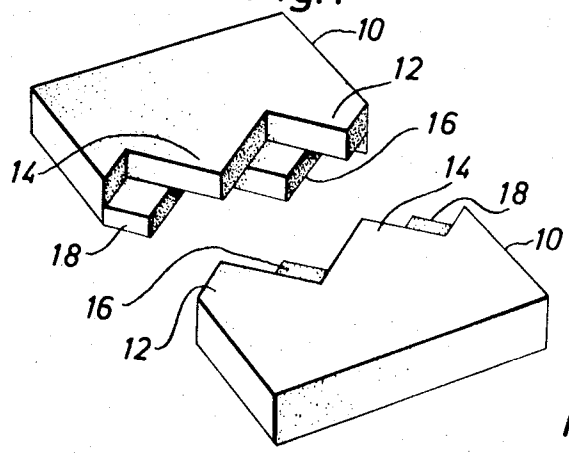
Nov. 30, 1971 L. W. FREESE 3,623,261

BUILDING UNITS WITH INTERLOCKABLE TOOTHED EDGES

Filed July 27, 1970 3 Sheets-Sheet 1

Fig. 1



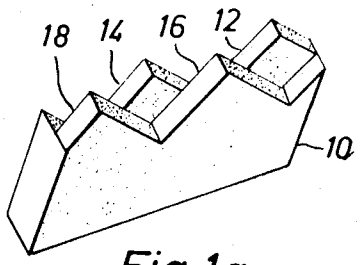


Fig. 1a

Fig. 2

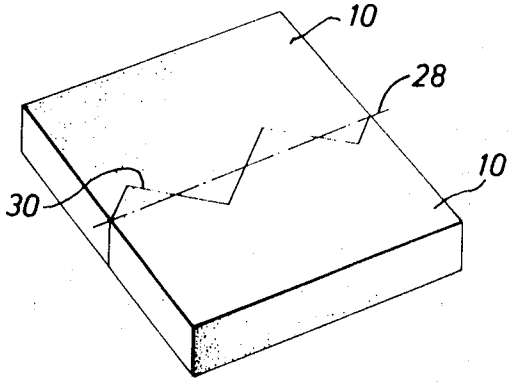


Fig. 3

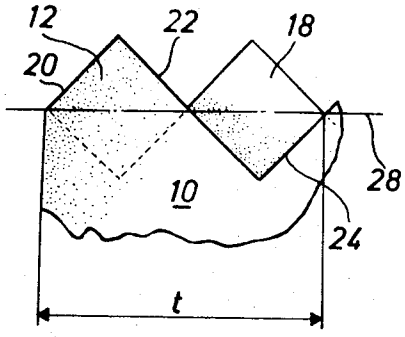
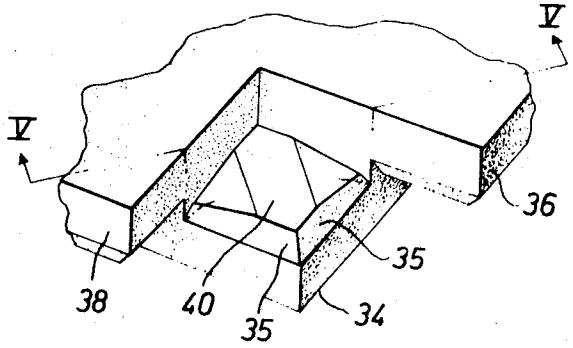


