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(54) **Method of making composite building elements.**

(57) A method of keying a moulded layer (20) to a solid layer (16) in a composite building element comprising drilling or boring openings (58,60) into a block of solid material (16), cutting said block axially of said openings (58,60) so that same form one or more grooves (64) and then allowing a settable composition (20) to set in contact with said grooves (64) whereby a layer of said settable composition is keyed thereto.

A method of making a composite building element comprises moulding a sandwich assembly comprising a layer of natural stone (16), marble or the like between layers (18,20) of a relatively inexpensive building composition and dividing the sandwich assembly, after setting, by a sawing operation, whereby two identiacal building elements (12,14) can be produced, each having an adhering layer of natural stone. In this way production costs are significantly reduced. Where it is desired to have all six faces of a building element having a saw-cut finish, this is produced by means of only 3.5 cuts per rectangular block.

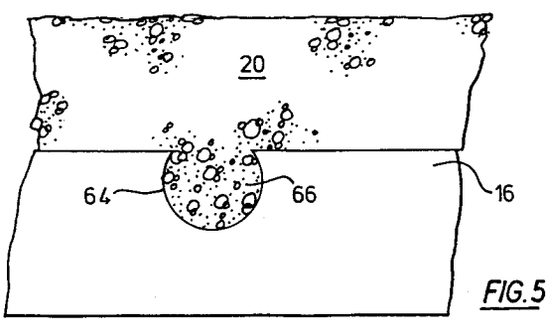

FIG.5

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This invention relates to a method of making composite building elements, and to the products of such method. An example of the application of the invention is to the manufacture of building blocks for use in the construction of building walls. A further example is the manufacture of facing slabs or sheets for the external walls of buildings. The invention is also applicable to paving slabs. More particularly, the invention is concerned with such building elements for use in situations where a surface of a natural material such as stone or marble is required.

It has been previously proposed to manufacture composite building elements comprising a natural stone material and a mouldable composition such as concrete, using a moulding technique. However, this prior proposal suffers from the shortcoming that the manufacturing cost is relatively high and there are manufacturing difficulties including limitations on the extent to which the natural stone material can be provided in a thin and therefore economic form. It will be understood that the intention is to provide a building element in which the visual qualities of the natural stone material on the external side of the building element are combined with the maximum reasonable possible use of relatively cheap alternative materials behind the natural stone.

In prior specification GB 2197005A there is disclosed a method of making composite building blocks utilising a surface material of synthetic stone. The synthetic stone is manufactured by a casting or moulding technique. However, the techniques disclosed are not suitable for use in relation to natural surfacing materials such as marble and natural stone, since the techniques disclosed in the prior specification relate to the use of a moulded or cast surface material, which is poured into the mould so as to produce the required surface finish, and such a technique is not directly applicable to already existing natural materials, though it is mentioned that these latter materials may be incorporated in the synthetic cast surface layer, in particulate form. There is disclosed in the prior specification a technique in which the cast or moulded building element is divided into two substantially identical portions.

We have identified a requirement for a building element providing a surface finish of natural material such as stone or marble, which is nevertheless significantly less costly than the natural material itself, and indeed which can be produced more advantageously than by the prior proposal involving moulding a natural stone material into concrete, and an object of the present invention is to provide a method of making a composite building element offering one or more improvements in this regard, or generally.

According to the invention there is provided a method of making a composite building element, and a composite building element produced thereby, as defined in the accompanying claims.

In a preferred embodiment the piece of natural material sandwiched between the two layers of the settable building composition is divided after setting, so as to leave a layer of the natural material adhering to both portions after division. In this way, by means of a single dividing step, for example by sawing, there is produced two building elements which may be identical in size and form, whereby economy of production is achieved. A single moulding operation has produced two building elements, combined with a single cutting operation. The cutting operation produces a saw-cut finish, as is required for many building purposes.

As regards the dimensions of the building elements which can be thus-cut, it will be understood that modern techniques of cutting using carbide or diamond-tipped saw blades enable relatively deep cuts to be made, whereby the width of a thus-sawn block or element can be considerable, and indeed by cutting from opposite sides, the effective width can be doubled. It will be understood that the length of such a block or element is not subject to any appreciable limitation.

