March 18, 1969 K. G. OLSSON 3,433,322

MONOLITHIC ACOUSTIC STRUCTURAL BUILDING ELEMENT

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Fig. 2

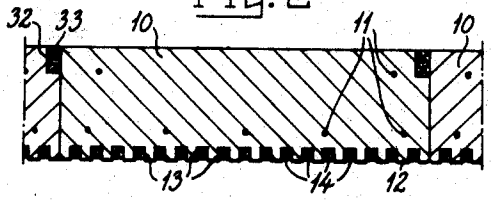


Fig. 3

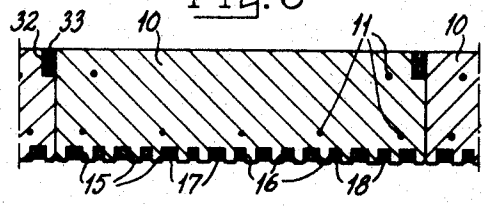


Fig. 4

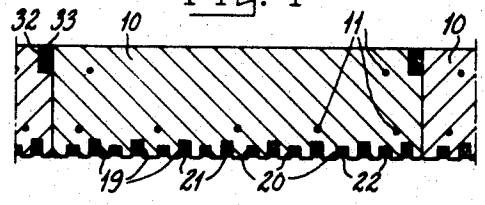


Fig. 5

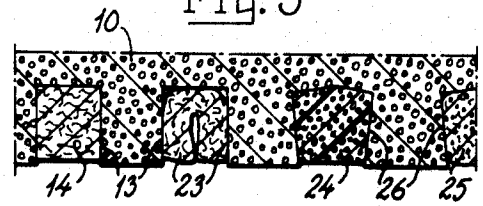


Fig. 7

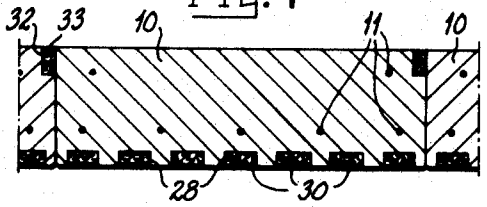


Fig. 1

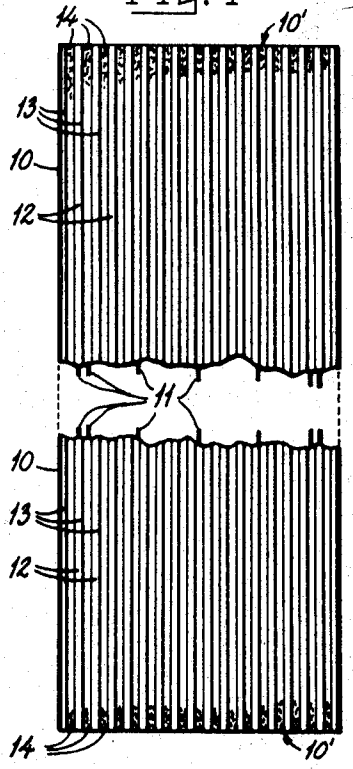
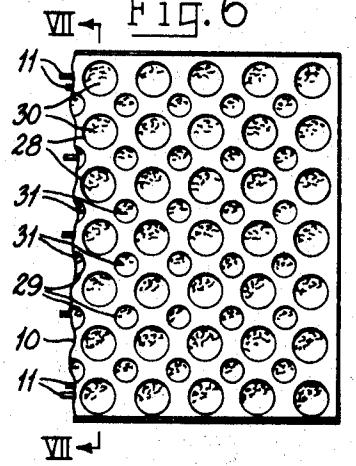


