units U comprise at least two panels, 10, 20, each panel 10, 20 comprises a front face 1, a rear face 2, an upper edge 3, a lower edge 4 and side edges 5. The orientation of the panels is vertically upright, and perpendicular to the road surface, in this way the panels 10, 20, are arranged substantially vertically and connected one to another along a vertical side edge 5. The connection is such that the front faces 1 of panels 10, 20 are angled towards each other 1, whereby the repeating units U form a zig zag arrangement together, created by the panels 10, 20 standing next to each other in the angled orientation.

The construction details of the panels 10, 20 of one embodiment is set out below with reference to Figures 5 and 6. The panel 10, 20 is formed as a multi celled box built and assembled from a front board 30 and a back board 40 and internal stiffener portions 50. In the illustrated embodiment the length of each panel is 3m, the height of each panel is 4m and the thickness, t, is 200mm. The choice of the length of the panel is not trivial, with the zig zag pitch at around 3m this a similar magnitude to the wave length of the traffic noise. The different directions of the panels may act to introduce complex patterns of reflected and diffracted sound which has a beneficial influence on noise reduction by the barrier. There may also be further benefits to altering the length and pitch of the panels to spread the reflection and diffraction of noise energy over different frequencies.

The boards are MgO, as shown in an exploded view of MgO board construction in the example shown in Figure 3. The front board 30 and the back board 40 have a thickness of 18mm and the internal stiffeners 50 have a thickness of 25mm and are placed at 600mm centres. In the illustrated embodiment there are 4 stiffener portions in each panel 10, 20.

The edges 5, at which the panels 10, 20 are joined together comprise a column portion 60 having a trapezoidal cross section as shown in Figure 4. The angle between the front faces 1, of the panels 10, 20 is a shallow angle arranged to be less than 180 degrees so that the faces point towards each other. In the illustrated embodiment the angle is 144 degrees and the angles in the right angled triangle made by the line subtending the angle of 144 degrees between the front faces, the panel front face 1 and the horizontal are 28 degrees and 77 degrees, as shown in Figure 4. An alternative arrangement of panels and set of angles may be required for a particular location and environmental factors such as extreme or variable wind conditions.

A side on view of the barrier unit is illustrated in Figure 5. Foundation components 70, 72 and 74 are shown. MgO material forms the front board 30 and back board 40. The MgO

boards are spaced apart by 164mm. The airgap provides an improved sound insulation performance than compared with a solid monolithic panel. The air gap or void of 164mm provides sound insulation, and is particularly effective sound insulation at the low frequencies found within the traffic noise spectra.

In operation on site, the construction of the barrier is such that the parts are welded or mechanically fixed together. The MgO boards 30, 40 and stiffeners 50 are glued together. Mechanical fixings are used on site to connect the panels 10, 20 and units U together. Foundations are required for the barrier units U, and a method of connection to foundations is with one or more piles, P comprising concrete or steel piles inserted into the ground, these can be around 2000mm deep in the ground. The material of the piles will be chosen depending upon the conditions of the system, the condition of the barrier and the expected environmental conditions and set up around the barrier. The steel component of the piles placed underground can be seen in Figure 6.

One method of connection to a foundation mat is that a steel shoe or insert 72 glued to the inside of the trapezoid column 5 which provides a mechanical connection to the top of the foundation 70. The foundation mat take several forms, but prefabricated steel helical screw piles 100 would be preferred. The actual choice of foundation and barrier support will depend on ground conditions.

It is noted, as has been discussed elsewhere, that in order to resist wind loads conventional barriers have to work as cantilever structures and so are required to have good bending resistance and heavy foundations to resist the wind induced moments. The zigzag shape resists wind loads differently and more efficiently by mobilising in-plane membrane behaviour, and transmitting forces to the foundations directly in either tension or compression, as well as horizontal shear. MgO boards have significant strength and stiffness to resist in-plane membrane and shear load effects, this means that as the panels

themselves are not required to resist bending, at least globally, they do not need wind posts for lateral support and do not need heavy foundations. The foundation posts and piles illustrated are sufficient even in challenging weather conditions. It has been suggested that concrete foundations for conventional barriers in this noise barrier situation would need to be 1.8m deep, requiring costly and time consuming site work. Designing foundations to resist purely axial loads, as transmitted with a zig zag barrier arrangement allows the above described small prefabricated solution to be used, such as steel helical piles, P. Moving to this type of foundation solution improves cost effectiveness by significantly reducing the time required for installation.