A further preferred feature of the invention comprises the step of cutting at least one other face of the building element with such a saw, or the like so as to define at least one other face. For example, where it is desired to produce a building element or block in which all six faces are thus-cut, as for example in the case of an ashlar block, the number of saw cuts to produce two such blocks is six, for the six faces of the moulded product produced by the moulding technique of the invention, plus one further cut to divide the sandwiched layer of natural material, whereby seven cuts has produced two building elements, whereby the number of cuts per element is only 3.5. This represents a significant further economy in terms of cutting techniques.

Where the method of the invention is used to produce paving slabs, for example for use in paved pedestrian areas, the production of the now conventional 3 inch thick slabs is readily carried out and the natural stone material is extremely well supported over its total area, whereby vehicular traffic over the slabs is unlikely to cause cracking. By providing a natural stone material thickness representing less than half, and preferably less than one quarter of the overall thickness of the slab or element, considerable economies of materials are achieved.

In the case of relatively small building elements and slabs, it is desirable to enhance the bonding effectiveness between the settable composition and

the natural material, such as stone. For this purpose, a bonding or bond-enhancing agent is employed, such as that obtainable in the UK at the date of filing this present application under the trade mark Unibond. Alternative other such compositions may be employed, these being applied to the relevant surface of the natural material prior to application of the settable composition.

In the case where the building element is of significantly larger size, as for example in the case of panels or the like for building facing use, where such a panel may for example be as large as 10 feet (3.05 metres) by 10 feet (3.05 metres), then it is desirable to provide mechanical key means for keying the settable composition to the natural stone material, rather than bonding it. For this purpose, dowell pins may be provided, for example five dowell pins per panel (one centrally, and four in the corner regions). Alternatively, drillings may be formed in the natural stone material, whereby the settable composition can enter therein and thus be keyed thereto. By drilling prior to slicing the stone to size for placement in the mould, a groove giving positive retention can be provided.

The method of the invention is preferably carried out in a mould wherein the natural material is supported centrally for cooperation with the layers of settable composition on each side thereof.

With respect to the question of differential thermal expansion between the two layers of the composite building elements, where possible the coefficient of thermal expansion of the settable composition and of the solid, for example natural material, should be sufficiently similar to avoid damage due to differential thermal expansion.

In a preferred embodiment, means is provided to minimise the effect of differential thermal expansion. Before casting the settable composition onto the solid material, for example natural stone, a layer of a flexible composition, for example latext, is applied to the solid material, particularly in the region of the keying grooves. The flexible composition can be applied either by spraying or brushing. The layer of flexible material provides a flexible barrier which accommodates differential thermal expansion.

To further enhance keying between the two layers, reinforcements may be located in the grooves formed in the non-cast layer so as to become embedded in the cast layer. For example stainless steel rings or other non-corrodible metallic reinforcements may be provided. The form of these may comprise a curved portion to correspond to that of the grooves, and diverging leg portions. For example, each reinforcement may be generally keyhole shaped. The reinforcements may be a spring-fit in the grooves so as to be self-held therein during setting of the composition.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which :-

Fig 1 shows an isometric view of a building element after casting and prior to division;

Fig 2 shows an elevation view of the same building element after division;

Fig 3 shows an elevation sectional view of a wall constructed from such building elements; and

Figs 4 and 5 illustrate the formation of keying grooves.

Referring to Figs 1 and 2 of the drawings, there is shown a composite building element 10. In Fig 2 the composite building element 10 of Fig 1 has been divided into two such elements 12, 14 as will be more fully described below.

The composite building element 10 of Fig 1 comprises a central portion 16 of stone, marble or other natural material, and this portion is sandwiched between two layers 18, 20 formed of a settable building composition, for example ready-mixed concrete, or a like composition, which forms a relatively low cost core or base or internal material of the composite building element, while the natural material provides an external or outer surface for exposure in use, as will be explained below.

Turning now to the method of making the composite building elements 10 and 12, 14, the first step comprises providing a settable building composition to form the layers 18, 20 of relatively low cost core of base material. For this purpose, ready mixed concrete or a like composition is employed. Any suitable fillers may be incorporated, as required for reasons of economy, availability, physical characteristics of the composition, or other requirements. It is desirable that the coefficient of thermal expansion of the settable composition be approximately the same as that of the natural stone of layer 16, in order to minimise the differential expansion and contraction as ambient temperatures change. This factor is more marked as the size of the building elements increase. In the case of relatively small elements employed in the manner of building bricks and the like, this factor is not particularly significant.