Fig. 6



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Fig. 8

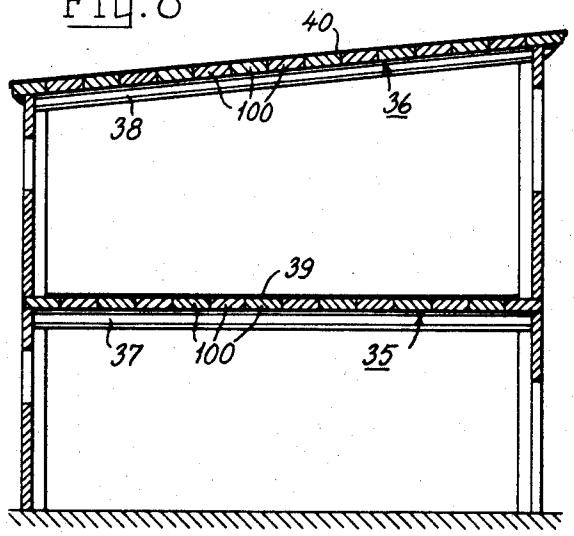
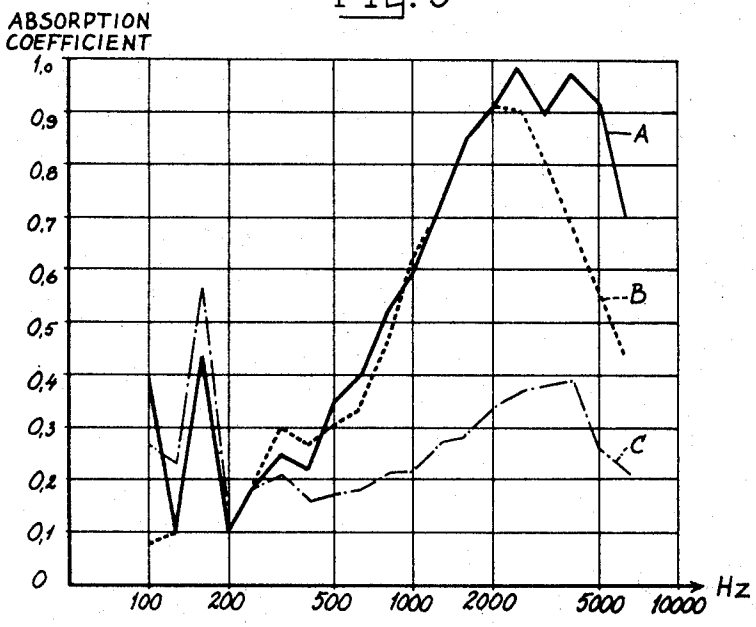


Fig. 9



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3,433,322

MONOLITHIC ACOUSTIC STRUCTURAL BUILDING ELEMENT

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U.S. Cl. 181—33 4 Claims
Int. Cl. E04b 1/82

ABSTRACT OF THE DISCLOSURE

This invention pertains to a monolithic structural building element in the form of a massive slab of reinforced cellular light weight concrete designed to form a load-supporting and room-enclosing body part of a building, especially a roof or floor spanning a workshop or factory hall and which has a surface presenting a plurality of substantially uniformly distributed, spaced, shallow recesses, preferably in the form of parallel grooves, cut out therein, said recesses containing frictionally retained masses of soft, porous and sound absorbent material which almost completely fills the recesses without projecting through the openings thereof.

It is well known per se to improve the acoustical properties of ceiling or wall surfaces by applying more or less complicated surfacing materials to them, and several types of sound-absorbing panels or tiles adapted to be either directly attached to such surfaces, e.g. by nails or adhesives, or suspended or otherwise supported at some short distance below or in front of them are commonly available on the market. The use of such panels or tiles is, however, very expensive and cumbersome, particularly because the attachment of them is time-consuming and most frequently requires bulky scaffolding impeding the accomplishment of other urgent works during the completion of the building.

The main object of this invention is to avoid all those disadvantages and to make it possible to provide for adequate acoustical correction simultaneously with the erection of the basic supporting structure of the building. Considerable savings may be achieved in this manner and extensive tests have proved that the use of structural building elements in accordance with this invention makes it possible to obtain acoustical improvements which are in no way inferior to the results obtained when ordinary acoustical panels, tiles or similar surfacing materials nowadays available at a reasonable purchase price are used.

In accordance with the invention a monolithic structural building element of the type hereinbefore defined is mainly characterized by the provision directly in the said element surface to be exposed towards the noisy room of a plurality of shallow recesses opening into said surface without considerable constriction and being at least almost filled with soft, porous fillings, the depth of said recesses being at most one fifth of the thickness of the element. The thickness of the element is then considered to be the smallest dimension of the commonly slab- or beam-shaped element.

Further objects and features of the invention will become apparent from the following detailed description in which reference is made to the accompanying drawings.

In the drawings:

FIG. 1 is a shortened plan view of the sound absorbing side of a preferred type of structural building element embodying the invention,

FIG. 2 is a partial cross-sectional elevation of a load-supporting building structure including elements of the type shown in FIG. 1,

FIG. 3 is a partial cross-sectional elevation similar to that in FIG. 2 but including elements of a slightly modified type,

FIG. 4 is another partial cross-sectional elevation similar to FIG. 2 but including elements of another modified type.

FIG. 5 is a diagrammatical partial cross-section at an enlarged scale of the sound absorbing surface portion of an element as shown in FIGS. 1 and 2 and illustrating various forms of grooves and fillings which may be used according to the invention,

FIG. 6 is a partial plan view of the sound absorbing side of still another type of structural building element embodying the invention,

FIG. 7 is a partial cross-sectional elevation similar to FIGS. 2–4 of a load-supporting building structure including elements of the type shown in FIG. 6—the section being taken along the line VII—VII in the latter,

FIG. 8 is a simplified sectional elevation of a factory building intended to illustrate typical applications of the building elements shown in FIGS. 1–7 inclusive, and

FIG. 9 is a diagram showing—as an example only—the acoustical properties of a building element of the type shown in FIGS. 1 and 2.