An installation operation is illustrated in Figure 6. Concrete foundations can be in the ground to accept the barrier base connection and steel piles P shown in Figure 6, or alternatively the steel piles P comprise foundations themselves. The steel piles P could be driven in or fitted with a piling machine or similar plant. In an embodiment the setting out of foundations would be accomplished by UAVs (Unmanned Aerial Vehicles) and point clouds developed from digital photogrammetric processes.

In a further embodiment illustrated in Figure 7 solar panels (also called PV modules) 130 are mounted to the barrier on the road side of the boards. Types of PV modules include Monocrystalline, Polycrystalline, and Thin-film technology. The embodiment illustrated is for Polycrystalline panels 130, often used in industry. This type of PV module is affordable, efficient and can be replaced easily.

They are mounted on aluminium frames at an angle approximately 10 degrees to the vertical 140. The angle can be changed to optimise performance. Only panels assessed to have good solar collection have PVs installed. Panels are connected together in groups with cabling, installed within the panels, to inverters and then to the grid. The aim with a barrier

length of 500m, for example, is that it will provide 133 kWp (p, peak output - noon and sunny).

The components required for achieving this electrical output are as follows; the solar PV panels, inverters to convert DC to AC, distribution boards, cabling and grid connection equipment. Standard PV modules are expected to be used, because of high cost associated with bespoke arrangements.

In addition to the PV modules the barrier includes solar chimneys 150 comprising one or more matt black panels 150 with a voided section. The black panels heat up through solar radiation and the temperature gradient that develops then drives a thermal (convective) flow which helps disperse emissions above the barrier and adjacent panels 10, 20. The solar chimneys are only expected to help disperse emissions when there is no wind during very calm conditions, which is also when emissions can accumulate. To increase thermal flow the air cooled inverters required for the photovoltaic panels can be positioned at the base of the solar chimneys to draw air into the bottom opening.

Various modifications may be made to the described embodiment without departing from the scope of the present invention. The structure and orientation of the barrier apparatus may be of an alternative design and shaping, there may be two or more panels in any unit of the barrier. The apparatus may comprise any suitable material and may be of any length and thickness. Alternative forms of construction may be considered. The stiffeners in the panel may be vertically orientated, horizontally orientated or be in another direction or orientation. In addition to further enhance sound absorption at the road side, if required, could be achieved by minimising reflections back to the opposite side of the highway. Typically this would involve fixing an acoustic absorbing material on the road side of the barrier, or perforating the facing to the road-side MgO board, and filling the panel void with mineral wool. Generally, enhanced absorption is not anticipated for major highways as the

requirement to shield properties and communities tends to be on one side or the other of the motorway.

**CLAIMS**

1. A traffic noise barrier for reducing traffic noise arranged as a series of repeating units; each unit comprising at least two panels, each panel comprising a front face, a rear face, an upper edge, a lower edge and side edges, wherein the panels are arranged substantially vertically and connected one to another along a vertical side edge with the front faces angled towards each other, whereby the repeating units comprise panels positioned to stand in a zig zag arrangement.

2. A traffic noise barrier as claimed in Claim 1, comprising at least two units of two panels.

3. A traffic noise barrier as claimed in Claim 1 or Claim 2, wherein each panel comprises a front board, a back board, a top plate, a base kicker plate, a panel to panel connection portion and one or more internal stiffener portions orientated vertically and arranged to extend between the front board and the back board.

4. A traffic noise barrier as claimed in Claim 3, wherein the panel connection portion is located at a vertical side edge and comprises a column arranged to connect the panel to a barrier foundation using mechanical fixings.

5. A traffic noise barrier as claimed in any preceding claim, wherein each unit is connected to the next, in a non- cantilever arrangement.