Fig. 4



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BUILDING UNITS WITH INTERLOCKABLE TOOTHED EDGES

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Fig. 5

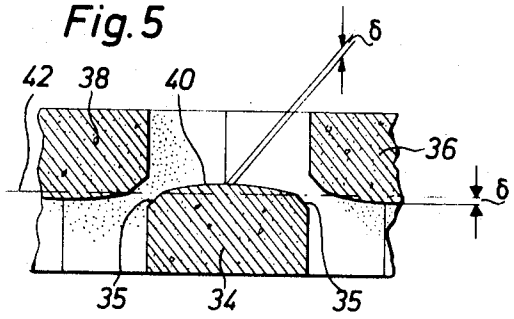


Fig. 6

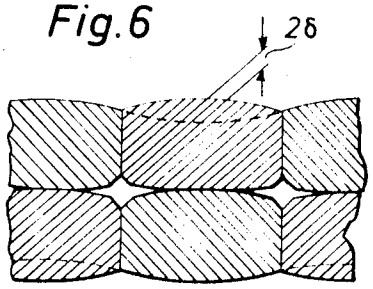


Fig. 7

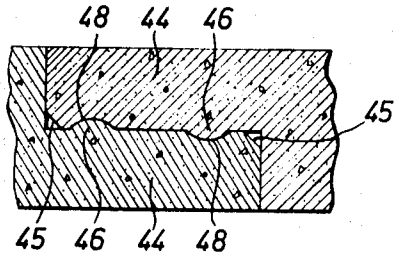


Fig. 8

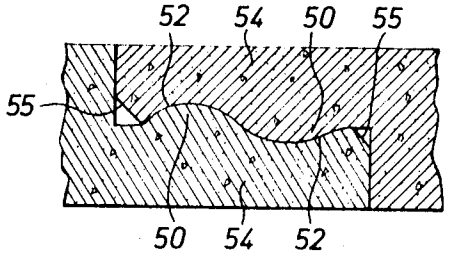


Fig. 9

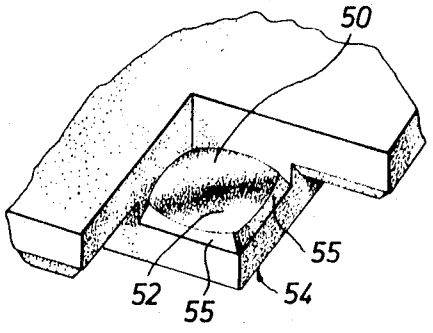
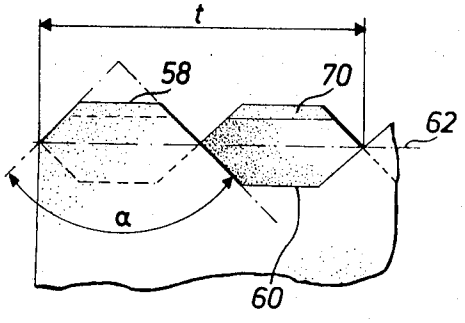