The settable building composition which produces layers 18 and 20 is provided in a soft or pourable condition. Next in the method there is provided the solid element to cooperate with the soft or pourable building composition, namely the piece of stone or marble or other natural material 16. This latter is supported in contact with the settable composition, while permitting same to set. This operation is performed in a mould (not shown). The stone 16 is mounted in the mould and the composition forming layers 18 and 20 is inserted at each side face of the stone layer, so that

the latter is intimate contact with the composition while the latter sets. An adhesive or adhesion-promoting compound such as that available under the trade mark Unibond may be applied to the two side faces of stone element 16 to improve bonding, in the case of relatively small building elements.

The mould in which the setting of the settable composition proceeds is of such dimensions as to conveniently locate the stone element 16, approximately centrally therein, while the settable composition is poured or inserted afterwards. Alternatively, it would be possible to simply insert the stone layer into the relatively liquid settable composition by downward pressure of the stone element into the composition within the mould. This latter procedure might well eliminate the need for specific support means to maintain the attitude of the stone element prior to filling the mould with the settable composition. Thus, the step of supporting the stone element in contact with the settable composition need not necessarily require the use of any specific support means for the stone element, other than the settable composition itself.

In the case where the piece of natural stone or other material is not of dimensions to conform closely with the internal dimensions of the mould, it may well be that the settable composition to some extent extends around the periphery of the stone and thus somewhat encloses it. This need be of no particular significance since the subsequent operation of dividing the composite building element from its Fig 1 position to that of Fig 2 will in any case produce the required natural stone faces 22, 24. Moreover, any excess of the settable composition can be removed in subsequent sawing steps if necessary.

Usually however the stone layer of building element 10 will itself have been prepared in well-defined rectangular form by sawing operations, commencing from a piece of stone sufficient to provide several such natural stone layers, these being effectively sliced from the larger rectangular stone block in a series of parallel sawing operations, and thus stone layer 16 will have the rectangular form shown in Fig 1. This series of sawing operations has significance in relation to the embodiment of Fig 4 and 5, as described below.

The manufacturing process thus far produces the set composite building element 10 shown in Fig 1. Attention is drawn particularly to the sandwich form of this element, with the natural stone layer 16 largely hidden from view by the outer layers of concrete. There will be described below the shoulder or lip 26 seen in Fig 1, which is provided for building assembly purposes.

The next main step in the method of production comprises dividing the building element 10 into its two halves 12, 14 by a dividing operation, preferably performed using available stone cutting equipment, such as rotary diamond or carbide-coated or tipped cutting elements. It is envisaged that the sawing operation will be performed on a regular production line basis using a conveyor feed system for the pre-formed blocks and accurately positioned sawing equipment to effect a symmetrical division of the block 10 into its portions 12, 14 as shown in Fig 2.

The result is the production of two substantially identical composite building elements 12, 14. Each is faced with a natural stone layer 16 having respective sawn faces 22, 24 of well-defined planer form, exactly as required for many stone facing purposes. It will be seen that the width of the stone layers 16 is one half that of the concrete layers 18, 20 in this embodiment. The sawing techniques permits, if desired, an even smaller width for the stone or marble layers 16, for further economy.

Attention is now turned to the lip or shoulder 26 seen in Fig 1, which produces the corresponding lips or shoulders 26 seen in Fig 2. The purpose of these is concerned with assembly of the building elements, and is illustrated in Fig 3.

The lip or shoulder 26 can be produced either by a moulding technique, or by cutting the composite element 10 after moulding. The moulding technique can be carried out by employing suitable inserts placed in the mould above the settable composition which produces layers 18, 20, the inserts corresponding in dimensions to the depth of lip or shoulder 26 and whose other dimensions correspond to the length and width of layers 18, 20. If a cutting technique is employed, it is a matter simply of removing by sawing the portions of the layers 18, 20 indicated in Figs 1 and 2, to produce the lips or shoulders 26.