6. A traffic noise barrier as claimed in in any preceding claim, wherein the angle between the respective front faces in the zig zag formation is in the range from 90 degrees to 179 degrees, preferably 144 degrees.

7. A traffic noise barrier according to any preceding claim, wherein the length of the panels is in the range from 1 to 5 m, preferably 3m.

8. A traffic noise barrier according to any preceding claim, wherein the board or panel comprises a composite material including MgO.

9. A traffic noise barrier according to claim 8, wherein the composite material comprises a MgO binder and a fibre net.

10. A traffic noise barrier according to any preceding claim, whereby the barrier comprising two panel units extends for a length of at least 100m.

11. A traffic noise barrier according to any preceding claim, further comprising foundation elements.

12. A traffic noise barrier according to any preceding claim, further comprising one or more photovoltaic panels.

13. A barrier according to any preceding claim, further comprising one or more solar chimney sections.

14. A barrier as claimed in claim 12, whereby the panel is arranged at an angle away from the vertical, and angled upwardly in the range from 5 degrees to 25 degrees.

15. A composite material board comprising a net and a binder, wherein the binder is MgO cement and the net is glass or nylon.

16. A composite material board as claimed in claim 15, further comprising an inner core of MgO and perlite cement, a layer of fiberglass and an outer cover of MgO.

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Intellectual Property Office

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|---|---|---|---|
| **Application No:** | GB1606642.5 | **Examiner:** | Mr Joshua Nolan |
| **Claims searched:** | 1-14 | **Date of search:** | 17 October 2016 |

## Patents Act 1977: Search Report under Section 17

**Documents considered to be relevant:**

| Category | Relevant to claims | Identity of document and passage or figure of particular relevance |
|---|---|---|
| X,Y | X: 1-7 and 10-14, Y: 8 and 9 | US4529174 A (PICKETT), see in particular figures 10 & 12, noting zig zagging panels 78, 80, and columns 22 with foundation elements 90. |
| X,Y | X: 1-7 and 10-14, Y: 8 and 9 | US4402384 A (SMITH ET AL), see in particular figure 9, noting zig zagging panels 26, and columns 30 with foundation elements 42. |
| X,Y | X: 1-7 and 10-14, Y: 8 and 9 | US4899498 A (GRIEB), see in particular figures 1 & 3, noting zig zagging panels 20, and columns 16 with foundation elements 18. |
| X,Y | X: 1-7 and 10-14, Y: 8 and 9 | CN203559362 U (CHENGDU CHENGDIAN ELECTRIC POWER ENGINEERING DESIGN), see in particular figure 4, noting zig zagging panels 2, and columns 1 with foundation element 3. |
| X,Y | X: 1-7 and 10-14, Y: 8 and 9 | KR 1020150056126 A (OH), see in particular figure 1, noting zig zagging panels 40, and columns 20 with foundation element. |
| X,Y | X: 1-7 and 10-14, Y: 8 and 9 | KR 1020140023139 A (KIM), see in particular abstract and figure 6, noting zig zagging panels 300, columns 200, and solar panels 500. |
| Y | Y: 8 and 9 | CN104860633 A (GUANGHAN HONGSHENG BUILDING MATERIAL CO), see abstract, noting composite sound absorbing panel comprising MgO and fiberglass mesh layers. |

Categories:

| | | | |
|---|---|---|---|
| X | Document indicating lack of novelty or inventive step | A | Document indicating technological background and/or state of the art. |
| Y | Document indicating lack of inventive step if combined with one or more other documents of same category. | P | Document published on or after the declared priority date but before the filing date of this invention. |
| & | Member of the same patent family | E | Patent document published on or after, but with priority date earlier than, the filing date of this application. |

Intellectual Property Office

**Field of Search:**

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[X] :

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Worldwide search of patent documents classified in the following areas of the IPC

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| E01F |

The following online and other databases have been used in the preparation of this search report

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|---|
| EPODOC, TXTA, WPI |

**International Classification:**

| Subclass | Subgroup | Valid From |
|---|---|---|
| E01F | 0008/00 | 01/01/2006 |
| E04B | 0001/82 | 01/01/2006 |