Fig. 10



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BUILDING UNITS WITH INTERLOCKABLE TOOTHED EDGES

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Fig. 11

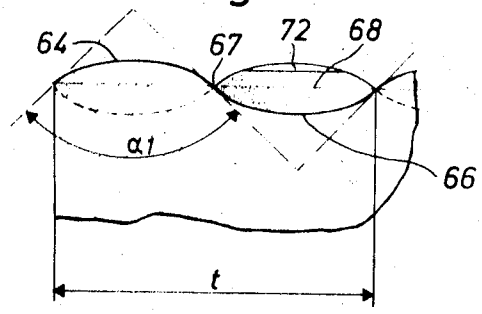


Fig. 12

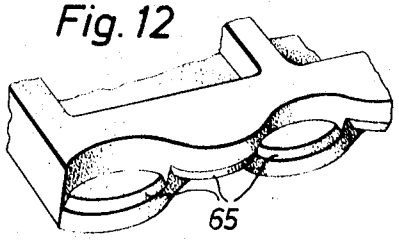


Fig. 13

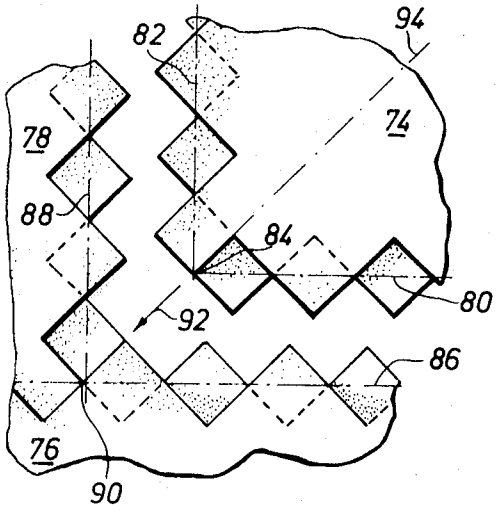


Fig. 14

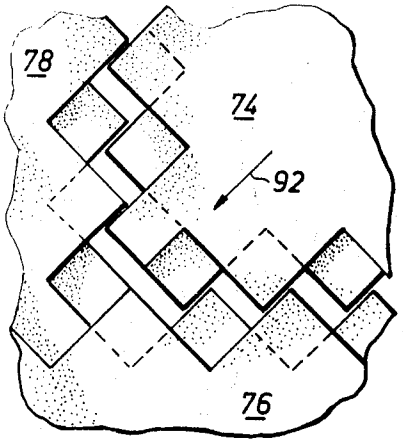
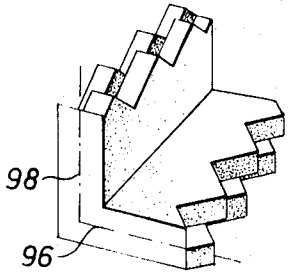


Fig. 15



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BUILDING UNITS WITH INTERLOCKABLE TOOTHED EDGES

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Int. Cl. A63h 33/08
U.S. Cl. 46—30 9 Claims

ABSTRACT OF THE DISCLOSURE

Model building units which may be readily joined together in great numbers to form continuous areas in plan or space. The units are joined edge to edge by means of an interlock-device provided along the interengaging edges. The interlock-devices comprise two rows of uniformly pitched teeth extending on either side of a common dividing plane, the teeth of one row being offset half a pitch in relation to the teeth of the second row. When the building units are pushed together to be joined, the inner side or inside of each tooth, i.e. the side lying in the common dividing plane, engages by friction and/or snap action a corresponding inside of a tooth in an opposite interlock-device, forming a firm, readily detachable joint wherein the holding forces are acting smoothly and uniformly distributed.

The present invention relates to building units for building kits or the like which units are intended to be joined manually, and without auxiliary means or tools, into larger systems, in plan as well as in space. The essence of the invention resides in the feature that the building units along one or more of their edges are provided with specifically shaped interlock or coupling devices by means of which the units are joined, simply by said interlock-devices being pushed together, whereby the units arrive at a stable interengagement.

Building units of a similar kind are known, which are adapted to be joined along their edges by various gripping means, but these previous building units have in common that the necessary interlock or locking effect of the gripping means in the joined condition of the units is unsatisfactory in one respect or another. The interlock-device may be complicated, particularly by the occurrence of separate latch members or the like, and the locking engagement may be on the one hand—or in time be—too loose and weak or, on the other hand, too positive so that forces unnecessarily great and wearing are requested for the manipulation of the units.

Thus the invention has for its object to provide a building unit of the kind under consideration, more particularly to provide locking means or interlock-devices for such building units which are simple as well as present a reliable and reasonably firm locking engagement when the units are moved together to be united. The object is attained and a building unit is provided, wherein the inconveniences indicated above of prior similar building units are eliminated by the building unit according to the invention obtaining the characteristics defined in claim 1.