The structural building element shown in FIGS. 1 and 2 comprises a monolithic body **10** of cellular artificial stone material having reinforcements **11** embedded therein so that the element will be capable of spanning freely over relatively large distances between girders supporting the respective ends thereof and of then resisting considerable loads with only negligible deflection. By preference the material, of which the body **10** is made, is cellular light weight concrete of a weight by unit of volume below that of pure water. This also applies to all the elements described hereinafter, but there is nothing preventing the use of other cellular artificial stone materials in the monolithic element bodies.

As will more clearly appear from the following, the element of FIGS. 1 and 2 is intended to be used in such a manner that the one side surface **12** thereof will form, without covering, a part of a ceiling or, possibly, a wall surface for defining a room, such as a factory hall, in which disagreeable noises are likely to occur and in which, therefore, a sound absorbing capacity of said surface is highly desirable. The ordinary flat surface of an element of the kind described has no such capacity which can noticeably improve the acoustical conditions in the room but according to this invention the sound absorbing capacity of the element surface **12** may be considerably improved in a surprisingly simple, work-saving and inexpensive manner.

To achieve this result there have been provided in the surface **12** of the element body **10** a plurality of shallow grooves **13** extending parallelly in the longitudinal direction of the element and having open ends at the respective short end edges **10'** of the body **10**. In these grooves **13** there are introduced and retained in any suitable manner, such as by gluing and/or mechanical friction, fillings **14** of a soft, porous material. The grooves **13** are preferably cut, e.g. by milling or sawing, in the cellular body material so that the bottom and side walls thereof will present open pore cavities which will not only improve the acoustical properties to a certain degree but also, and above all, assist in retaining the fillings **14**.

In FIGS. 1 and 2 all the filled grooves **13** are uniformly spaced over the element surface **12** and are all of the same width and depth. The grooves may, however, be of alternating widths, as are the grooves **15** and **16**

with their respective soft fillings **17** and **18** in FIG. 3, or they may be of alternating depths, as are the grooves **19** and **20** with their respective soft fillings **21** and **22** in FIG. 4. As a further alternative there may be provided filling receiving grooves in the element surface which differ from each other both in width and depth. The use of at least two differently sized groups of grooves has been found to broaden the range of absorbed sound frequencies but ordinarily it will be quite satisfactory to use one size of groove only which is carefully selected to provide, when filled with a suitable soft and porous filling material, for a maximum sound absorption within that frequency range which is most physiologically harmful to the human ear.

The grooves **13**, **15**, **16**, **19** and **20** are all very shallow—in fact they never need to be deeper than about one inch, which is always well below one fifth of the thickness of the element body **10** so that they will not considerably impair the structural strength of the element or interfere with a proper location of the reinforcements **11** thereof—and they preferably all have a width of approximately the same order of size as their depth as shown. The fillings **14**, **17**, **18**, **21** and **22** in their turn have cross sectional dimensions which are so chosen that they will almost completely fill their related grooves but not project outside the original surface of the body **10**. This appears more clearly from FIG. 5 in which various types of fillings are illustrated. The filling **14** to the left therein is a relatively thick strip of felted mineral wool which has been cut with a sufficient width to be slightly compressed in its lateral direction when inserted in the square groove **13**. In the second groove from the left the filling consists of a double-folded, relatively wide strip **23** of felted mineral wool. In the third groove the filling consists of a strip **24** of soft foamed plastic having open pores, and in the fourth groove the filling consists of a soft, porous plait or twine **25** of asbestos fibres.

FIG. 5 also shows that the grooves may—as the right hand grooves **26**—have side walls which very slightly converge towards the opening of the groove for the purpose of better retaining the fillings, but under all circumstances the constriction of the opening should then be kept very small partly because the remaining ridges of the element body intermediate the grooves would otherwise easily break and partly because a too accentuated constriction could prevent easy and rapid insertion of the fillings in the grooves through the openings thereof.

Although it has been found particularly advantageous from manufacturing points of view to use grooves running in the longitudinal direction of the element there is nothing preventing the use of other types of shallow recesses having fillings of soft, porous material. This is illustrated in FIGS. 6 and 7 where the monolithic element body **10** has been provided with a plurality of circular recesses or holes **28**, **29** in its room defining side surface. The holes have been shown as being of two different diameters but if so desired one single size may be used. Suitable fillings **30**, **31** have been inserted in the shallow holes to almost completely fill them and also these latter fillings are made of a soft, porous material of the same kind as already described in connection with FIG. 5.

