(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 031 671 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
30.08.2000 Bulletin 2000/35

(51) Int Cl.7: **E04B 1/84**

(21) Application number: **99305582.1**

(22) Date of filing: **14.07.1999**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **24.02.1999 GB 9904253**

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(54) Acoustic structural elements

(57) An acoustic structural element such as a block for use in constructing an acoustic structure such as a party wall. In preferred embodiments, the element contains at least two acoustic chambers that each communicate with the exterior of the element through at least one respective orifice positioned to be exposed in use to impinging sound.

In the embodiments, the element has first and second opposed sides each of which contains at least one of said orifices. The respective chambers are tuned to resonate at substantially different frequencies of impinging sound by being of substantially different volumes, and are defined by walls that are integral with the element.

The elements include integral spacer means for maintaining a cavity between the element and a cover sheet defining the cavity. The cavity communicates with the orifices of the elements.

In some embodiments, end faces of the elements are shaped to fit one another in a manner that imposes a sequence upon the elements within a course, thus creating a desired mix of elements in an acoustic structure.

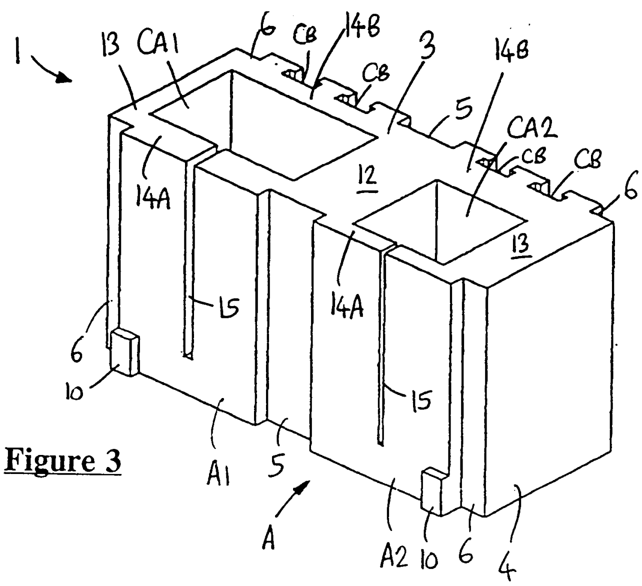

Figure 3

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Description

[0001] This invention relates to acoustic structural elements such as blocks, particularly sound-absorbing acoustic blocks that are adapted to absorb sound energy and are preferably of load-bearing design. Such elements can be used to construct, or can be incorporated into, the walls, floors and ceilings that define rooms or other spaces within a building. The elements can also be used to construct acoustic barriers beside noise sources, for example beside busy highways running through residential areas.

[0002] By "structural elements", we mean elements that can bear their own weight and that of other similar elements laid above, including but not limited to elements that can contribute to the overall structural strength of a building. These elements are preferably mass-produced to a standard design.

[0003] As the acoustics of a building can have a major impact upon its utility to its occupants, careful acoustic design is not merely the preserve of concert halls: various buildings, both public and private, can benefit from acoustic design measures. The aim of these measures is usually to absorb sound energy, thereby to reduce transmission of sound through, from or into the building and also to reduce reflection of sound in spaces within the building.

[0004] To date, sound absorption techniques have mainly been used to avoid excessive reflection of sound from the walls, floors and ceilings that define a space. This problem is particularly prevalent in public spaces such as leisure centres, school halls and sports arenas in which the shouts of players, schoolchildren or spectators or the sound of public address announcements can reflect around the space to unpleasant and detrimental effect.

[0005] Examples of anti-reflective acoustic blocks are sold under the trade mark ACOUSTAWAL by Trenwyth Industries, Inc., headquartered in Pennsylvania, USA. The blocks are designed to be exposed in use and can present a bare or painted rough concrete face, or can have a glazed or ground face finish. They share several features with the blocks taught by the patent literature, which will be discussed later.

[0006] Anti-reflective measures notwithstanding, sound transmission between neighbouring rooms or properties is perhaps the most common acoustic problem requiring sound-absorption techniques. Party walls shared by neighbouring private dwellings such as terraced houses are of the greatest concern; such walls are classically constructed of courses of structural blocks that may be of only one or two blocks' thickness. Where neighbours are above or below, this concern extends to the design of floors. Accordingly, the acoustic design of party walls and sometimes of floors is subject to building standards and regulations in many countries.

[0007] As an example, Part E of the current United Kingdom Building Regulations, also known as Document E, outlines brick and block party wall constructions that are deemed to provide adequate sound insulation between neighbouring properties. The subject matter of Document E is incorporated herein by reference. Document E was drafted with the aim of reducing sound levels from one property to the next by about 53 to 55 dB. However, to avoid the onerous task of testing and supervising the construction of actual party walls in the field, Document E simply lays down a set of approved construction options that, when the Regulations were drafted, were expected to achieve the desired sound reduction.

[0008] The result is that UK Building Regulations permit three party wall options for dense concrete blockwork and one for lightweight blockwork. All involve attaching a sheet of plasterboard to the face of the finished blockwork on each side of the party wall, while preserving a gap between the plasterboard and the blockwork. This gap creates a shallow air-filled cavity or dead air space extending over the face of the blockwork behind the plasterboard. Air trapped within the cavities, one on each side of the party wall, lends a measure of thermal insulation and sound absorption to the wall.

[0009] With experience, it has become apparent that the options permitted by Document E are not performing as well as was originally expected. This has been blamed to some extent upon variations in workmanship, which variations are permitted or even encouraged by poor design. For example, in practice, attachment of plasterboard to blockwork while preserving the gap necessary to create a cavity is usually achieved simply by pressing each sheet of plasterboard onto appropriately-positioned dabs of mortar applied to the blockwork. A particular problem with this technique has been how to control the size and consistency of the gap between plasterboard and blockwork and thus the depth of the cavity.

[0010] As will be discussed below in relation to the present invention, the inventors believe that a consistent and accurate gap creating a cavity of optimum depth is important for evenly distributing sound waves across the face of a blockwork wall. Achieving this in practice is a particular problem because of the imprecise nature of building work, especially if that work is carried out by unskilled or semi-skilled labour working against time pressure. It is impractically difficult to monitor the size and consistency of the gap around all edges of a sheet of plasterboard while the plasterboard is being attached to the blockwork. Worse, it is almost impossible to check the gap after the wall has been finished, at least without damaging the newly-built wall.

[0011] Accordingly, the practice among workers building in accordance with Document E has been to guess at the correct gap and merely to hope that it is achieved when pressing the plasterboard onto the supporting mortar dabs. This brand of guesswork is simply not good enough for accurate acoustic control that may depend upon the depth and consistency of the gap.

[0012] The problem of inadequate sound absorption has been particularly marked in the only option permitted by Document E for lightweight concrete blockwork. This option has been found to be particularly prone to excessive transmission of the higher-frequency sounds associated with speech. Very dense concrete blockwork with a specific gravity greater than say 2.2 is better in this respect, though not ideal; it comes with the penalty of heavier blocks that are more difficult to transport and to build with. In general, it is desirable that construction blocks each weigh less than 25kg and preferably less than 20kg, particularly in view of health and safety legislation which limits the load that any individual worker can be asked to lift repetitively.

[0013] Applicant currently regards the frequency range of about 100 Hz to about 4 kHz typically encountered in a private dwelling as being of most concern to acoustic designers, although frequencies as high as approximately 8 kHz may be encountered and so, ideally, should be considered too. Unfortunately, the UK Building Regulations do not identify the sound frequencies that are typically encountered in a building, and give no guidance as to if, or how, the permitted options may be adapted to suit different frequencies.

[0014] Probably as a result of this lack of attention, party wall designs employing plain concrete blockwork and plasterboard as defined in Document E cannot effectively absorb different frequencies across such a range. For example, experiments with party walls constructed in accordance with Document E have shown that sound with a frequency of 100 Hz is reduced by approximately 23 dB, whereas sound with a frequency of 4 kHz is reduced by approximately 60 dB.

[0015] The party wall designs specified in Document E result from tables of mass requirements deemed to achieve desired levels of sound reduction expressed in dB, following the mass law curve that is familiar to acoustics engineers. Unfortunately, this table is based upon a theoretical and highly artificial 'average range' of sound frequencies and so is not apt to design a party wall that can block each of the different major frequencies that are likely to be encountered in use.

[0016] A further omission from the UK Building Regulations is that there is no standard for preventing reflection of sound within the room that contains the sound source. The emphasis in Document E is very much upon sound transmission through the wall as a whole, although the air spaces behind the plasterboard may be expected to contribute some limited anti-reflection effect.

[0017] Turning now to the patent literature, known sound-absorbing measures extend beyond the inherently sound-absorbing quality of the materials from which a building is constructed. They may take the form of add-on fittings to the building or may be incorporated into the structure of the building itself.

[0018] An example of the former category is the acoustic space absorber of US Patent No. 4,319,661 to Proudfoot, which is a self-contained unit that is simply suspended in a room in which the noise level is to be reduced. It is of no use in constructing a wall, and so need not be discussed further.

[0019] Examples of the latter category are the structural blocks of US Patent Nos. 3,866,001 and 3,837,426 to Kleinschmidt et al, 3,506,089 to Junger and 2,933,146 to Zaldastani et al. These blocks can be used to build an inherently sound-absorbing structure, thereby to reduce or eliminate dependence upon add-on acoustic measures with their inherent cost and other disadvantages.

[0020] Telling the story from the beginning, US Patent No. 2,933,146 to Zaldastani et al dates back to the late 1950s and discloses a sound-absorbing block of a moulded structural material, classically concrete. As was standard practice even then, the block is hollow; it contains a series of internal cavities, all essentially of equal size to one another, whose main purpose is to lighten the block and to improve its thermal insulation properties.

[0021] The innovation of Zaldastani et al was to provide an orifice through which each cavity can communicate with a source of impinging sound when the block is in use forming part of a blockwork wall. By virtue of the orifices, the impinging sound energy can enter the cavities which therefore double as acoustic chambers that participate in absorbing that energy. The term "chamber" will be used hereinafter to avoid confusion with the cavities of the aforementioned party wall construction.

[0022] The orifices of Zaldastani et al are each defined by a respective tapered slot penetrating one major face of the block. That face therefore presents an array of slots to a sound source whereas the opposed major face of the block is uninterrupted by such slots. The slots are kept small so as to avoid unduly weakening the block. Whilst the chambers are all of the same size, the slots are of different lengths; in this way, each slot tailors its associated chamber to respond to a different respective frequency/wavelength of impinging sound.

[0023] Zaldastani et al contains a useful discussion of the various processes of sound absorbance, all of which have the ultimate effect of converting sound energy into heat that is absorbed by the block and/or by the air within the chambers. These processes all depend to some extent upon friction of air moving past the (usually rough) walls of the block and are:

1. The Helmholtz resonance effect resulting in dissipation of sound energy in the walls of the chambers. In particular, Helmholtz resonance underlies the resonant absorptive effect in which a standing wave within the chamber has a velocity antinode (that is, maximum air velocity) at the orifice to the chamber. Sound energy is thus dissipated effectively by viscous friction of air oscillating at maximum amplitude with the walls defining the orifice.

2. The "black-body" effect in which sound energy is dissipated by multiple reflections within the chambers.

[0024] The later US Patent Nos. 3,506,089 to Junger and 3,837,426 and 3,866,001 to Kleinschmidt et al all acknowledge the influence of and discuss US Patent No. 2,933,146 to Zaldastani et al.

[0025] Junger starts by noting that the effectiveness of a chamber in absorbing impinging sound is a function of: (a) the aperture area of the orifice that is exposed to impinging sound; and (b) its acoustic impedance to impinging sound of a particular frequency. If the acoustic impedance is high, the chamber will appear opaque as viewed from the source of the impinging sound. Put simply, the chamber will be relatively reluctant to admit sound energy and therefore will be less effective as a sound absorber. The opposite is true if the acoustic impedance is low. A chamber of low acoustic impedance is therefore the designer's aim.

[0026] Further, the acoustic impedance of a chamber is frequency-related, meaning that the effectiveness of each chamber as an absorber of an impinging sound depends upon the frequency of that sound. Impedance is small and resistive when the frequency of the impinging sound is near the natural or Helmholtz resonance frequency of the chamber. Here, the impedance of the chamber is close to that of air, being well matched to the impedance that characterises the incident sound waves. So, at and around the natural or Helmholtz resonance frequency, absorption is at a peak.

[0027] Junger goes on to state that the natural or Helmholtz resonant frequency of a chamber in a construction block in accordance with US Patent No. 2,933,146 to Zaldastani is typically in the range 10 Hz to 300 Hz. Below the natural or Helmholtz resonant frequency range, the acoustic impedance of a chamber is spring-like and large, and absorption is correspondingly low; but in this instance such low frequencies are not practically important.

[0028] Frequencies above the Helmholtz range are a major problem, however, for here lie sounds whose absorption is most desirable; most notably the frequencies associated with speech. The problem in this frequency range is that absorption is also low, the acoustic impedance of a chamber being mass-like and large. This impedance mismatch limits the transmission of sound energy through the slot into the chamber, thus reducing the sound absorption capability of the block.

[0029] Junger and the later US Patent No. 3,837,426 to Kleinschmidt address this problem by flaring the slots to shift the Helmholtz resonance to a frequency about 20% higher than before, but as the more recent US Patent No. 3,866,001 to Kleinschmidt et al says, this flaring has only a minor effect at frequencies more than 100 Hz above Helmholtz resonance. Accordingly, in their US Patent No. 3,866,001, Kleinschmidt et al proposed that each chamber should be divided into two or more portions by inserting at least one frequency-filtering 'septum' into each chamber.