Some embodiments of the invention will now be described by way of example with reference to the accompanying drawings, wherein FIG. 1 is a perspective view of two building units of a simple design which are provided along their opposing edges with each its interlock-device according to the invention. FIG. 1*a* shows one of these units in another perspective, while FIG. 2 is a perspective view of both units in a position pushed together under mutual engagement. FIG. 3 is a plan view of a part of the interlock-device of one of the building units shown in FIG. 1. FIG.4 is a perspective view of a tooth component of an interlock-device for building units according to the invention, including the adjacent surroundings of said tooth, and FIG. 5 is a cross-section along the line V—V in FIG. 4, while FIG. 6 is a section corresponding to that shown in FIG. 5 but through to interengaging interlock-devices having teeth according to FIG. 4. FIGS. 7 and 8 are fragmentary cross-sections through interengaging teeth component of interlock-devices according to the invention, the sections being taken at right angles to the longitudinal direction of the edge of the devices, the figures illustrating alternative forms of the interengaging surfaces. FIG.9 is a view corresponding to FIG. 4 but shows a tooth component of an interlock-device according to FIG. 8 FIGS. 10 and 11 are fragmentary plan views of alternative designs of the plan form or profile of the teeth component of the interlock-devices according to the invention. FIG. 12 is a perspective view of a portion of an interlock-device having the tooth profile shown in FIG. 11. FIGS. 13 and 14 are fragmentary plan views illustrating two steps in a particular case of mounting the building units according to the invention and FIG. 15 finally shows a perspective view of a building unit according to the invention, more particularly an angular piece provided with two interlock-devices perpendicular to one another.

Thus there is schematically shown in FIG. 1 a pair of building units **10** according to the invention which are provided along two opposing edges with interlock-devices according to the invention. As will be seen below the interlock-devices of the units are identical, for which reason corresponding details of the two interlock-devices have been provided with the same reference characters. Thus in this case the units comprise flat, uniformly thick, rectangular plates having along their interlock edges rows of teeth **12, 14, 16, 18,** which between themselves have tooth spaces, said spaces and the teeth having identical plan forms, that is, their projections in plan are identical. As clearly seen in FIGS. 1 and 1*a* the teeth of each plate are arranged in two rows, one on either side of the medial plane or symmetry plane of the plate, said plane being parallel to the sidesurfaces of the plate, and so that one side of the teeth, here denoted "inside," coincides with this medial plane. Each tooth may be considered as a flat, uniformly thick projection on the plate, having a thickness equal to half of that of the plate. The side surface of each tooth opposite to the inside, thus here denoted "outside," coincides with the adjacent side surfaces of the plate. The mutually identical teeth are in this case defined by straight peripheral edges **20, 22, 24,** see FIG. 3, whose projections in plan form a right angle to each other and exhibit together the profile or plan form of the teeth; thus in this case an isosceles right-angled triangle. The edges of the teeth will of course define at the same time the tooth spaces, and thus it follows from the above stated that also the space profile has the form of an

isosceles right-angled triangle in agreement with the tooth profile.

In accordance with conventional principles a common pitch line **28**, see FIGS. 2 and 3, may be defined for the two adjacent or contiguous tooth rows as a straight line extending in the common plane, that is the medial plane, of the two tooth rows, the pitch line halving the edges **20**, **22** etc. of the teeth or, more correctly, the projections in the medial plane of said edges. It is readily appreciated that the pitch t of the teeth is represented by the distance between two subsequent, equally oriented or situated intersections between the pitch line and the tooth profile, see FIG. 2.

As a final general geometrical condition of the arrangement of the tooth rows it is stipulated that they are mutually displaced half a tooth pitch $t/2$ in the longitudinal direction of the rows, that is, along the pitch line **28**. Thus, if therefore two building units **10** are placed with their edges having interlock-devices opposite one another according to FIG. 1, teeth and tooth spaces will lie in pairs opposite each other and arrive into engagement with each other when the building units are pushed together, as illustrated in FIG. 2. The joint between the building units will then only be indicated by a zig-zag line **30** in the plane, see FIG. 2, corresponding to the above mentioned tooth edges **20**, **22** etc.; according to the conditions given each tooth will fill out completely an opposite tooth space. By reasons of symmetry it will be appreciated that the building units may be united in the same way if one of them is turned upside down.