As may be seen from the embodiments of the invention illustrated in the drawings it will be found advantageous for obtaining the best possible acoustical correction results to distribute the filled grooves or holes at least substantially evenly over the element surface in question and to let the grooves or holes take up a considerable part and at least one third of the area of said surface. On the other hand it is, of course, important that the ridges or partitions formed between the grooves or holes by the cellular and rather fragile body material do not become too thin and weak. At least when the element body is made of cellular light weight conrete it may be hazardous to make those ridges or partitions thinner than about half an inch. It should also be kept in mind that the ridges or partition grating protruding between the filled grooves or holes act as stiffening fins and thus add structural strength to the element.

The elements described hereinbefore are all intended to be jointed together with similar elements in side by side relationship as indicated in FIGS. 2, 3, 4 and 7 to form a platform or, possibly, a wall structure capable of supporting considerable loads. The jointing of the elements has been shown as accomplished by casting a suitable concrete mix **32** into joint channels **33** but any other appropriate jointing technique, e.g. one utilizing tongue and groove connections, may be used and does not form part of this invention. Typical applications of the elements are shown in FIG. 8 where elements **100** according to this invention have been used in a factory building to form both a floor-supporting joisting structure **35** and a roof structure **36** which has to support the load of snow, etc. In both cases the elements **100** are supported on girders **37**, **38** and span freely between them to form with their grooved lower side faces the ceiling surface for the room or hall below, while their upper sides are covered with suitable flooring and roofing materials **39** and **40** respectively. It should be readily understood that since the lower side faces of the elements **100** have themselves sufficient sound absorbing properties there is no need for covering them and much work and expenses will thus be saved. If desired, the lower side surfaces of the elements may, of course, be painted or otherwise colored to meet esthetic requirements and this may also be done before the elements are incorporated in the building structure.

To illustrate by way of an example the surprisingly good sound absorbing properties which can be obtained in a monolithic load-supporting building element according to the invention, the diagram in FIG. 9 indicates the absorption coefficient in a slab of cellular light weight concrete, the surface of which has grooves cut therein in the manner described hereinbefore with particular reference to FIGS. 1 and 2, the width of each groove being about ⅝″ or 16 millimeters and depth thereof about ¾″ or 20 millimeters, while the width of the ridges separating adjacent grooves is equal to the width of the grooves. The full curve A indicates the absorption at various sound frequencies when the grooves contain fillings of felted mineral wool. The dotted curve B indicates the absorption when the same grooves contain fillings made of soft, foamed plastic and, for comparison, the dash and dot curve C illustrates the sound absorption obtained when there were no fillings in the grooves. It appears clearly from the diagram that the soft, porous fillings in the grooves ensure a considerable improvement of the sound absorption within that particular frequency interval which is commonly considered to be physiologically most harmful to the human ear.

I claim:

1. As a new article of manufacture, a monolithic structural building element in the form of a massive slab of reinforced cellular light weight concrete designed to function as both a load-supporting member and as a portion of the room enclosing surface of a building and having an overall thickness substantially equal to the overall thickness of the wall of the building, said building element having a room-confining main surface containing a plurality of substantially uniformly distributed, spaced recesses having a depth which does not exceed one fifth of the total thickness of the element, said spaced recesses, by virtue of being cut out of the hardened cellular element material exposing a plurality of open pores in their bottom and wall portions, said recesses having substantially uniform cross-sectional width without substantial reduction in cross-sectional width towards depth, the openings of said shallow recesses taking up between about one third and two thirds of the total area of said room-confining element surface; fillings of a coherent, soft, porous and at least slightly elastic material having a high sound absorbing capacity that can be readily inserted under

slight lateral compression in said recesses, said fillings almost completely filling said recesses and not projecting above the surface openings of said recesses.

2. A monolithic structural building element according to claim 1, wherein said spaced recesses are grooves extending in spaced parallel relationship the full length between two opposite edges of said room-confining element surface and having open ends at both said edges, the depth of said grooves being approximately of the same order of size as the width of the grooves as well as the width of the groove-separating ridges remaining between them, and wherein said fillings are strips of soft, porous, sound absorbent material extending the full length of said grooves and frictionally retained therein.

3. A monolithic structural building element according to claim 2, wherein the side wall portions of said grooves are slightly converging towards said room-confining element surface to assist in retaining said filling strips.

4. A monolithic structural building element according to claim 2, wherein at least two groups of shallow grooves are cut out in said room-confining element surface, the grooves in each group having a different width.

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ROBERT S. WARD, JR., *Primary Examiner.*