[0030] The septa of Kleinschmidt et al are thin partitions of, for example, aluminium foil that block and reflect relatively high frequency sounds, thus confining higher-frequency sounds to reflect around merely a portion of the chamber. Conversely, the septa allow the passage of lower-frequency sounds which can therefore reflect around the entire chamber. This differential transmission characteristic creates a secondary absorption peak at a frequency above the natural or fundamental frequency at which the chamber as a whole will resonate. The designer's aim is to position each septum in such a way that the portions of the chamber thus defined are appropriately tuned. This matches the secondary absorption peak to the higher-frequency sound that one wishes to absorb.

[0031] To absorb a wider range of sound frequencies, different chambers in a block can be provided with differently-positioned septa that divide the chambers in respectively different proportions. Further, more than one septum can be used in each chamber.

[0032] Despite its theoretical promise and its adoption by some manufacturers including the aforementioned Trenwyth Industries, the solution proposed by Kleinschmidt et al in US Patent No. 3,866,001 is not ideal. Adding perhaps two, three or more components to each block, presumably by hand, is bound to increase production costs. It will also be noted that, after moulding, the blocks would have to be kept in the production facility for curing before the septa can be added.

[0033] Furthermore, if a septum is to be effective in blocking higher-frequency sound, it is essential that it is sealed around its periphery to the walls of the chamber in which the septum is placed. US Patent No. 3,866,001 to Kleinschmidt et al speaks of achieving this seal by an adhesive bond, a caulked joint or a friction fit, any of which appear to require manual labour and careful quality control. There is also the prospect of the septa working loose in transit or on installation.

[0034] For whatever reason, in both the patent literature and in practice, the building industry has tended to use acoustic blocks only anti-reflectively, especially to create or to line walls around public spaces like sports arenas. In these anti-reflective walls, the orifices and chambers of the blocks all face inwardly toward the source of the sound energy that is to be absorbed. No specific measures are taken to reduce sound transmission through the wall, particularly from the outside in, although absorption will of course inherently reduce transmission through the block. The only measures taken to reduce sound transmission through a wall are constructions like those set out in Document E of the UK Building Regulations, with all of their problems as outlined above.

[0035] It is against this background that the present invention has been made. Whilst the invention solves several problems, Applicant has particularly addressed the problem of how to construct, consistently, a party wall that gives improved acoustic performance in absorbing sound energy to reduce both reflection and transmission. Applicant has aimed to do so without any significant cost penalty over conventional non-acoustic structural blocks and while satisfying existing building guidelines, especially Document E of the UK Building Regulations.

[0036] From one aspect, the invention resides in an acoustic structural element containing at least one acoustic chamber that communicates with the exterior of the element through at least one orifice positioned to be exposed in use to impinging sound, the element being adapted to be laid in a planar course of elements aligned end-to-end mating with neighbouring non-identical elements, wherein the element has opposed ends at least one of which has interface formations shaped to prevent an identical mated element lying in the course and preferably shaped to prevent the identical element lying in the plane of the course when the elements are laid end-to-end with their interface formations mating with one another.

[0037] The interface formations may, for example, each comprise a stepped end face which is preferably stepped in plan, the stepped end face defining a rebate comprising a shoulder between first and second end face portions.

[0038] Where opposed ends of the element each have a stepped end face defining respective first and second end face portions, the first end face portions being on one side of the block and the second end face portions being on an opposite side of the block, it is preferred that the shoulders of the respective end faces are not aligned with each other. In this way, the aggregate width of the first and second end face portions of one end may be less than the aggregate width of the first end portion of one end and the second end portion of the other end.

[0039] Where each opposed end of the element has a shoulder between first and second end face portions, end-to-end mating with the identical element to bring the respective first and second end face portions of the elements into mutually opposed relationship preferably brings the shoulders of the respective elements into mutual abutment to prevent the identical element lying in the plane of the course.

[0040] This aspect of the invention may also be expressed as an acoustic structural element containing at least one acoustic chamber that communicates with the exterior of the element through at least one orifice positioned to be exposed in use to impinging sound, the element being adapted to be laid in a planar course of elements aligned end-to-end with neighbouring non-identical elements, wherein the element has opposed ends at least one of which has interface formations comprising a stepped end face having a shoulder between first and second end face portions for mating with a correspondingly equipped but non-identical element.

[0041] In any event, it is preferred that the orifice opens to one side of the element and that the acoustic chamber is defined by walls of the element and is offset toward that one side to define a substantially thicker wall of the element on a side of the chamber opposed to the orifice than on the side of the chamber including the orifice. More preferably, the element defines a height dimension and the acoustic chamber is a greater acoustic chamber that occupies a major portion of the height of the element and the thicker wall contains at least one lesser acoustic chamber that occupies a minor portion of the height of the element and opens to the side of the element opposed to the orifice.

[0042] The invention extends to a set of acoustic structural elements comprising a plurality of non-identical elements, each having acoustic characteristics that are substantially unique within the set and being adapted to be laid in a course of elements mating with at least one neighbouring non-identical element of the set, at least one element of the set further including interface formations that prevent an identical mated element lying in the course. The set may for example comprise a plurality of non-identical elements, each having acoustic characteristics that are substantially unique within the set and being adapted to be laid in a course of elements mating with at least one element of the set, the elements of the set further including interface formations that impose a sequence upon the elements within the course.

[0043] Advantageously, at least one element of the set can be mated with any other element of the set and that element can also be mated with another identical element. It is also advantageous if at least one element of the set can be mated only with one or more specific other elements of the set.

[0044] These features facilitate the construction of an acoustic structure having a predetermined mix of different acoustic elements. For example, at least one element of the set may be substantially solid and at least one other element may contain an acoustic chamber that communicates with the exterior of the element through an orifice positioned to be exposed in use to impinging sound. Where the set includes a plurality of elements each containing an acoustic chamber, the chambers of those elements are suitably tuned to resonate at substantially different frequencies of impinging sound.

[0045] The set of the invention may include elements as previously defined wherein the shoulders of the end faces are positioned progressively closer to a datum face of the element when progressing through successive elements of the sequence of the set. In that case, where the set includes an element that can be mated with any other element of the set, that element preferably has a shoulder at one end that is closer to the datum face and a shoulder at an opposed end that is further from the datum face than the corresponding shoulder of any other member of the set.

[0046] The invention also encompasses an acoustic structure comprising an array of elements as herein defined or at least one set of elements as herein defined. The acoustic structure may be defined as a mix of substantially solid acoustic elements and acoustic elements that contain an acoustic chamber communicating with the exterior of the element through an orifice positioned to be exposed in use to impinging sound, different ones of the elements that contain an acoustic chamber preferably being tuned to resonate at substantially different frequencies of impinging sound.

[0047] The elements of the structure are preferably laid in at least one course with substantially solid elements situated at the end of the or each course. Where the structure is a party wall, the substantially solid elements are advantageously positioned where the party wall joins to a flanking wall.

[0048] The elements in a course are preferably similarly oriented but the orientation of elements in any neighbouring course is preferably reversed. For example, the orientation of elements suitably alternates from course to successive course.

[0049] The above-defined interface formations co-operate and mate to define a labyrinthine junction that helps to prevent transmission of sound through gaps between elements laid end-to-end in a course. This aspect of the invention has benefit even if control over the sequence or mix of elements is not required and so, from another aspect, the invention extends to an acoustic structural element containing at least one acoustic chamber that communicates with the exterior of the element through at least one orifice positioned to be exposed in use to impinging sound, the element being adapted to be laid in an acoustic structure in a manner mating with at least one neighbouring element in the structure, wherein the element has at least one face that is shaped to define a labyrinthine junction between itself and a corresponding mating face of a neighbouring element of the structure.

[0050] The term labyrinthine does not necessarily require a very complex junction shape but the shape should at least prevent direct transmission of sound energy between mated elements through any gap between them, by blocking and/or diverting such sound energy. Preferably, therefore, the face is stepped to define a shoulder between first and second face portions. The shoulder suitably opposes or faces toward the exposed gap between neighbouring mated elements and thereby blocks or at least diverts sound energy entering that gap.

[0051] It is particularly advantageous if, when mated, the faces defining the junction are in contact along at least a line or area of contact, for example shoulder-to-shoulder, so that sound transmission through the junction is blocked by that contact. Nevertheless, it is also advantageous if the desired contact is achieved without requiring contact across the entire mating face area, thus leaving room for mortar between elements to seal the gap and to block or at least attenuate sound energy entering the gap.

[0052] The invention may also be defined in terms of an acoustic structural element containing at least two acoustic chambers that each communicate with the exterior of the element through at least one respective orifice positioned to be exposed in use to impinging sound, wherein the element has first and second opposed sides each of which contains at least one of said orifices.

[0053] By providing orifices on both exposed sides of the element, a partition such as a party wall constructed of a plurality of the elements, such as blocks, is capable of effectively absorbing sound impinging from both sides of the partition. The surfaces of the element are also exploited to maximum sound-absorbing effect.

[0054] For flexibility of design of an acoustic structure and to absorb the widest possible range of sound frequencies, it is preferred that the element is tuned to offer a substantially different acoustic response to sound impinging the element from one side than from the other side. This may be achieved in an arrangement where the or each orifice on the first side leads to a first chamber and the or each orifice on the second side leads to a second chamber, the first and second chambers having a substantially different resonant frequency to each other.

[0055] From another aspect, the invention resides in an acoustic structural element containing at least two acoustic chambers that each communicate with the exterior of the element through at least one respective orifice positioned to be exposed in use to impinging sound, the respective chambers being tuned to resonate at substantially different frequencies of impinging sound by being of substantially different volumes, wherein the respective chambers are defined by walls that are integral with the element.

[0056] In this way, the frequency response of a chamber can be tuned without recourse to septa or other insertions and without compromising the manufacture or utility of the element. A preferred way of achieving this is to select the local thickness of at least one wall defining a chamber, thereby to determine the volume of that chamber; different ones of said chambers may then be defined by walls of respectively different local thickness.

[0057] In a particularly elegant arrangement, at least one greater chamber is defined by walls that are integral with the element and at least one lesser chamber is embedded in a wall of the element that defines the or each greater chamber. This maximises the number and range of chambers, without significantly compromising the strength of the block. Indeed, the lesser chambers can be made so small that they do not significantly weaken the wall in which they are situated and yet can be provided in such numbers as to achieve a large aggregate orifice area.

[0058] As the embedded lesser chambers can be provided in any wall of the greater chamber that is integral with the element, the invention extends to an acoustic structural element containing at least two acoustic chambers that each communicate with the exterior of the element through at least one respective orifice positioned to be exposed in use to impinging sound, the respective chambers being tuned to resonate at substantially different frequencies of impinging sound by being of substantially different volumes, wherein at least one greater chamber is partially defined by a wall that is integral with the element and at least one lesser chamber is embedded in the wall that defines the greater chamber. To this end, it is advantageous if the lesser chamber is positioned between the greater chamber and an exterior surface of the element to be exposed in use to impinging sound.

[0059] In the element of the invention as variously defined above, it is preferred that the or each wall also defines an exterior surface of the element; the or each wall may also be adapted to bear structural loads. In this way, the or each wall of the element performs more than one function, to the benefit of simplicity.

[0060] The element of the invention advantageously includes integral spacer means for maintaining a cavity between the element and a cover sheet defining the cavity when the element is in use in an acoustic structure that includes the cover sheet. It is preferred that the spacer means comprises at least one protrusion standing proud from a face of the element that includes an orifice. The spacer means suitably comprises first and second mutually spaced protrusions. Where the element has at least one face including an orifice, said face having opposed edges, each protrusion may be situated at or adjacent to a respective one of the opposed edges. Where the element is moulded, it is preferred that the protrusions are situated at or adjacent to the edge of the element that is the first to leave the mould upon demoulding.

[0061] The invention extends to an acoustic structure comprising an array of substantially identical elements as hereinbefore defined. For example, it is preferred that the elements are blocks and that the array is part of a wall. Thus, in relation to the abovementioned spacers, the structure of the invention preferably includes a sheet spaced from the array of elements to define a cavity that communicates with the orifices of the elements. It is preferred that the sheet is permeable to sound and that the cavity is configured to lead sound passing through the sheet to the chambers of the elements via the orifices. The sheet would most commonly be a sheet of plasterboard.

[0062] The structure described hereinbefore advantageously includes fixing means for fixing the sheet to the array of elements, wherein the fixing means, including battens or mortar dabs applied to the array of elements, are accommodated in recesses. In this way, where the fixing means include a batten, the batten may extend from the recess of one block to the recess of another juxtaposed block in a neighbouring course.

[0063] In a related method, the invention encompasses a method for absorbing sound energy impinging an acoustic structure having a plurality of sound-absorbing chambers that each receive a portion of the impinging sound energy through at least one respective orifice, the method comprising permitting at least part of the impinging sound energy to pass through a sheet and spreading or diffusing the impinging sound energy across a face of the structure within a cavity that communicates with the orifices, the cavity being defined between the sheet and the face of the structure.

[0064] This aspect of the invention may also be expressed as a method for improving the absorption of sound energy by an acoustic structure having a plurality of sound-absorbing chambers that each receive a portion of the impinging sound energy through at least one respective orifice, the method comprising applying a sound-permeable sheet to a face of the structure while preserving a cavity between the sheet and the face of the structure, which cavity communicates with the orifices.

[0065] The invention extends to a method for fixing a sound-permeable sheet to an acoustic structure, comprising applying the sheet to a face of the structure, pressing the sheet against spacers integral with the structure that define a cavity between the sheet and the face of the structure, and fixing the sheet to the structure in a manner that preserves the cavity. To this end, the element of the invention preferably includes at least one recess for accommodating fixing means capable of fixing a cover sheet to the element when the element is in use in an acoustic structure that includes the cover sheet. Where the element is moulded, the or each recess is suitably elongate and extends in the demoulding direction.