For assembly purposes, it can be seen from Fig 3 that the lip or shoulder 26 on one block cooperates with the adjacent edge of the next block to produce a relatively narrow joint front portion 28, while the rear portion 30 is of conventional width to enable mortar 32 to perform its proper and normal function. The depth of portion 28 is approximately 3 millimetres while that of joint portion 30 is approximately 10 millimetres. Other dimensions shown in Fig 3 for the building element 14 include a front side depth 34 of 300 millimetres, a rear side depth 36 of 293 millimetres and thicknesses 38 and 40, respectively for the stone layer 16 and the concrete layer 20 of 25 to 32 millimetres and 68 to 75 millimetres respectively.

In the embodiment of Fig 3 there are shown dowell pins 42 provided to key the concrete 20 to the stone 16. Five such pins 42 are provided per building element 14, four in the corner regions, and one centrally. A greater or lesser number may of be used. The dowell pins are inserted into drillings

or openings formed in the stone prior to the moulding operation. For certain applications, a degree of flexibility in the connection between the dowell pins and stone may be desirable, having regard to the possibilities of differential thermal expansion. The dowell pins are preferably of stainless steel.

In the embodiment of Figs 4 and 5 there is provided an alternative method of keying the concrete layer 20 to the stone layer 16.

Fig 4 shows a plan view of a block 44 of natural stone, from which are to be cut a series of stone layers 46, 48, 50 etc by means of transverse saw cuts 52, 54 etc. In Fig 4 the direction of the plan view is, with respect to Fig 1, the direction indicated by arrow IV in Fig 1. Thus edge 56 in Fig 4 corresponds to edge 56A in Fig 1.

In this embodiment, before the saw cuts 52, 54 are made, there are formed a series of pairs of drillings 58, 60, each pair having the centre of one hole off-set to one side of the saw line, and the other hole likewise equally off-set on the other side. The holes need not necessarily be drillings, but could be formed in other ways provided the keying function (to be described below) is correspondingly produced.

After formation of the holes 58, 60 the saw cuts 52, 54 are made, whereby the stone layer 62 has a series of pairs of keying grooves or openings extending vertically (as they would be seen in Fig 1) up and down its side faces, so that the concrete will enter therein during the moulding process. Such a groove is shown at 64 in Fig 5, with the concrete 66 entering therein. It will be readily understood that because of the shape of groove 64, the concrete which sets therein is positively held and located. This is less so for the corresponding groove (not shown) in the same face produced from drilling 60.

It will be understood that the drilling-prior-to-sawing technique represents an extremely simple and straightforward method of positively keying the concrete layer to the stone layer.

If it is desired to provide a still more secure and positive connection between the two, there could be inserted into the grooves 64 a series of metallic retainer elements (not shown) which are positively retained by the shape of the groove and which become embedded in the concrete. For this embodiment it is highly desirable that the coefficient of thermal expansion of the stone and concrete be approximately equal.

Interestingly, the above embodiments provide significant improvements in relation to the manufacture of composite building elements comprising natural stone. The division of the pre-formed double building element 10, by for example a sawing operation produces two identical building elements each having a saw-cut face 22, 24. This enables a double quantity of building elements to be produced from a single moulding operation, and likewise from a single sawing operation. Considerable economies in production are thereby achieved. Corresponding economies in sawing operations are likewise achieved where totally saw-cut-defined "ashlar" type blocks are required. In such a case, a total of only 3.5 separate cuts per block produced are required.

The consumption of natural stone by the use of natural stone faced blocks as described above when compared with traditional natural stone blocks produces a materials savings of 67 to 75 per cent of natural stone ie it is possible to construct three to four buildings from natural stone faced blocks compared with one building using pure natural stone.

By providing a simple and effective keying system for the natural stone layer, there is provided security of anchoring same in combination with cost-efficiency of production. This enables the use of natural stone faced panels in surfacing large building areas. Such an approach enables the wider use of natural stone and permits planners to maintain or extend conservation areas where such materials are prescribed for building purposes.

In a further embodiment, not illustrated, the effect of differential thermal expansion between the cast and non-cast layers in the embodiment of Figs 4 and 5 is minimised by applying a layer of a flexible composition, for example latext, to the grooves formed in the solid material prior to applying the settable composition. In this way, a layer of latext is provided between the two keyed layers, after the composition has set, whereby this layer can accommodate thermal expansion and contraction, and avoid cracking.

Claims

1. A method of keying a moulded layer to a solid layer in a composite building element comprising drilling or boring or otherwise forming an opening into a block of solid material and then cutting said block axially of said drilling or bore or opening so that same forms one or more grooves in opposite sides of the cut, and then allowing a settable composition to set in contact with said groove whereby a layer of said settable composition is keyed thereto.