The interlock-device disclosed above is capable of fixing the building units in their mutual position shown in FIG. 2, and in this position it is able to transmit forces perpendicular to the medial plane of the joint and bending and turning moments about axes in this plan. The prerequisite hereof is that at least four teeth are components of each interlock-device and are engaging each other. If one or both interlock-devices contain an odd number of teeth the same position may be attained by means of only three teeth in engagement.

It is obvious, however, that with the teeth form described above the interlock-device according to FIGS. 1–3 is unable to transmit tensile forces, that is, the building units may be pulled apart even by forces very small and, for instance, they may fall apart under the action of gravity. This deficiency of the device, which of course limits strongly the general usefulness of building units provided with such interlock-devices, is remedied, however, according to the invention by the shape of the insides of the teeth being modified, as illustrated in FIGS. 4–6. Of these figures FIG. 4 shows a perspective view, as seen obliquely from above, of a tooth **34** in the one tooth row together with teeth **36** and **38** in the other row, which thus is offset in relation to the first row of teeth. From FIG. 5, which thus represents a section along line V—V in FIG. 4, it may now be seen that the teeth are partly thickened in such a way that a portion **40** of their insides raises above their common dividing plane **42**, viz, projects into the opposing tooth space in the opposite tooth row. Within this area **40** of the inside of the teeth each tooth will in fact raise a distance δ, see FIG. 5, above the medial plane or dividing plane **42**. When two such interlock-devices are pushed together a sinusoidal elastic deformation of the teeth is occurring, see FIG. 6, which shows a section corresponding to the section of FIG. 5 but with the two interlock-devices pushed together or joined. Teeth belonging to the one interlock-device will "crowd" by its insides the opposite insides of teeth component of the opposite interlock-device, and by the compression force caused hereby a connecting friction force is created between the devices. But the difference 2δ in level or thickness caused by said "crowding" and occurring in the joint is imperceptible in practice; by way of illustration the measure δ has been strongly exaggerated in the figures.

The protuberance **40** on the insides of the teeth may be formed in a plurality of different ways. First and foremost the thickening or protuberance may be uniformly distributed across the whole exposed inside of the tooth so that an even engagement takes place over the whole contact surfaces of the teeth. Further, the protuberance may be locally restricted and shaped as low bosses, ribs and the like which meet and press against each other when the interlock-devices of the building units are pushed together. The inside of the tooth may also be fluted or patterned and, finally, the protuberances may be shaped in such a way that they form interengaging hooks which permanently locks the joined interlock-devices.

Another possibility to impart to the interlock-device according to the invention the capacity of assuming tensile forces is illustrated in FIG. 7, which shows a section perpendicular to the longitudinal direction of the interlock-device, e.g. through the device shown in FIG. 2. In this case the locking action is of the type known as "snap-locking," that is, the teeth **44** of the device are in this case provided with protuberances in the form of bosses or ribs **46** adapted to engage into depressions in the form of small pits or grooves **48**, the protuberances and depressions being so located on the insides of the teeth that they will engage in pairs with each other in the locking position of the devices, as may be clearly seen in FIG. 7. In this type of locking the protuberances and depressions need not be as distinctly marked or pronounced as shown in FIG. 7, thus in the form of bosses and pits, but the junction between them can take place more continuously or in wave form, as shown in FIG. 8. This figure represents a section analogous to that shown in FIG. 7 but illustrates how a protuberance **50** near the base of the teeth **54** merges continuously into a depression **52** near the apexes of the teeth so that the insides of the teeth will interengage in locking position, as shown in FIG. 8. The inside of a tooth **54** will then appear approximately as shown in FIG. 9.