[0066] The element of the invention is preferably adapted to be laid in courses with similar elements to form an acoustic structure with the recesses of juxtaposed elements in neighbouring courses in mutual alignment when the elements are laid in straight or broken bond. The aligned recesses of juxtaposed elements may extend into one another, thereby allowing fixing means such as a batten lying in the aligned recesses to extend from one element to another. To allow this while the elements are laid in broken bond, each element may have one first recess and two second recesses, the width of the first recess being greater than or equal to the aggregate width of the second recesses.

[0067] It is advantageous if the element of the invention as described above has a face including an orifice and a first recess divides that face into first and second face portions, wherein the face has opposed edges, and a second recess is situated at or adjacent to each respective one of the opposed edges.

[0068] In the acoustic structure of the invention, at least one element of the array may be reversed with respect to another element of the array. If it is desired to create a structure having a different acoustic response on each side, a substantially greater number of elements of the array may be reversed than are not reversed, Conversely, a substantially equal number of elements of the array can be reversed as are not reversed if a similar acoustic response is required on both sides of the structure. In that event, reversed and non-reversed elements suitably alternate in rows or courses.

[0069] In any event, by tailoring the elements and/or their dispositions appropriately, the structure of the invention can have a different acoustic response to sound impinging from one side of the structure than from another, opposed side of the structure. For example, one side may be configured primarily to absorb sound and an opposed side may be adapted primarily for decorative purposes. Such a structure can be useful as an acoustic barrier, for example beside a highway. The structure may also be a wall which is a partition or party wall between adjoining spaces in a building, an external wall of a building, or an acoustic barrier built adjacent a noise source.

[0070] In a further embodiment of the invention, the acoustic structure has a plurality of sound-absorbing chambers each for receiving, in use, a portion of impinging sound energy through at least one respective orifice, the structure including a sound-permeable sheet defining a cavity between itself and a face of the structure, which the cavity communicates with the orifices.

[0071] In order that this invention can be more readily understood, reference will now be made by way of example to the accompanying drawings in which:

Figure 1 is an isometric view from above and one side of a prototype structural acoustic block of the invention, showing the block oriented for use with its closed top face uppermost;

Figure 2 is an isometric view corresponding to Figure 1 but viewed from the other side of the block;

Figure 3 is an isometric view corresponding to Figure 1 but showing the block inverted to display its open bottom face and its three different chamber sizes;

Figure 4 is an isometric view corresponding to Figure 2 but showing the block inverted and thus akin to Figure 3;

Figure 5 is a top plan view of the block of Figures 1 to 4;

Figure 6 is a bottom plan view of the block of Figures 1 to 5;

Figure 7 is a side elevation of a side face A of the block of Figures 1 to 6;

Figure 8 is a side elevation of a side face B of the block of Figures 1 to 7;

Figure 9 is a partially cut away isometric view of a party wall construction comprising courses of the blocks of Figures 1 to 8 laid in broken bond and having plasterboard attached to the blockwork by mortar dabs situated in recesses defined by the blocks;

Figure 10 is an enlarged top plan view of the party wall construction of Figure 9, showing the upper course of blocks supporting sheets of plasterboard on opposite sides of the wall by means of the mortar dabs and spacer nibs integral with the blocks;

Figure 11 is a partially cut away isometric view of a party wall construction corresponding to Figure 9 but showing the plasterboard attached to the blockwork by timber battens situated in the recesses defined by the blocks;

Figure 12 is a partial isometric view of blockwork suitable for the party wall constructions of Figures 9, 10 and 11;

Figure 13 is an isometric view from above and one side of an inverted block akin to the prototype block of the preceding Figures but having four different chamber sizes and being adapted for mass production by moulding;

Figure 14 is an isometric view corresponding to Figure 13 but viewed from the other side of the block;

Figure 15 is an isometric view from above and one side of an inverted sequence of blocks laid in a row to form part of a course, the blocks being modified in accordance with a further embodiment of the invention; and

Figure 16 is an isometric view corresponding to Figure 15 but viewed from the other side of the row and including a further block.

[0072] Referring firstly to Figures 1 to 8 of the drawings, a concrete structural acoustic block 1 of the invention is of generally cuboidal shape, having six generally oblong rectangular faces A, B, 2, 3 and 4 each disposed at a right angle to its neighbouring faces. The concrete can be of any composition that meets the designer's requirements for weight, strength, finish and cost.

[0073] The block 1 presents opposed first and second major side faces which, when laid with other similar blocks 1 to form a blockwork wall, define the exposed sides of the wall. For brevity, these major side faces of the block 1 will be referred to hereinafter simply as side faces A and B. The block 1 also has a top face 2, a bottom face 3 and two end faces 4.

[0074] The prototype block 1 illustrated in the Figures and tested to date measures overall 440mm in length, 190mm in width and 215mm in height. For the health and safety reasons mentioned previously, the weight of the block 1 is less than 25kg. These dimensions and this weight are mentioned merely to help the reader to visualise the invention: none of the dimensions or weights expressed in this specification should be taken as limiting the invention in its broad sense.

[0075] Each side face A and B is indented by three continuous elongate recesses 5, 6 - one inner recess 5 and two outer recesses 6 - that cross the side faces A and B from the top face 2 to the bottom face 3. The recesses 5, 6 are parallel to the end faces 4 and to each other, and each interrupt the long side edges of the top face 2 and the bottom face 3.

[0076] The inner recess 5 bisects each side face A and B to define generally equal face portions A1 and A2 on side face A and B1 and B2 on side face B. The inner recess 5 has a base and two parallel sides. A respective outer recess 6 or rebate is situated at each end of each side face A and B. Each outer recess 6 has a side defining a respective end edge of the corresponding side face A or B but is open to the corresponding end face 4 of the block. The plain rectangular end faces 4 of the block 1 are therefore narrower than the distance between side faces A and B, by twice the depth of each outer recess 6.

[0077] In the prototype block 1 illustrated in the Figures, the recesses 5, 6 are all 15mm deep. The width of each outer recess 6 is marginally less than half the width of the inner recess 5, for example 27.5mm for each outer recess 6 vs. 65mm for the inner recess 5 in the prototype block. The idea of this is that when identical blocks 1 are laid end-to-end in horizontal courses, the adjoining outer recesses 6 of two adjacent blocks 1 will abut to form a recess of similar width to the inner recess 5, allowing for a typical thickness of say 10mm of mortar between the blocks.

[0078] So, when courses of blocks 1 are laid in broken bond with mortar between them in conventional fashion, the inner recess 5 of a block 1 aligns with juxtaposed outer recesses 6 of the blocks 1 in the courses above and/or below. The recesses 5, 6 thereby combine to form an elongate vertical channel as shown in Figures 9 and 11 which can accommodate mortar dabs 7 (Figure 9) or timber battens 8 (Figure 11) that fix sheets of plasterboard 9 to the blockwork.

[0079] Each side face A and B has two integral rectangular spacers 10 or nibs that protrude orthogonally outwardly from the general plane of the respective side faces A and B. The spacers 10 are situated in an outermost and uppermost position with respect to the side faces A and B: the spacers 10 therefore create projections that interrupt the long side edges of the top face 2 and the end edges of the side faces A and B. In the prototype block 1 illustrated, the spacers 10 stand proud by 10mm from the side faces A and B and are 35mm high by 22.5mm wide.

[0080] The purpose of the spacers 10 is best illustrated in Figure 10 which shows a course of blocks 1 from above when in use, supporting two sheets of plasterboard 9 (one on each side) via an array of mortar dabs 7 applied to the recesses 5, 6 of the blocks. When first applied to the recesses 5, 6, the mortar dabs 7 were initially thicker than the combined depth of the recesses 5, 6 and the height of the spacers 10. In Figure 10, however, the dabs 7 have been flattened by applying the plasterboard 9 to them and then pressing the plasterboard 9 against the blockwork until it bears against the spacers 10 and so can go no further. In this way, the spacers 10 ensure that a cavity 11 of whatever depth may be deemed optimum (in the prototype block 1, 10mm) is maintained between the plasterboard 9 and the face of the blockwork.

[0081] The spacers 10 allow positioning of the plasterboard 9 to be transformed from a matter of inaccurate guesswork or, at best, a painstaking task for skilled labour to a foolproof process allowing readily-achievable and repeatable accuracy.

[0082] Similar accuracy can be achieved by using timber battens 8 in the channels or recesses 5, 6, either instead of or in addition to mortar dabs 7. The battens 8 have a thickness equal to the depth of the recesses 5, 6 plus the height of the spacers 10 - in the prototype illustrated, 25mm. The battens 8 can be attached to the blockwork by any suitable means, preferably by nails, and the plasterboard 9 can in turn be attached to the battens 8 by any suitable means but again preferably by nails.

[0083] It is preferred that the battens 8 are short discontinuous pieces leaving intermittent gaps in each channel, rather than defining closed cells bounded by lengthy battens. This is to allow a reasonably unobstructed flow of air across the cavity 11, which is believed to help the sound waves spread across the face of the blockwork, aiding their subsequent absorption by the blocks 1. This process of spreading or diffusion may be helped by the undulating face of the blockwork due in large part to the recesses 5, 6. Other shaping may be applied to the side faces A, B of the blocks 10 to aid the diffusion of sound energy.

[0084] When the blocks 1 are laid in courses, their spacers 10 stand proud from the general plane of the blockwork in a regularly-spaced array that affords excellent support to the plasterboard 9 across substantially all of its width. This applies particularly when the blocks 1 are laid in broken bond as illustrated in Figures 9, 11 and 12, whereupon it will be seen that the spacers 10 are disposed in diagonal arrays that minimise the maximum gap between adjacent spacers 10.

[0085] As can best be seen in the views from underneath of Figures 3, 4 and 6, the block 1 is hollow: it contains two major acoustic chambers CA1 and CA2 and four minor acoustic chambers CB. Each chamber CA1, CA2, CB is generally cuboidal, being defined by five internal faces each disposed at right angles to each of its neighbouring faces. There are only five internal faces because each chamber CA1, CA2, CB is wholly open at its bottom end to the bottom face 3 of the block 1. This is a prerequisite of manufacturing by moulding.

[0086] The major chambers CA1, CA2 occupy respective opposed end portions of the block 1. They are separated and partially defined by a thick central partition 12 that extends from side face A to side face B within the block 1, in the region of the inner recesses 5. Otherwise, the major chambers CA1, CA2 are defined by end walls 13 that define the end faces 4, side walls 14A, 14B that define the side faces A and B respectively and a top wall (visible only as the top face 2 in the Figures) that defines the top face 2 of the block. In the prototype block 1 of the Figures, all of these walls 12, 13, 14A, 14B are at least 20mm thick and in most cases thicker than that: this ensures good load-bearing characteristics.

[0087] The depth of the major chambers CA1, CA2 occupies most of the height of the block 1 between the top face 2 and the bottom face 3, except for the thickness of the top wall that closes the top of each major chamber CA1, CA2. In the prototype block 1 illustrated, the top wall is 35mm thick.

[0088] In contrast, the minor chambers CB are set in to or embedded in the side wall 14B that defines side face B of the block. They are much smaller than the major chambers CA1, CA2 both in width and also in depth, which does not extend far from the bottom face 3 of the block 1, occupying only a minor portion of the height of the block 1 as can be seen. Indeed, the minor chambers CB are so small that they do not significantly weaken the side wall 14B in which they are situated. Moreover, the minor chambers CB can be provided in such numbers as to offset their small size by increasing their aggregate orifice area, thus absorbing more of the sound energy to whose frequency they are tuned.

[0089] Each chamber CA1, CA2, CB is entirely closed on three sides as well as at its top, but the other side - the side adjacent to side face A for the major chambers CA1, CA2 and to side face B for the minor chambers CB - is penetrated by an orifice in the form of an oblong parallel-sided slot 15 that penetrates the respective side face A or B as appropriate. The slots 15 extend generally parallel to the end faces 4 of the block 1 and, like the chambers CA1, CA2, CB, are open to the bottom face 3 of the block. The chambers CA1, CA2, CB therefore assume a general C-shape in bottom plan view, as best shown in Figure 6.

[0090] Chamber CA1, the largest acoustic chamber and the larger of the two major chambers, lies behind one face portion A1 of side face A. In a prototype of the invention as illustrated in the Figures, chamber CA1 measures 105mm x 170mm in plan and is 170mm deep. It communicates with a slot 15 10mm wide that penetrates a side wall 14A 40mm thick and bisects side face portion A1. The resonant frequency of this chamber has been found to be 173 Hz.

[0091] Chamber CA2 lies behind another face portion A2 of side face A; it is the smaller of the two major chambers. In the abovementioned prototype block 1, chamber CA2 measures 105mm x 105mm in plan and is 170mm deep. It communicates with a slot 15 5mm wide that penetrates a side wall 14A 20mm thick and bisects side face portion A2. Its resonant frequency has been found to be 208 Hz.

[0092] The four minor chambers CB are all identical in the abovementioned prototype block. They each measure 37mm x 10mm in plan and are 30mm deep. Each communicates with a slot 15 25mm wide that penetrates 10mm into the wall 14B. The resonant frequency of these, the smallest chambers, has been found to be 3109 Hz.

[0093] Returning now to the party wall constructions of Figures 9 and 11, it will be noted how the blocks 1 of each course alternate. One block 1 presents side face A to a first side of the wall - it follows that side face B is presented to the opposed second side of the wall - whereas the neighbouring juxtaposed blocks 1 at each end are reversed to present side face B to the first side of the wall and side face A to the second side of the wall. And so it goes on until blockwork as shown in Figure 12 is formed, ready for the application of plasterboard 9 via mortar dabs 7 or battens 8 as previously described.