2. A method according to claim 1 characterised by the step of applying to said grooves formed in said block of solid material, a layer of a flexible composition, for example latex, prior to allowing said settable composition to set in contact therewith, whereby said flexible composition can accommodate differential thermal

expansion.

3. A method according to claim 1 or claim 2 characterised by the step of cutting or moulding a recess in said settable composition whereby a shoulder or lip is provided by the solid material, which shoulder of lip stands slightly proud of said settable composition so that, when assembled with an adjacent building element, the joint between said shoulder or lip and the adjacent building element can be significantly narrower at the exterior side of the structure formed, than is the width of the joint rearwardly thereof, the latter being capable of accepting mortar to produce a joint of conventional mortar thickness.

4. A method according to any one of claims 1 to 3 chracterised by the step of locating reinforcement members at intervals in the grooves formed in said solid material, said reinforcements each having a part-annular portion to cooperate with said grooves, and extension portions projecting from the ends of said part annular portion.

5. A method according to any one of claims 1 to 4 characterised in that said axial cutting of said block is executed off-centre with respect to said drills or bores or openings formed therein.

6. A method of making a composite building element comprising :-

a) providing a settable building composition;

b) providing a solid element of said composite building element and supporting same in contact with said settable composition while permitting same to set and therefore adhere to said solid element; and

c) dividing said building element after setting, to produce two building elements;

characterised by

d) providing said solid element of the composite building element as a piece of natural non-manufactured material, such as stone or marble, said settable building composition forming a relatively low cost core or base or internal material of said composite building element, while said piece of natural material provides an external or outer surface for exposure in use; and

e) said step of supporting said solid element in contact with said settable composition comprising sandwiching said solid element between two layers of said settable composition; and

f) said step of dividing said building element after setting comprising cutting through said element of natural material so as to leave a layer of the latter adhering to both portions after division.

7. A method of making a composite building element comprising allowing a settable building composition to set in contact with a solid element, characterised by said solid element comprising a natural material and being sandwiched between layers of said building composition and being divided after setting so as to leave a layer of the natural material secured to both portions after division.

8. A method according to claim 6 or claim 7 characterised by the steps of cutting at least one further face of said building element with a saw to define said further face.

9. A method according to claim 8 characterised by the step of cutting all six faces of the rectangular composite element after setting of said composition, and then cutting through said piece of natural material, whereby two similar or identical blocks or elements having saw-cut faces have been produced by seven such cuts.

10. A method according to any one of the preceding claims characterised by said building element being in the form of a paving slab or the like and said settable composition being moulded to provide a planar base surface of said slab.

11. A method according to any one of claims 6 to 10 characterised by said natural material being of a thickness less than one half and preferably less than one quarter of the overall thickness of said building element.