To facilitate the mounting or pushing together of the building units the teeth of the interlock-devices are preferably bevelled or rounded at **35**, see FIG. 4, along the outer edges of the insides or at least along a part of these edges, particularly at the apexes of the teeth. Hereby the interlock-devices "seek" each other at the initial pushing together, this operation, as described above, being terminated by the portions of the insides of the teeth within the bevelled edges entering in one way or another into a strong frictional interengagement during a simultaneous slight elastic deformation of the teeth. Said bevelled edges may form 45° or some other suitable angle to the medial plane and may be provided on all teeth or on the teeth of one row only. Also the other tooth forms described may be bevelled as shown at **45** in FIG. 7 and at **55** in FIGS. 8 and 9. However, it should be noted that such bevelling of the teeth is not always necessary; in certain cases, particularly in small teeth, the mounting may be carried out quite readily even with no bevels being provided.

The plan form or profile of the teeth and the tooth spaces may be modified within certain limits in various ways, for instance, as shown in FIGS. 10 and 11. In the "truncated" design according to FIG. 10 the apexes of the teeth and thus (in accordance with the basic condition of identity between the plan form of the teeth and tooth spaces) the bottoms of the tooth spaces have been cut off, straight portions **58** and **60**, respectively, being left at the same distance from the pitch line **62**. In other respects the plan form has not been changed. Alternatively the apxes may be rounded or the profiles of the teeth and the tooth spaces may together form a wave line, approximately as indicated in FIG. 11. With regard to the apex angle α, according to the invention an interesting limit condition holds for this angle, viz, it may be greater than but not less than 90°, as will be discussed in greater detail below. As regards the tooth space profile shown in FIG.

11 the apex angle, in this figure denoted α_1, will be the angle between tangents to the profile curve **64**, **66** at its points of inflexion that is, at the point **67** of intersection with the pitch line **68**. Generally it holds that if the teeth and the tooth spaces have the same plan form this may have an arbitrary geometrical form. As to the above mentioned bevelling of the teeth, in tooth forms according to FIGS. 10 and 11 it may suffice to bevel along the tooth apexes parallel to the pitch line, as indicated at **70** and **72**, but of course bevelling may also be extended along the projecting or exposed part of the teeth, as shown at **65** in FIG. 12, which in other respects illustrates an interlock-device having a tooth profile according to FIG. 11.

The above mentioned limit condition of the apex angle α or α_1 relates to the conditions prevailing in uniting, on the one hand building units exhibiting at least two mutually perpendicular edges provided with interlock-devices and forming an indenting corner and, on the other, building units having right-angled edges intended to be fitted in into said corner, as illustrated in FIGS. 13 and 14. It will be readily appreciated that such a case of mounting will be frequently occurring in joining together units into larger areas. Thus in the case shown in said figures a building unit **74** has as its lower left corner, as viewed in the figures, two interlock-devices whose pitch lines **80** and **82** intersect at right angles in the point **84**, which thus forms the end point of the tooth rows along the lower edge of the unit **74** as well as of the tooth rows along the left edge of the unit. A second building unit **78** has a lower right corner formed in the corresponding way and is joined along its lower edge to the upper edge, provided with interlock-devices, of a third building unit **76**. As seen in the figures the last mentioned edge continues beyond the unit **78**, and thus an "internal" right-angled corner is formed between the two last mentioned units, and the sides of this corner are formed by the interlock-devices of the respective units, said devices comprising tooth rows according to the above, and which rows have pitch lines **86** and **88** intersecting in a point **90**.

Now, if the apex angle of the teeth is at least 90° the units **74** with the "external" corner may be pushed quite simply into the "internal" corner in the direction of arrow **92**, that is, along the bisector **94** of the last mentioned corner; in other words, the pushing direction forms 45° to the direction of the interlock-devices. In FIG. 14 the situation is illustrated when the pushing together has been carried through half ways, and it is terminated by the intersection points **84** and **90** of the pitch lines of the respective interlock-devices of the units coinciding. Hereby, the three building units form, in the manner presumed, a common smooth wall surface. From FIGS. 13 and 14 it is immediately seen that in order that right-angled corners be filled out and fit together in the manner described above the apex angle of the teeth has to be at least 90°; at smaller apex angles the teeth will collide and their flanks cannot slide past each other.