[0094] The visible face of the blockwork of Figure 12 presents an equal distribution of side faces B to side faces A, but it would be equally possible to vary the relative proportions of the side faces simply by reversing more or less of the blocks 1 in relation to the other blocks 1 of the wall. This is an exceptionally simple way to tailor the acoustics of the wall if different sound frequencies are expected from different sides of the wall. Indeed, in the extreme, all of the blocks 1 could be disposed the same way round. However, in most party wall constructions one would normally expect and cater for the same sound frequencies from both sides of the wall: in that case, the simple alternation of the blockwork of Figure 12 is all that is required.

[0095] Those skilled in the art will note from Figures 9, 11 and 12 how the closed top face 2 of each block 1 will prevent mortar falling into the chambers CA1, CA2, CB or the slots 15 while the wall is being built. Mortar dropped in this way could otherwise obstruct the slots 15 or adversely affect the resonant frequency of the chambers CA1, CA2, CB.

[0096] Referring now to Figures 13 and 14 of the drawings, a block 16 is akin to the prototype block 1 illustrated in the preceding Figures, and like numerals are used to identify like parts. However, it will be apparent that the walls, faces and edges defining features such as the slots 15, chambers CA1, CA2, CB1, CB2 and spacer nibs 10 taper, all with the aim of easing demoulding. The walls of female features such as the slots 15 taper inwardly towards the top 2 of the block 16, whereas the walls of male features such as the spacers 10 taper inwardly towards the bottom 3 of the block 16. Similar tapering may also be applied to the main external faces of the block 16, for the same reason.

[0097] Another variation of block 16 is that the four minor chambers CB are no longer all identical: they are divided into two pairs CB1, CB2, one pair on each side face portion B1 and B2 of side face B. Taper aside (balanced by being enlarged to 40mm x 10mm in bottom plan view), chambers CB1 are the same as chambers CB of the prototype block 1 and have the same nominal resonant frequency of 3109 Hz. Chambers CB2, on the other hand, are a little larger than chambers CB1 and hence resonate at a correspondingly lower frequency: chambers CB2 are 40mm x 15mm in bottom plan view and have a nominal resonant frequency of 2511 Hz, although they communicate through slots 15 of the same size as those associated with chambers CB1.

[0098] A further variation of block 16 is that only one spacer 10 is provided on each side face A, B. These two spacers 10 of the block 16 are diagonally opposed about the top face 2. Thanks to this, when two blocks 16 are laid side face-to-side face in a 'cubed' arrangement, their spacers 10 do not clash; instead, each spacer 10 bears against the adjacent side face of the other block 16.

[0099] Though not illustrated in Figures 13 and 14, it is also possible to provide hollows on each side face A, B in corresponding but opposed positions with respect to the spacers 10. Each hollow would be shaped and dimensioned to accommodate a spacer 10 of an adjacent block laid in a cubed arrangement, thereby allowing the side faces A, B of the cubed blocks to lie flush against each other.

[0100] Another variant not illustrated in Figures 13 and 14 pairs the larger of the minor chambers CB2 together in the thicker part of the side wall 14B that lies between chamber CA2 and side face portion B2. This leaves the smaller of the minor chambers CB1 paired together in the thinner part of the side wall 14B that lies between chamber CA1 and side face portion B1. In this way, the minor chambers CB1, CB2 are distributed and positioned in accordance with their size with the aim of maximising the wall thickness of the block in the region of the side wall 14B.

[0101] Finally, Figures 15 and 16 illustrate a set of blocks 17, 18, 19, 20 laid sequentially end-to-end in a row to form part of a course, the blocks being modified in accordance with a further embodiment of the invention. The blocks 17, 18, 19, 20 in the row are shown inverted in Figures 15 and 16 to display the internal features that are only evident from their undersides, particularly the different chamber sizes therein. The blocks 17, 18, 19, 20 would of course be laid the other way up in practice to prevent mortar falling into the chambers CA, CB or the slots 15.

[0102] To the extent that the blocks 17, 18, 19 and 20 illustrated in Figures 15 and 16 are generally cuboidal and have slots 15 communicating with internal chambers CA, CB and other features akin to those of the blocks 1 and 16 illustrated in the preceding Figures, like numerals are used to identify like parts.

[0103] It will be noted from Figures 15 and 16 that the blocks 17, 18, 19, 20 therein are of four different types. Three blocks 17, 18, 19 each have a single major chamber CA of relatively large volume, intermediate volume and small volume respectively. In the row illustrated, the block 17 containing the large chamber CA lies between the blocks 18 and 19 containing the intermediate and small chambers CA. The fourth block 20 has no major chamber at all, being solid save for the pair of minor chambers CB1 and CB2 that are common to all of the four types of block 17, 18, 19, 20.

[0104] In a sense, the blocks 17, 18 and 19 are akin to a major portion of a block 1 or 16 of the preceding Figures created by dividing the block 1 or 16 along the offset central partition 12. This analogy is apt because the blocks 17, 18, 19 and 20 of Figures 15 and 16 are intended to be smaller than the blocks 1 and 16 of Figures 1 to 14. The aim is to ensure that no block 17, 18, 19, 20 is heavier than 20kg and is therefore comfortably within any foreseeable statutory limits on the weight that can be lifted repetitively by one worker.

[0105] This weight restriction imposes a relatively small overall size on each block 17, 18, 19, 20, for example a length of about 300mm. This in turn permits only one major chamber in each block 17, 18, 19 while leaving enough wall thickness for structural strength and acoustically-beneficial mass.

[0106] It will be noted in this respect that each major chamber CA is offset where possible towards the side face A with which it communicates through a slot 15. The side wall 14B is therefore substantially thicker than the side wall 14A to an extent permitted by the size of the chamber CA, creating a zone of increased mass behind the internal wall of the major chamber CA that is opposed to the slot 15. In acoustic testing, this zone of increased mass opposed to the slot 15 has been found beneficial to the absorption of sound that would otherwise tend to travel straight through the block 17, 18, 19, 20 via the slot 15.

[0107] The aforementioned need to absorb different sound frequencies in a party wall construction imposes a requirement for a mix of differently-sized major chambers CA and hence a mix of different blocks 17, 18 and 19 in the party wall. The combination of three blocks 17, 18 and 19 allows the acoustic properties of the wall to be tailored, each block responding to a selected frequency range so that, for example, the intermediate chamber CA of block 18 fills a gap in sound absorption curves between the larger and smaller chambers CA of blocks 17 and 19 respectively.

[0108] Of course, there could be a larger range of different blocks each defining a different chamber size, just as there could be fewer. This ability freely to tailor the range to suit the application is a benefit of having a single major chamber per block. Nevertheless, a range of three or, at most, maybe four or five differently-sized chambers is suitable for most practical purposes in the construction of party walls and is preferred because it achieves substantially all of its technical objectives without causing undue complexity of manufacture or use.

[0109] Whilst the substantially solid block 20 has no major chamber, its inclusion in the mix of blocks is desirable because the solid block adds to the overall mass of the wall. Mass is a fundamental factor in the sound absorption characteristics of a structure as a whole; generally speaking, more mass is better for sound absorption for reasons of rigidity and because a greater mass takes more energy to vibrate although, in isolation, mass is not a cure-all. Acoustic test results also suggest that it is advantageous to start and finish each course of blocks with a substantially solid block where the party wall joins to a flanking wall.

[0110] As mentioned previously, the construction worker hurrying under time pressure is not noted for the care with which he assembles blocks to build a party wall. All the wisdom of acoustic science counts for little if a careless worker leaves gaps without mortar between or around blocks that present a path for sound transmission. Similarly, there is little point in acoustic scientists optimising the theoretical mix and disposition of different blocks if those blocks actually end up being laid in the wrong mix and disposition, particularly as such a problem may require destructive analysis to detect and demolition to put right.

[0111] Accordingly, there is a need for a party wall construction system that addresses these problems: a system which, put simply, is more difficult to get wrong than to get right.

[0112] With this aim in mind, it may initially seem a retrograde step to provide a mix of four or more different types of blocks 17, 18, 19, 20 that, when oriented for use with the plain top face 2 uppermost, look much the same as one another. However, it will be noted that the end faces 4 of the blocks 17, 18, 19, 20 are not the plain, flat rectangles that define the ends 4 of the blocks 1 and 16 but instead are shaped to fit one another in a manner that imposes a sequence upon the blocks 17, 18 and 19 within the course. When averaged over the plurality of courses necessary to form a party wall, this ensures that a desired mix of blocks is created.

[0113] Specifically, it will be noted that each end face 4 of each block 17, 18, 19, 20 is heavily stepped in plan view to create a rebate defined by a shoulder 21 disposed orthogonally between first and second end face portions 4A and 4B. The shoulder 21 thus lies in a plane parallel to the side faces A and B of the block 17, 18, 19, 20, and each end face 4 is broadly of L-shape in plan view. End face portion 4A extends from the shoulder 21 to side face A and end face portion 4B extends from the shoulder 21 to side face B of the block 17, 18, 19, 20. The position or offset of the shoulder 21 in relation to the side faces A and B and hence the relative sizes of the end face portions 4A and 4B vary from one block 17, 18, 19, 20 to the next.

[0114] Starting from the left side of the row as illustrated in Figure 16, the shoulder 21 at the left end of a first, solid block 20 is close to side face B. Conversely, the shoulder 21 on the right end of that block 20 is centrally positioned between the side faces A and B. The shoulder 21 on the left end of the second, intermediate-chamber block 18 is correspondingly centrally positioned between the side faces A and B, so that the blocks 20 and 18 can seat snugly against each other with their shoulders 21 abutting and their side faces A and B aligned with their counterparts. The side faces A and B then lie in respective parallel planes that define at least one of the exposed faces of the courses and thus of the wall.

[0115] Moving on from left to right, the shoulder 21 on the right end of the second block 18 is closer to the side face B, and so the shoulder 21 on the left end of the third, large-chamber block 17 is positioned to match. The shoulder 21 on the right end of the third block 17 is still closer to the side face B, and the shoulder 21 on the left end of the fourth, small-chamber block 19 is positioned to match. Finally, the shoulder 21 on the right end of the fourth block 19 is as close to the side face B as was the shoulder 21 at the left end of the first, solid block 20 at the left end of the row. Accordingly, another solid block 20 can be the fifth block of the row as illustrated, and the sequence starts again.

[0116] If the blocks 17, 18, 19 are not positioned in the sequence determined by the diminishing or increasing rebates of their cooperating end formations, a mispositioned block 17, 18, 19 will lie substantially out of the desired plane of the wall because the shoulder offsets of the cooperating ends 4 will not match. This misalignment should be obvious enough to alert a construction worker that something is amiss, long before further blocks 17, 18, 19, 20 are irredeemably laid around the misaligned block 17, 18, 19.

[0117] A beneficial side-effect of the cooperating and mating end formations 4A, 4B, 21 is that they create a labyrinthine junction that helps to prevent transmission of sound through gaps between the blocks 17, 18, 19, 20, even if the application of mortar is incomplete. It will be noted in this respect that the facing shoulders 21 of adjacent blocks 17, 18, 19, 20 can be in direct face-to-face contact with each other while a space is preserved between the opposed end face portions 4A, 4B of the adjacent blocks to accommodate mortar.

[0118] As party walls are obviously of different widths, it is not possible to predetermine the length of a course of blocks and hence the number of blocks in that course. This presents a challenge in ensuring as far as possible that a substantially solid block 20 starts and ends each course, as is acoustically desirable. This challenge is met by the embodiments illustrated because the end formations of the solid block 20 are capable of mating with any of the end formations of the other blocks 17, 18, 19 and indeed with the end formations of another solid block 20 should circumstances ever necessitate that.

[0119] More specifically, the shoulders 21 of the solid block 20 will only abut the shoulder 21 of an adjacent block when laid in the positional sequence illustrated.

However, when the need arises, a solid block 20 can be placed out of sequence in a manner that leaves a gap between its shoulder and the shoulder 21 of an adjacent block 17, 18, 19, 20 but still allows the blocks 17, 18, 19, 20 to lie in proper alignment with their side faces A and B in the general plane of the course.

[0120] Geometrically, this is achieved by ensuring that one end 4 of the block 20 has its shoulder 21 closer than that of any other block 17, 18, 19 to one side face A and that the other end 4 of the block 20 has its shoulder 21 closer than that of any other block 17, 18, 19 to the other side face B. Thus, in the example illustrated, the shoulder 21 at the left end of the block 20 is closer than the shoulder 21 of any other block 17, 18, 19 to side face B and the shoulder 21 at the right end of the block 20 is closer than the shoulder 21 of any other block 17, 18, 19 to side face A.

[0121] The blocks 17, 18, 19, 20 are preferably laid so that successive courses alternate, one course having its major chambers CA all opening to one side of the wall and the adjacent course(s) above and/or below having their major chambers CA all opening to the other side of the wall.

[0122] Another, more minor, difference over blocks 1, 16 of Figures 1 to 14 is the lack of recesses 5, 6 to accommodate battens or dabs. The omission from the embodiment of Figures 15 and 16 of the recesses 5, 6 shown in Figures 1 to 14 still allows for application of mortar dabs or battens to the face of the finished blockwork to hold finishing panels such as plasterboard 9 (not shown). Again, the plasterboard will rest against the spacers 10 to define and preserve the desirable cavity 11. Acoustic testing suggests that wooden battens are preferable to mortar dabs because the boundary between wood and masonry, being fundamentally dissimilar materials, better interrupts sound transmission than the boundary between mortar and masonry.

[0123] As in blocks 1 and 16 of Figures 1 to 14, the minor chambers CB1 and CB2 are set in to or embedded in the side wall 14B that defines side face B of a block 17, 18, 19, 20, extending only a short distance from the bottom face 3 of the block 17, 18, 19, 20 to occupy only a minor portion of the height of the block 17, 18, 19, 20. Also, whilst the tapering of the various features evident in block 16 of Figures 13 and 14 is not evident in the schematically-illustrated blocks 17, 18, 19, 20 of Figures 15 and 16, such tapering can be applied in practice.