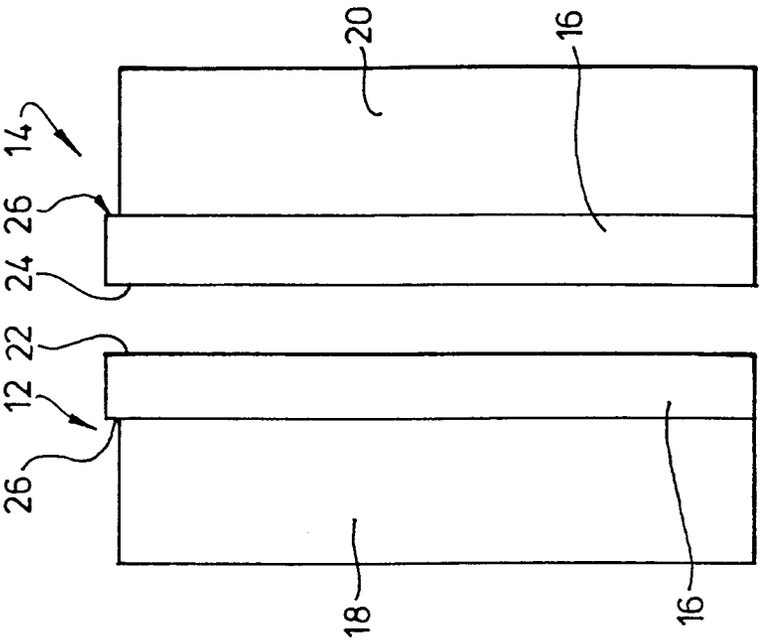

FIG.2

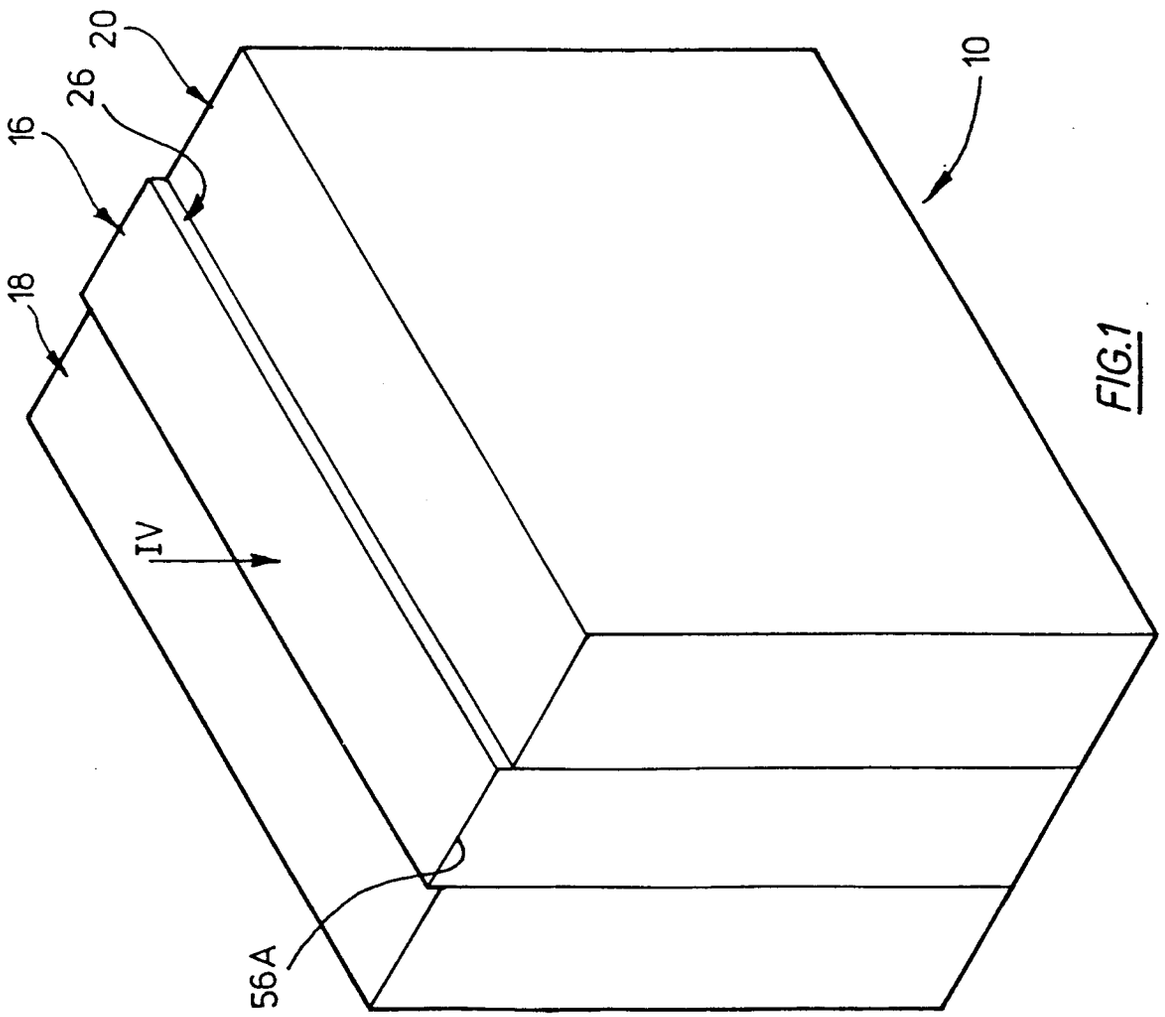

FIG.1