By the teeth and tooth spaces of the interlock-device being formed in the manner specified building units of rectangular or square form and provided with interlock-devices along some or all edges may thus be joined in any order when larger planes or plates are joined. As indicated above joining in corners occurring is further facilitated if the apex angle of the teeth is chosen larger than 90°, and if the teeth are formed with truncated or rounded apexes according to FIGS. 10 and 11, respectively.

As a matter of course, interlock-devices according to the invention may also be arranged on a building unit in such a way that their medial planes do not coincide with each other or with the medial plane of the main body of the units. FIG. 15 shows e.g. an angular building unit having two interlock-devices whose medial planes **96** and **98** are perpendicular to one another, thereby rendering it possible to build three-dimensional objects, as is requested in putting up model buildings and the like.

Those portions of a building unit which lies within or at the side of the interlock-device or devices may be arbitrarily formed, for instance, as flat surfaces with material-saving recesses, curved surfaces, frame structures or latticeworks and so on. Neither is it necessary that an interlock-device extends along the whole side or edge of a building unit but it may be divided into two or more sections separated by even or straight portions without teeth.

As the above discussion of the variation possibilities of the invention would show the building unit according to the invention is in no way limited to the embodiments shown and described but may be varied in further respects within the scope of the concept underlying the invention.

What is claimed is:

1. A building unit in the form of a plate member to be used in building kits or the like, each unit having a small thickness in relation to the dimensions of length and width thereof and adapted to be joined, by hand and without auxiliary means, with similar building units by means of at least one interlock-device provided along at least one edge of the unit, each interlock-device including a number of uniformly pitched teeth distributed in two rows, each said row extending on each side of a common dividing plane, said teeth of each row exhibiting a shape equivalent to that of the tooth spaces between the teeth of a row, wherein the teeth are arranged in such a way that the teeth of the one row are offset half a pitch in relation to the teeth of the other row, wherein the teeth of at least the one row are provided on the side thereof facing the opposing row with at least one protuberance extending beyond the said dividing plane and projecting into the opposite tooth space of the other row to engage an opposing tooth surface on another plate member when the interlock-devices of similar building units are joined together, and wherein the flanks of the teeth, or the tangents to the flanks if these are curved, form a maximum angle of 45° to the longitudinal direction of the row of teeth.

2. A building unit according to claim **1**, wherein said protuberances are uniformly distributed across the whole exposed inside of the associated teeth so that a uniform engagement takes place across the whole contact surfaces of the teeth when the interlock-devices are joined.

3. A building unit according to claim **1**, characterized in that the protuberance on the inside of the tooth surface corresponds to a depression in the opposing tooth inside surface so that any protuberance engages into a corresponding depression when the interlock-devices are joined.

4. A building unit according to claim **1** wherein the said protuberances are so shaped and orientated that they form interengaging hooks, which grip each other and lock permanently the joined interlock-devices.

5. A building unit according to claim **1** wherein the teeth, at least those of the one row of teeth, are provided on their inside with bevels along the edges, at least at the apex, to facilitate the initial engagement between the interlock-devices when the units are to be joined.

6. A building unit according to claim **1** having said interlock-devices along at least two of its edges, wherein the dividing planes of the respective interlock-devices form a certain angle to one another.

7. A building unit according to claim **6**, wherein the dividing planes of at least two of the said interlock-devices form an angle of 90° to one another.

8. A building unit according to claim **1** wherein the plan form of the teeth, or the tooth profile, is formed by a continuous wave line.

9. A building unit according to claim **1**, characterized in that the teeth have a truncated form, that is, their apexes are cut off straight, parallel to the direction of the tooth row, the tooth spaces being provided with corresponding straight or flat bottoms.

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7

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F. BARRY SHAY, Primary Examiner

U.S. Cl. X.R.

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