[0124] Like block 16 of Figures 13 and 14, only one spacer 10 is provided on each side face A, B so that, when two blocks 17, 18, 19, 20 are laid side face-to-side face in a 'cubed' arrangement, their spacers 10 do not clash. It so happens that the abovementioned exemplary overall block length of about 300mm cubes well. Again, in the blocks 17, 18, 19, 20, each spacer 10 is situated in a top corner of the respective side faces A and B and the spacers are diagonally opposed about the top face 2.

[0125] Many other variations are possible without departing from the inventive concept. For example, in principle, it would be possible for the respective orifices of the major chambers to lie in mutually opposed sides of the element. Indeed, the number, size, shape and disposition of the chambers and their associated orifices can be altered to suit different applications.

[0126] The same goes for the size, shape, purpose and composition of the structural elements themselves. For example, it will be evident to those skilled in the art that a sequence of blocks as described above could be integrated into a single multi-chambered combination block if the weight penalty of such a block, and the likely need for mechanical lifting, are acceptable.

[0127] Further, whilst the invention is particularly suitable for constructing partitions such as party walls, the invention could also be used with benefit in external walls where an internal side of the block is used for its anti-reflective properties and an external side is adapted to absorb incoming ambient sound. It is also possible to use structural elements designed in accordance with the invention to construct or to line floors and ceilings.

[0128] In yet another application suitable for building an acoustic barrier, which may be a free-standing wall or a retaining wall, sound-absorbing orifices and, optionally, sound-diffusing formations are concentrated on one side of a block. For example, minor chambers can be set in to the side wall of the block that includes orifices leading to major chambers situated within the block behind the minor chambers. The other side of the block can have a split face or other decorative finish that is free of orifices. When such blocks are used to construct a free-standing acoustic barrier, they are oriented the same way so that all of the orifices face towards a particularly directional noise problem, such as a highway. The other side of the wall presents the decorative finish to those viewing the wall from that other side, for example, those who live beside the highway and are separated from it by the wall.

[0129] Whilst aspects of the invention obviate the provision of septa within acoustic chambers, it should be understood that the invention is not limited to elements that are free of septa or other acoustic adaptations such as absorbent inserts like foam or fibrous material.

[0130] Finally, those skilled in the art will realise that the spacers and recesses of the preferred embodiments can also be applied to conventional elements such as the conventional acoustic blocks sold by Trenwyth Industries, Inc. or indeed typical non-acoustic blocks that do not have acoustic chambers and orifices.

[0131] Indeed, the present invention may be embodied in myriad specific forms without departing from its essential attributes. Accordingly, reference should be made to the appended claims and other general statements herein rather than to the foregoing specification as indicating the scope of the invention.

Claims

1. An acoustic structural element containing at least one acoustic chamber that communicates with the exterior of the element through at least one orifice positioned to be exposed in use to impinging sound, the element being adapted to be laid in a planar course of elements aligned end-to-end mating with neighbouring non-identical elements, wherein the element has opposed ends at least one of which has interface formations shaped to prevent an identical mated element lying in the course.

2. The element of Claim 1, wherein the interface formations are shaped to prevent the identical element lying in the plane of the course when the elements are laid end-to-end with their interface formations mating with one another.

3. The element of Claim 2, wherein the interface formations each comprise a stepped end face.

4. The element of Claim 3, wherein the stepped end face is stepped in plan.

5. The element of Claim 3 or Claim 4, wherein the stepped end face defines a rebate.

6. The element of Claim 5, wherein the rebate comprises a shoulder between first and second end face portions.

7. The element of Claim 6, wherein the opposed ends each have a stepped end face defining respective first and second end face portions, the first end face portions being on one side of the block and the second end face portions being on an opposite side of the block, and wherein the shoulders of the respective end faces are not aligned with each other.

8. The element of Claim 7, wherein the aggregate width of the first and second end face portions of one end is less than the aggregate width of the first end portion of one end and the second end portion of the other end.

9. The element of any of Claims 6 to 8 when appendant to Claim 2, wherein each opposed end has a shoulder between first and second end face portions and wherein end-to-end mating with the identical element to bring the respective first and second end face portions of the elements into mutually opposed relationship brings the shoulders of the respective elements into mutual abutment to prevent the identical element lying in the plane of the course.

10. An acoustic structural element containing at least one acoustic chamber that communicates with the exterior of the element through at least one orifice positioned to be exposed in use to impinging sound, the element being adapted to be laid in a planar course of elements aligned end-to-end with neighbouring non-identical elements, wherein the element has opposed ends at least one of which has interface formations comprising a stepped end face having a shoulder between first and second end face portions for mating with a correspondingly equipped but non-identical element.

11. The element of any preceding claim, wherein the orifice opens to one side of the element and wherein the acoustic chamber is defined by walls of the element and is offset toward that one side to define a substantially thicker wall of the element on a side of the chamber opposed to the orifice than on the side of the chamber including the orifice.

12. The element of Claim 11 and defining a height dimension, wherein the acoustic chamber is a greater acoustic chamber that occupies a major portion of the height of the element and the thicker wall contains at least one lesser acoustic chamber that occupies a minor portion of the height of the element and opens to the side of the element opposed to the orifice.

13. A set of acoustic structural elements comprising a plurality of non-identical elements, each having acoustic characteristics that are substantially unique within the set and being adapted to be laid in a course of elements mating with at least one neighbouring non-identical element of the set, at least one element of the set further including interface formations that prevent an identical mated element lying in the course.

14. A set of acoustic structural elements comprising a plurality of non-identical elements, each having acoustic characteristics that are substantially unique within the set and being adapted to be laid in a course of elements mating with at least one element of the set, the elements of the set further including interface formations that impose a sequence upon the elements within the course.

15. The set of Claim 14 wherein at least one element of the set can be mated with any other element of the set.

16. The set of Claim 15 wherein the element that can be mated with any other element of the set can also be mated with another identical element.

17. The set of any of Claims 14 to 16, wherein at least one element can be mated only with one or more

specific other elements of the set.

18. The set of any of Claims 13 to 17, at least one element of which is substantially solid and at least one element of which contains an acoustic chamber that communicates with the exterior of the element through an orifice positioned to be exposed in use to impinging sound.

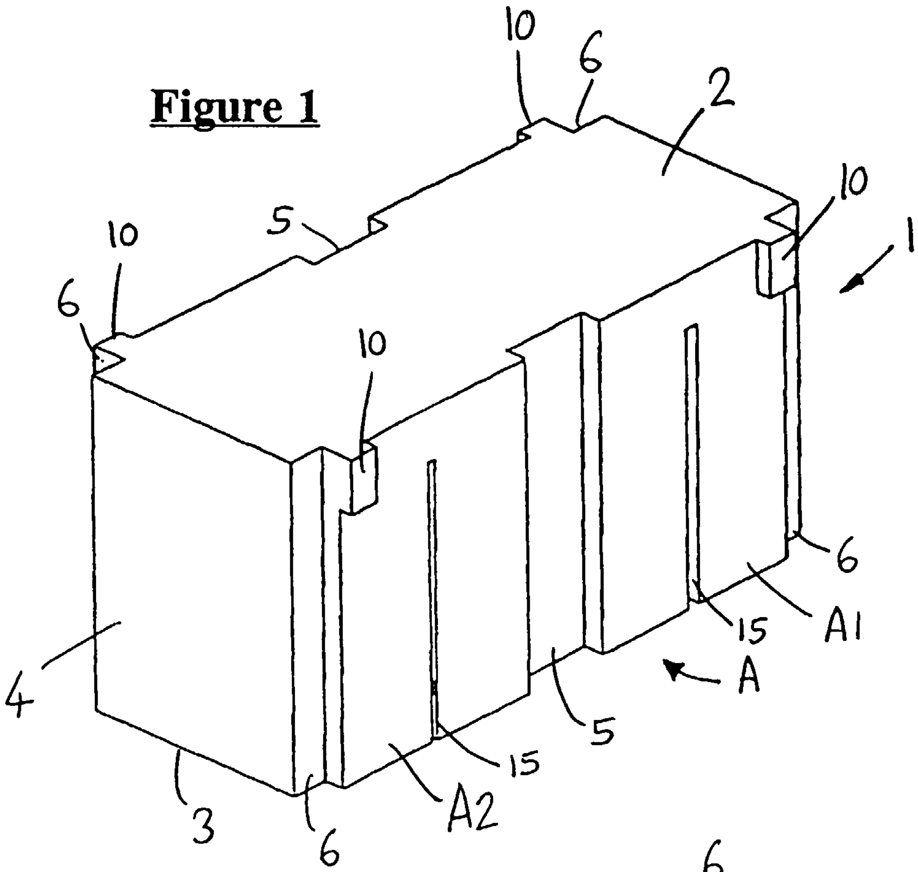
19. The set of Claim 18 and including a plurality of elements each containing an acoustic chamber, the chambers of those elements being tuned to resonate at substantially different frequencies of impinging sound.

20. The set of any of Claims 13 to 19 and including elements as defined in any of Claims 6 to 12, wherein the shoulders of the end faces are positioned progressively closer to a datum face of the element when progressing through successive elements of the sequence of the set.

21. The set of Claim 20 and including an element that can be mated with any other element of the set, wherein that element has a shoulder at one end that is closer to the datum face and a shoulder at an opposed end that is further from the datum face than the corresponding shoulder of any other member of the set.

22. An acoustic structure comprising an array of elements as defined in any of Claims 1 to 12 or at least one set of elements as defined in any of Claims 13 to 21.

Figure 1



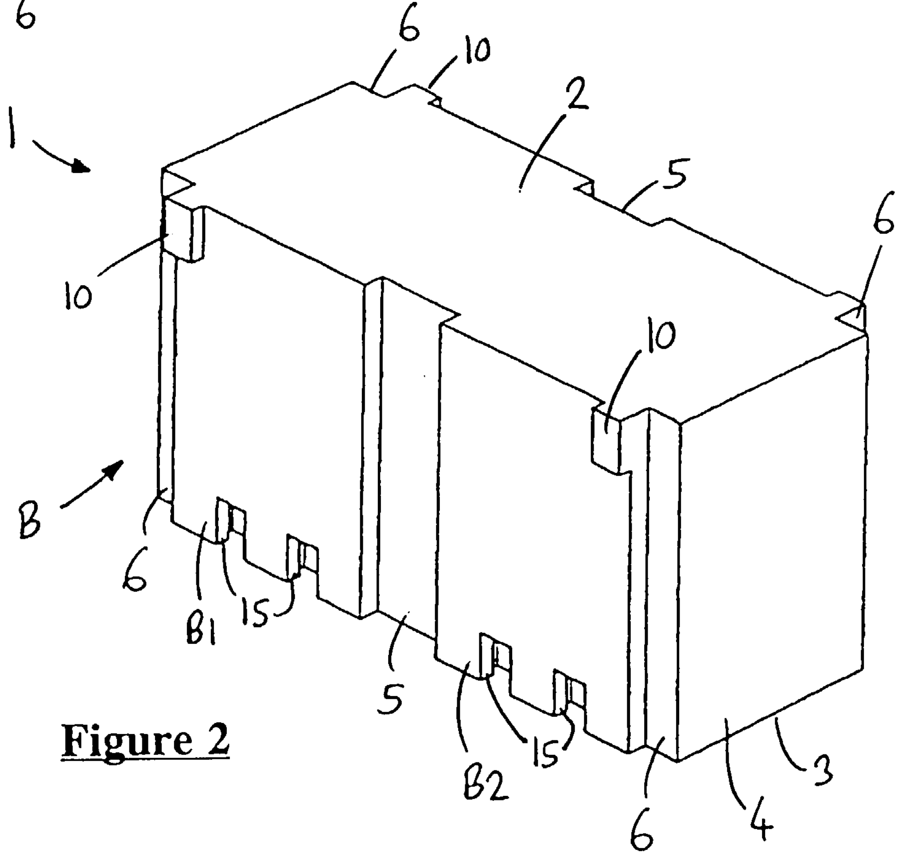
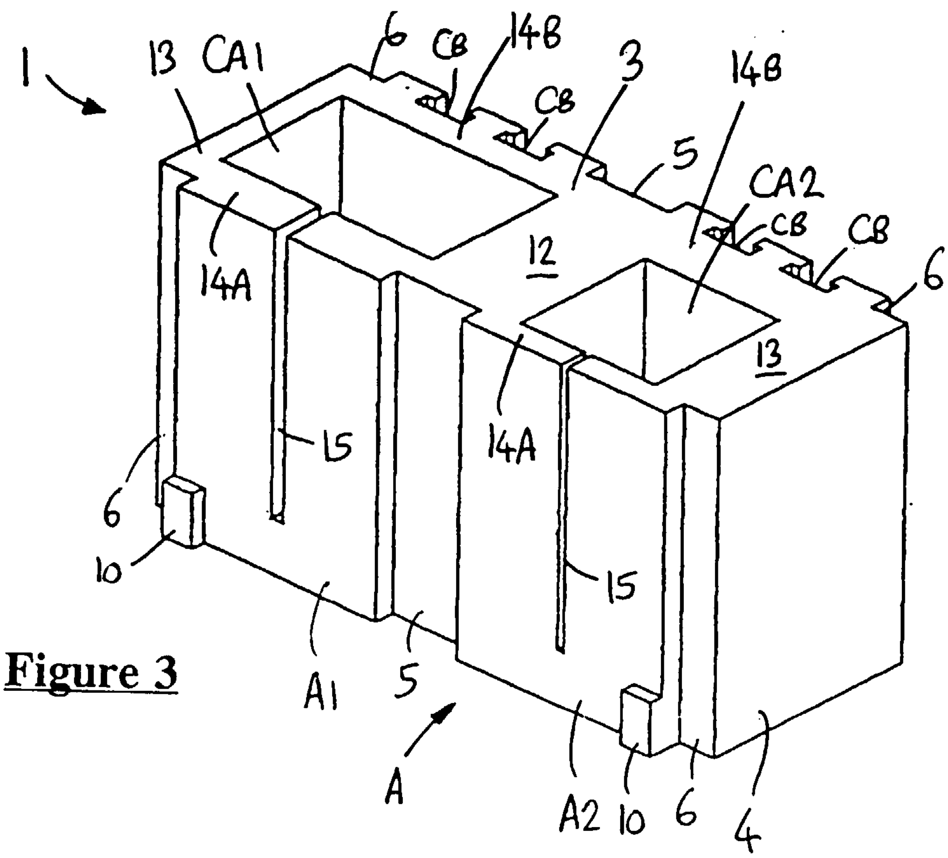


Figure 2



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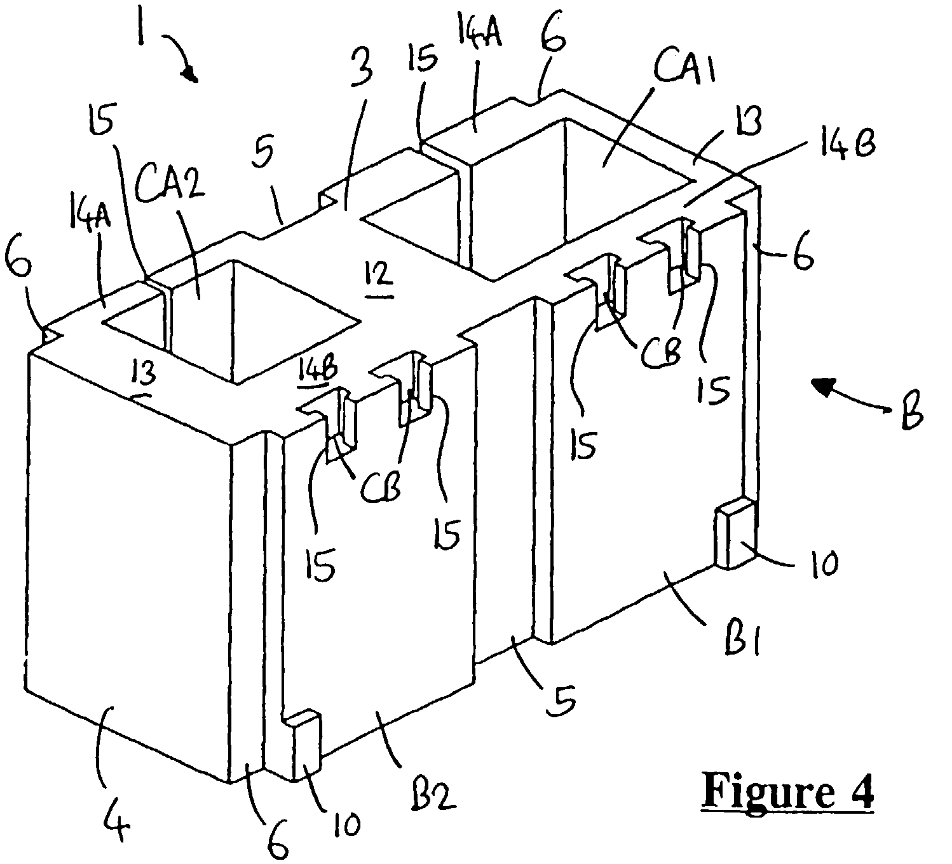
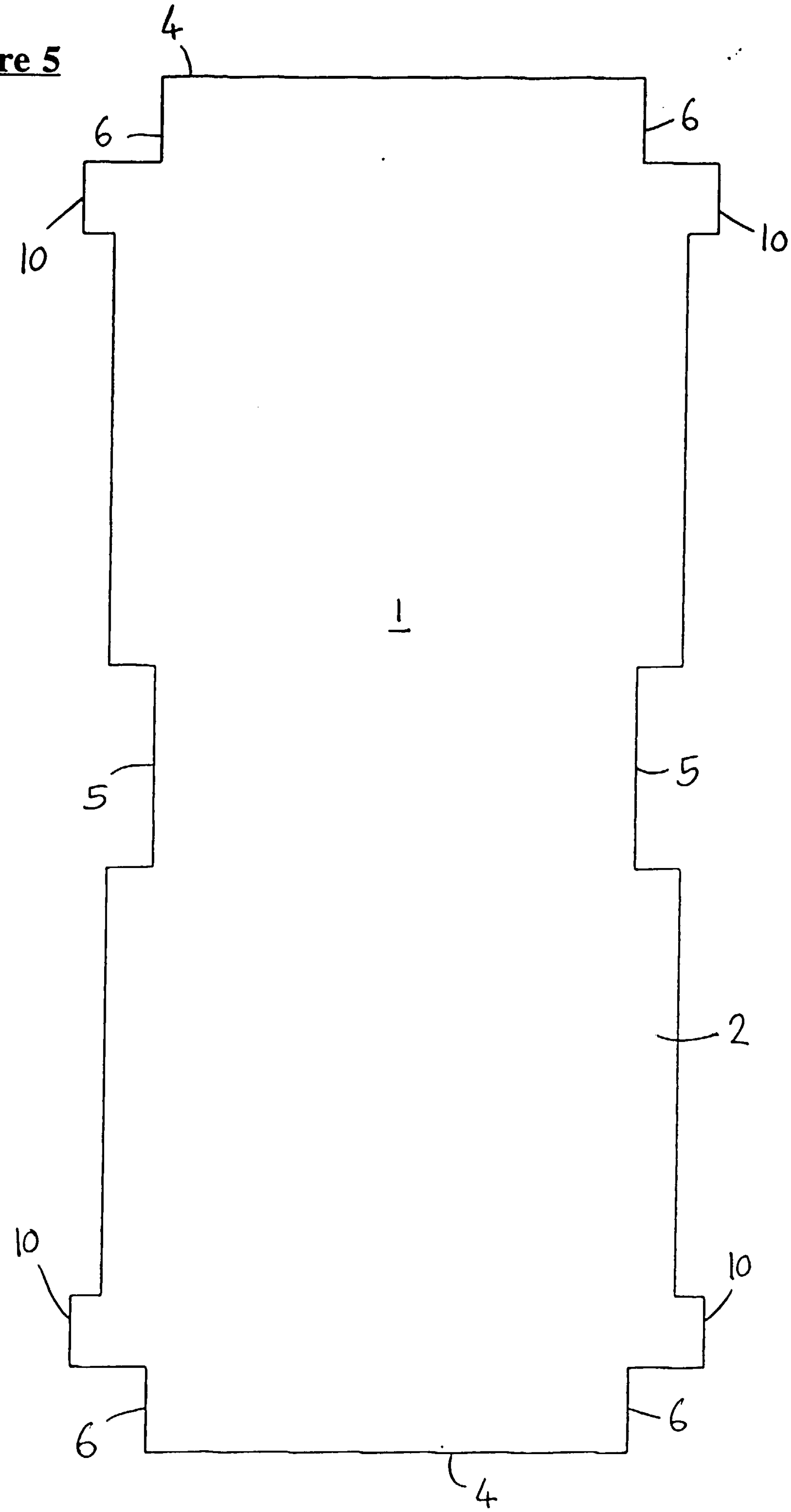


Figure 4

Figure 5



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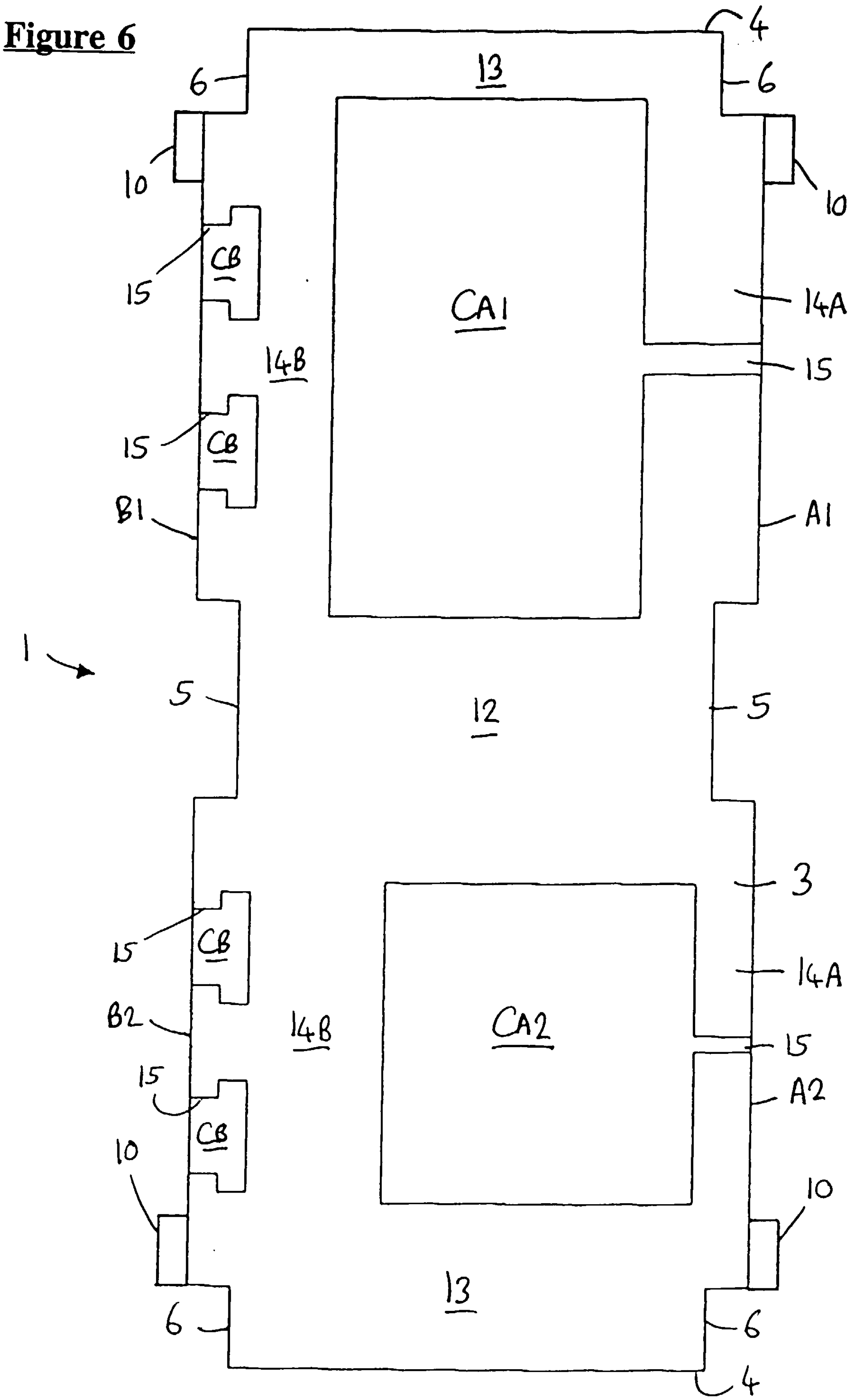
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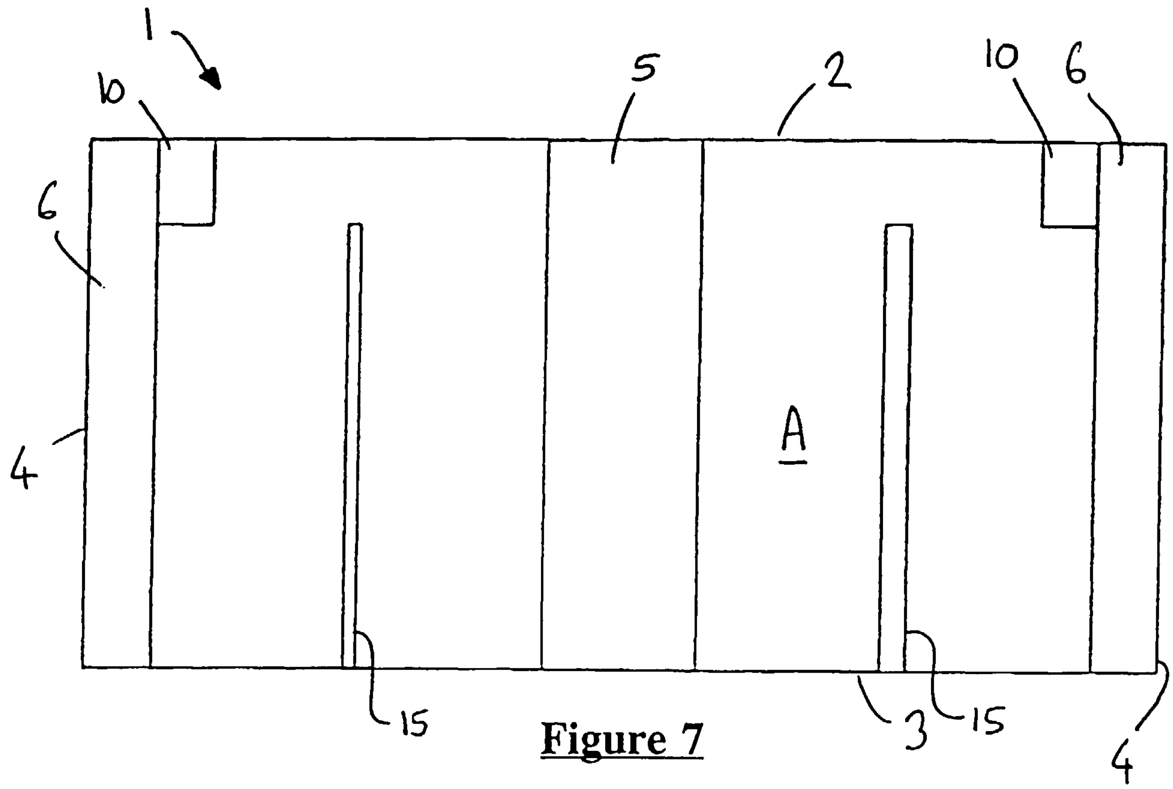

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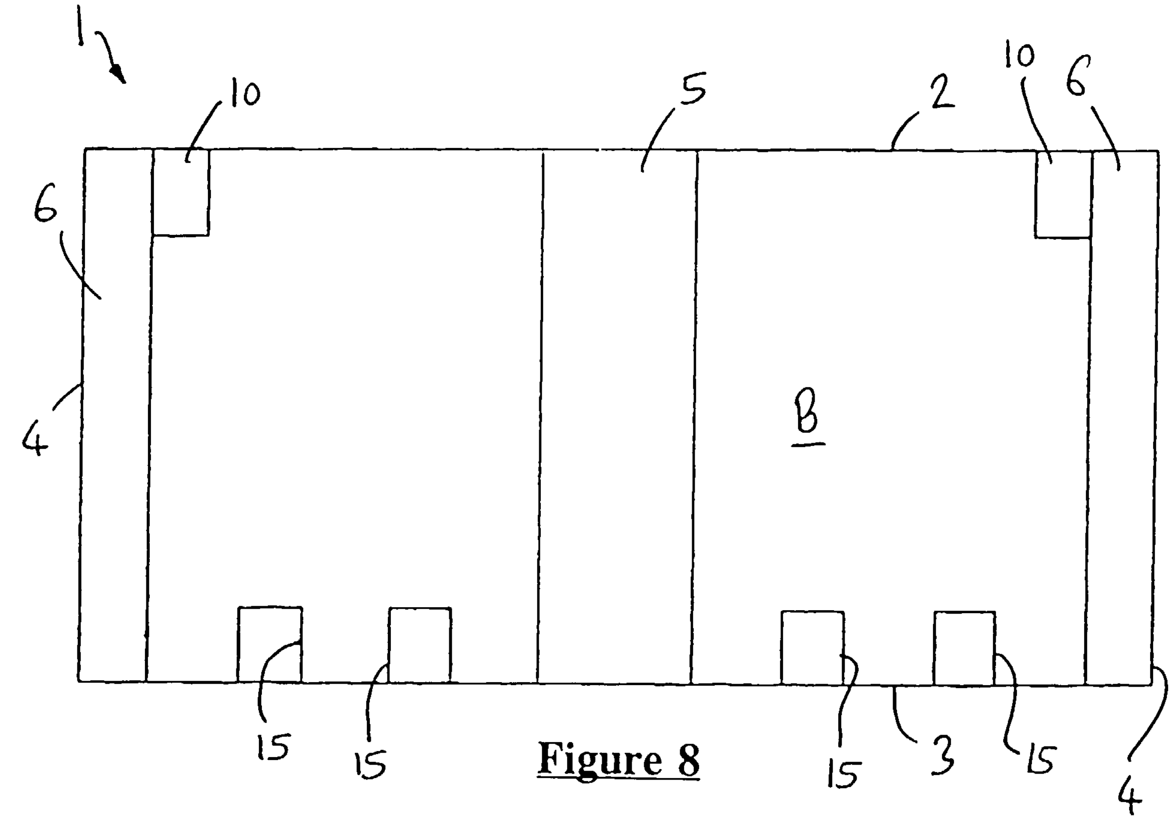

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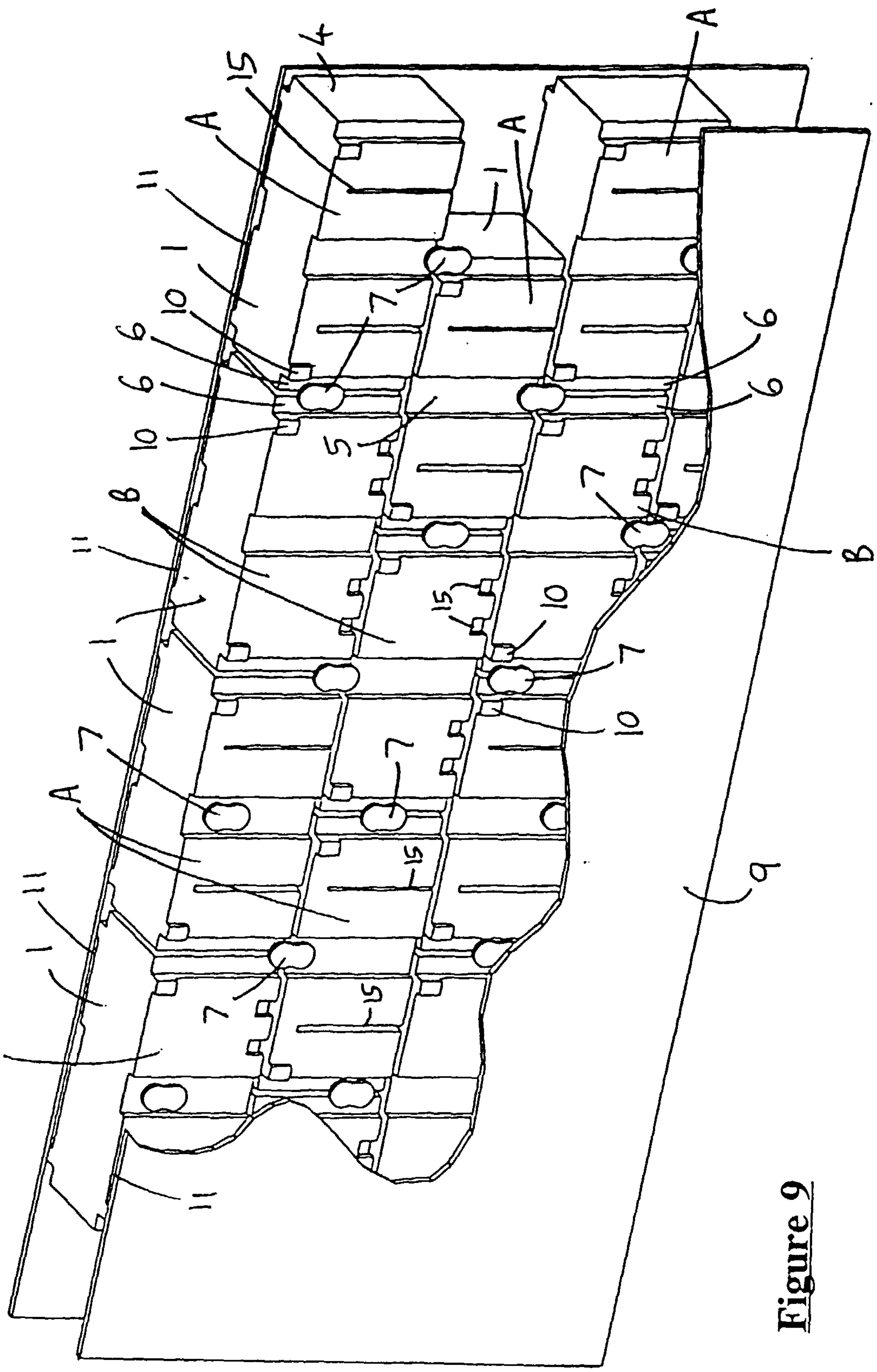

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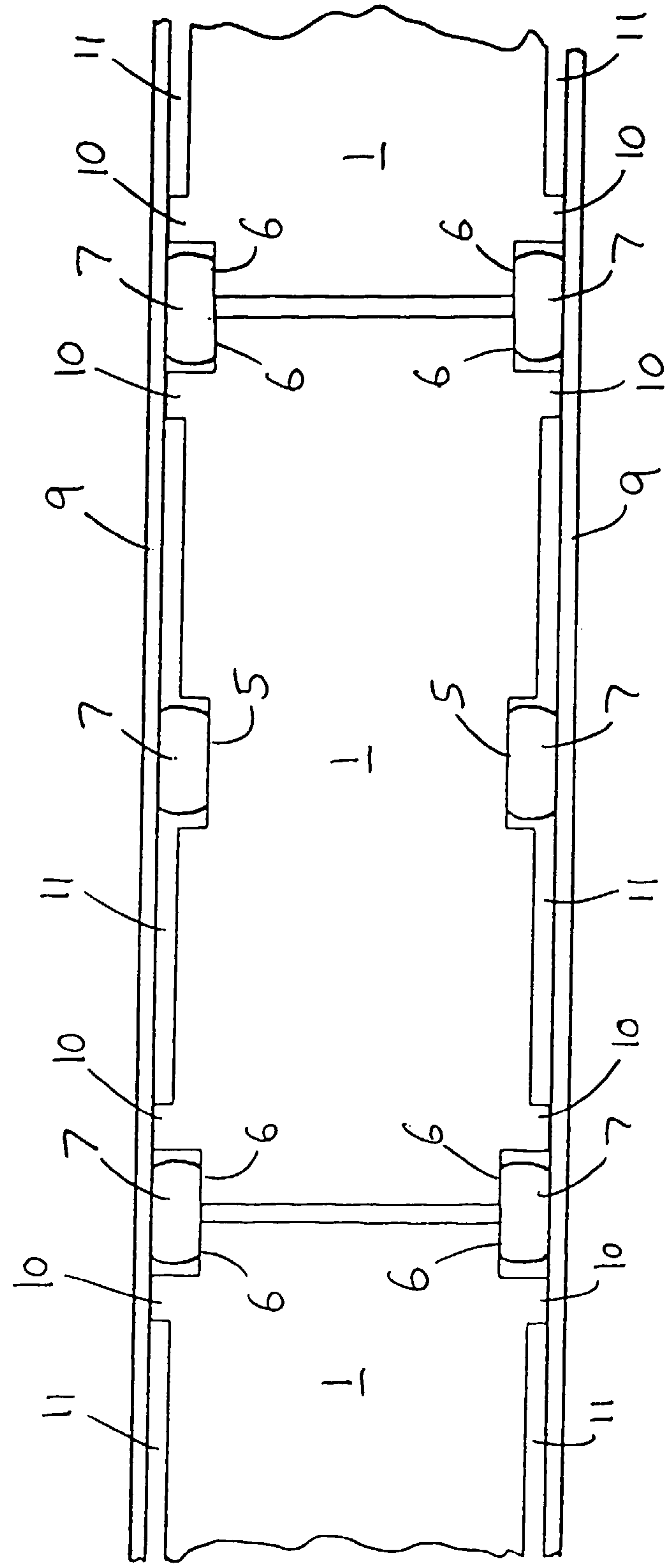

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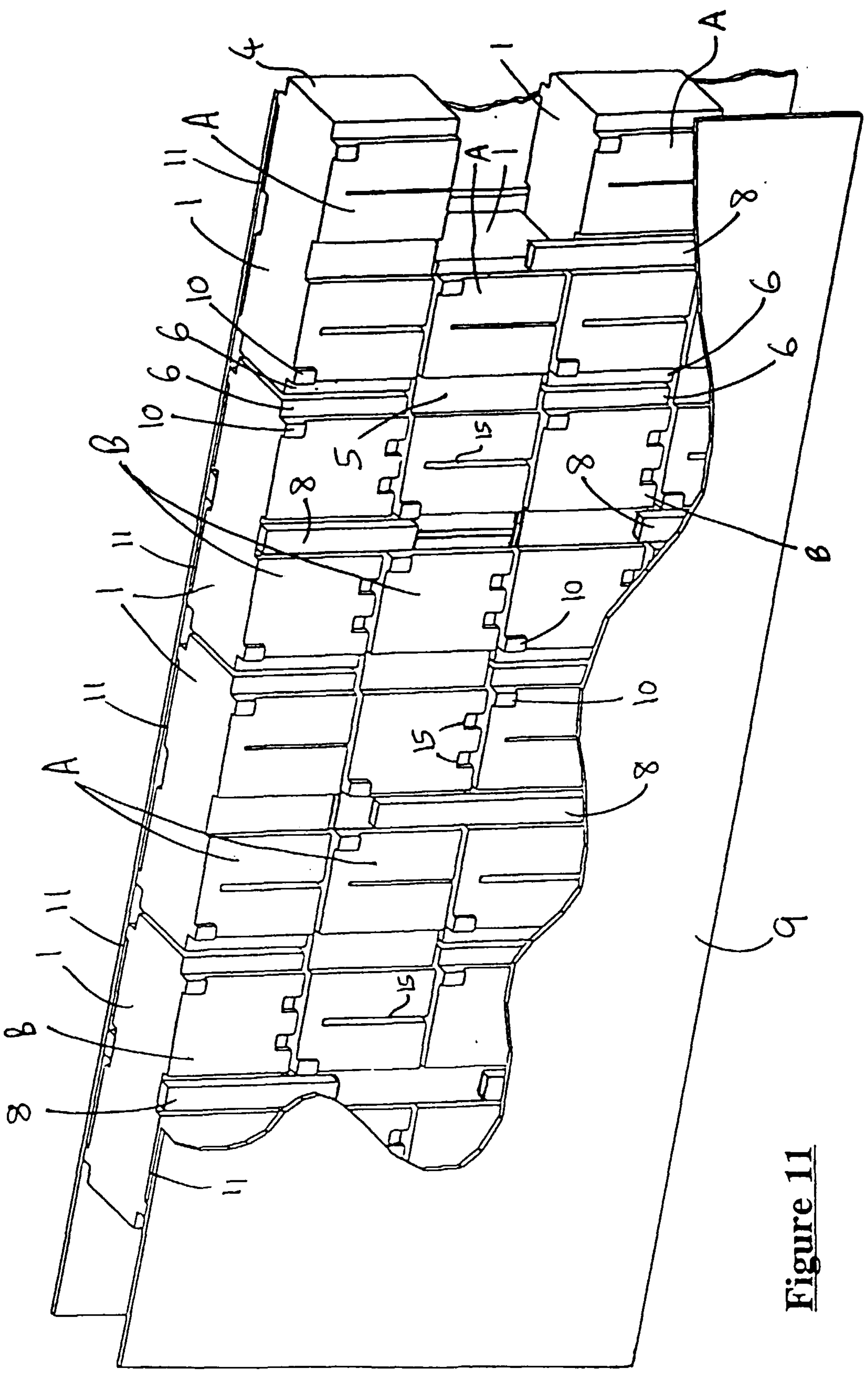

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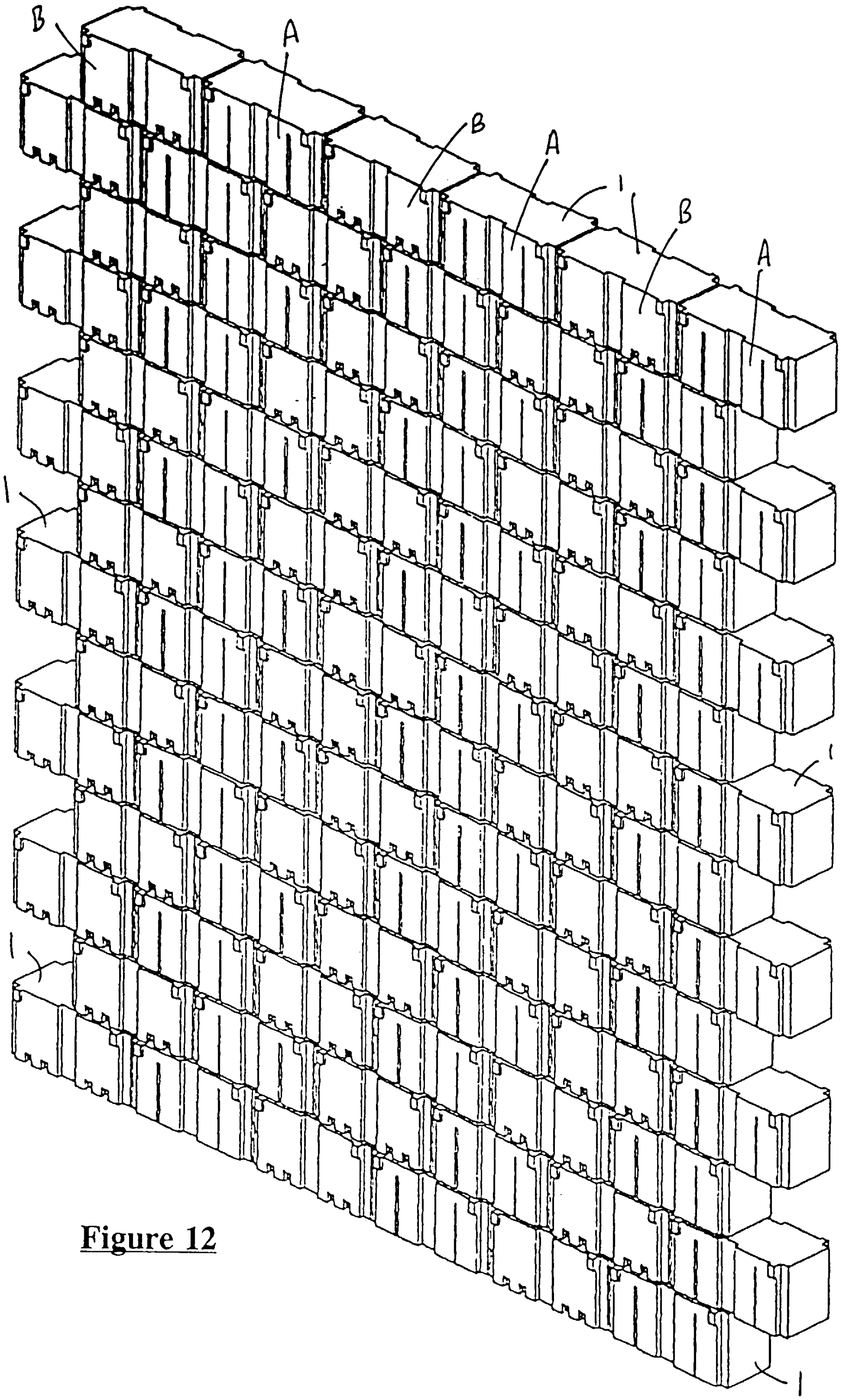

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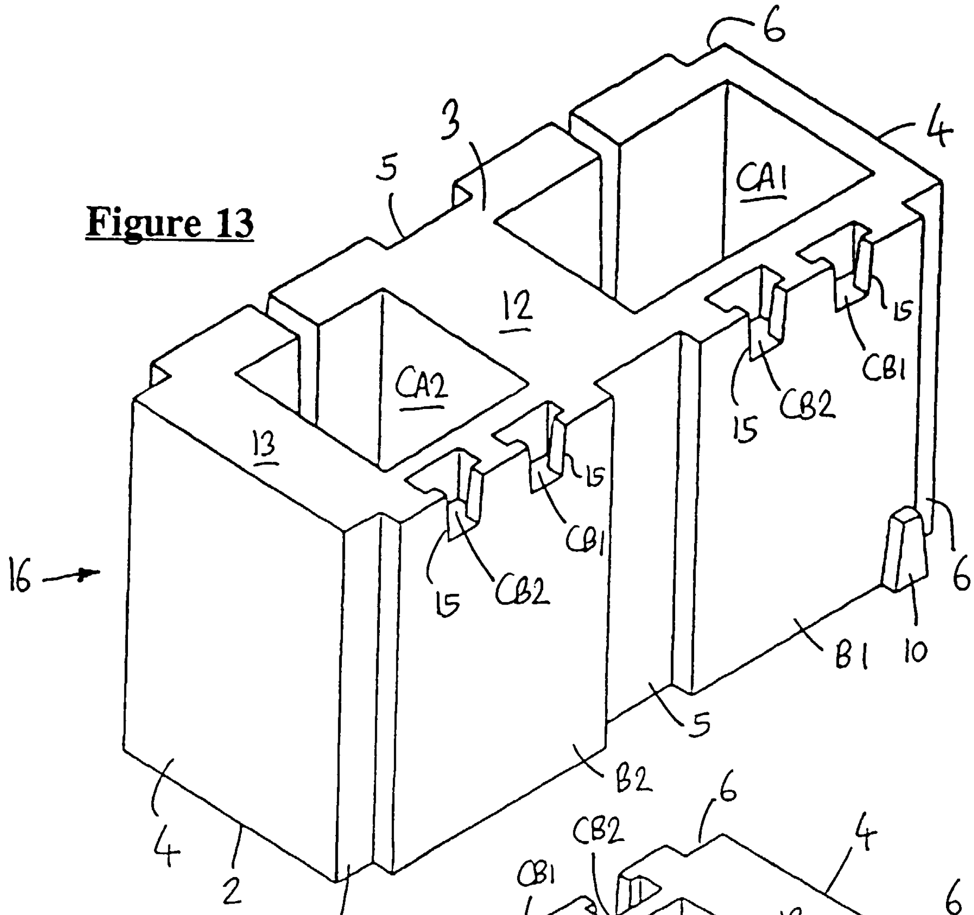

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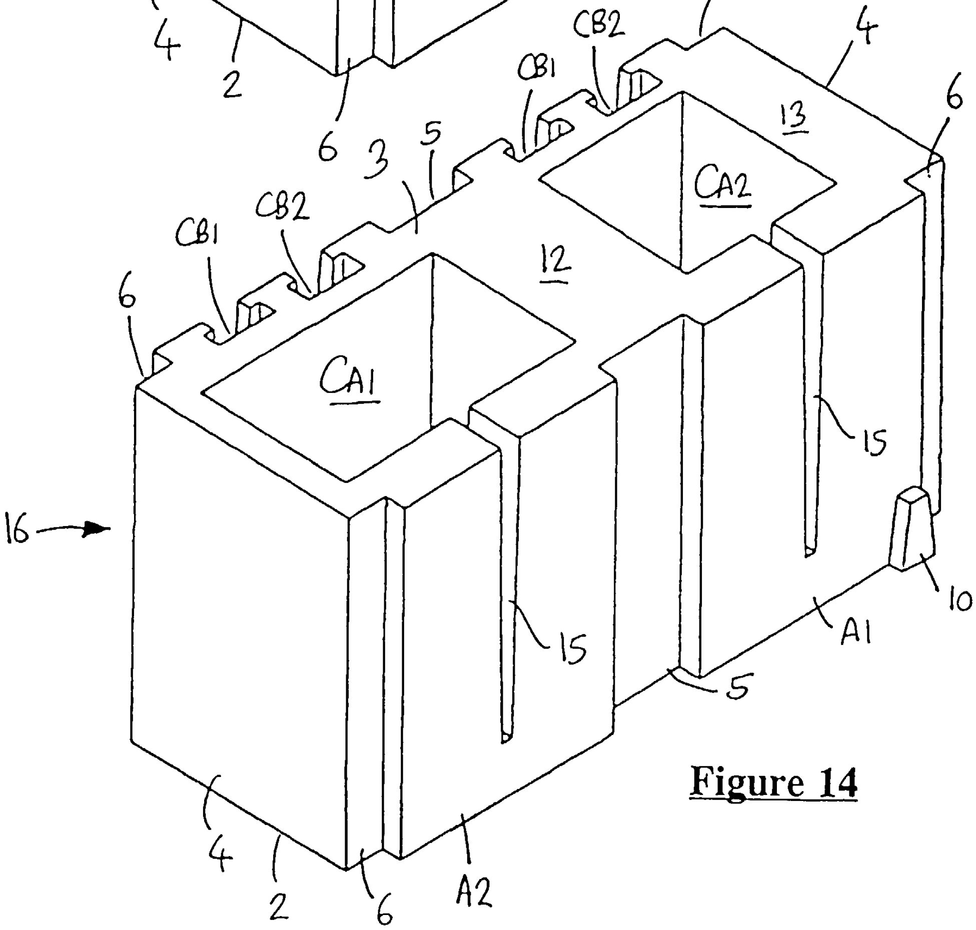

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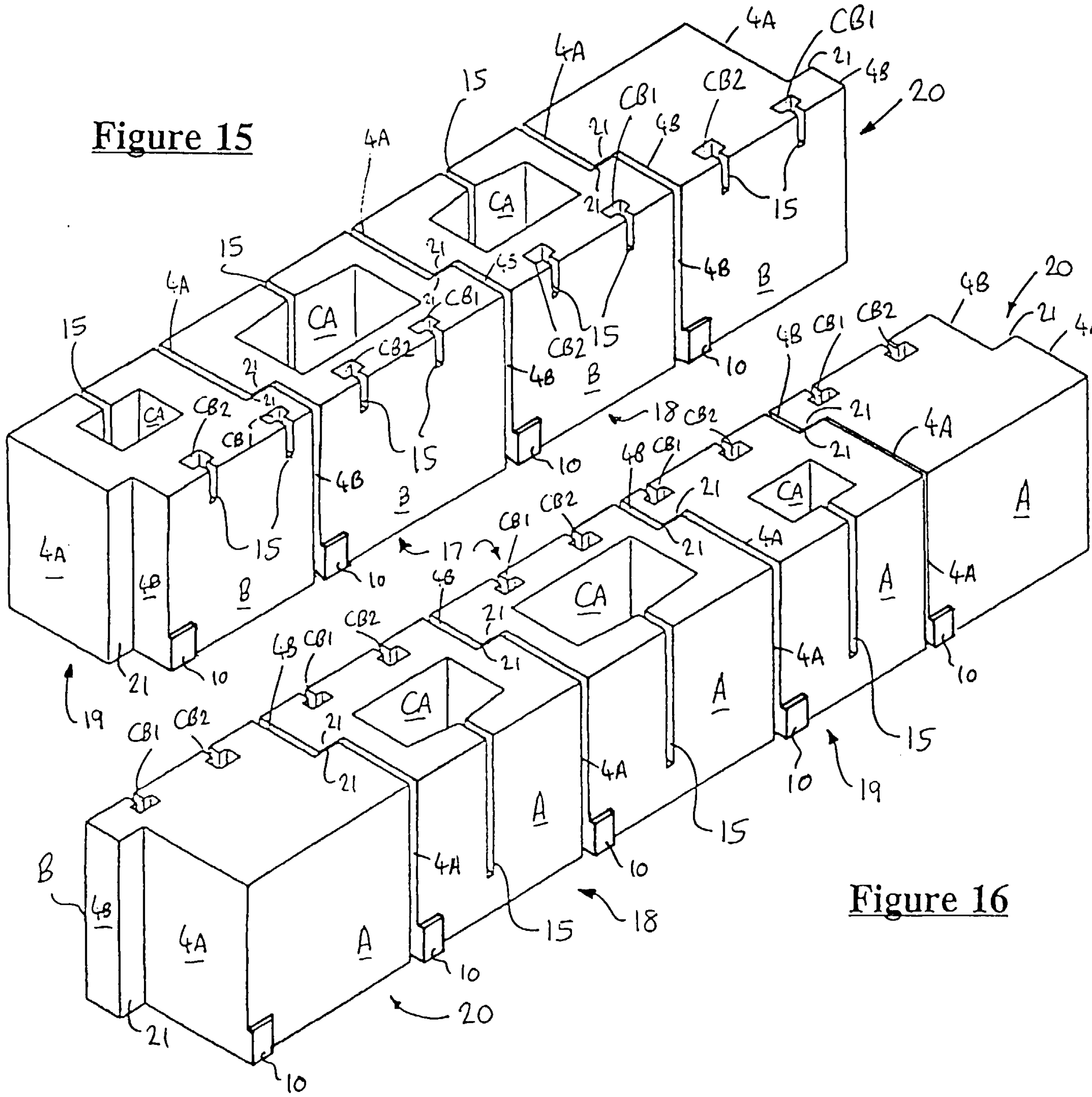

Figure 15

Figure 16