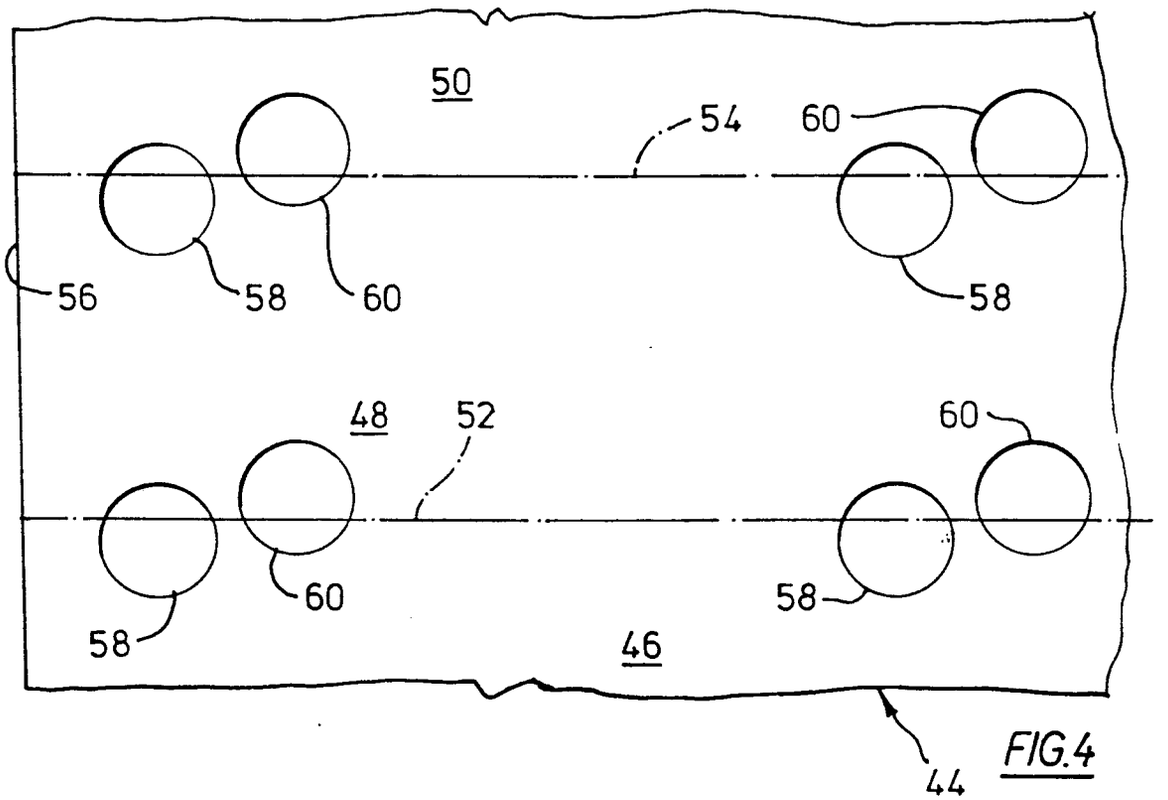

FIG.4

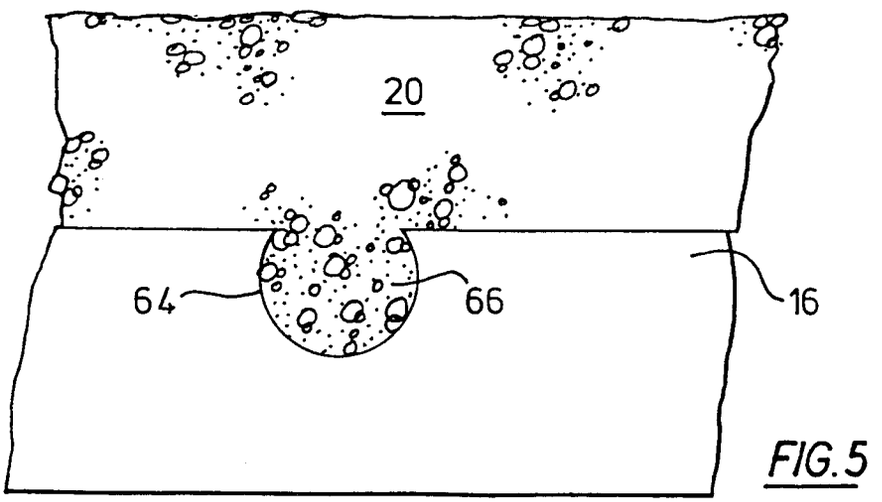

FIG.5

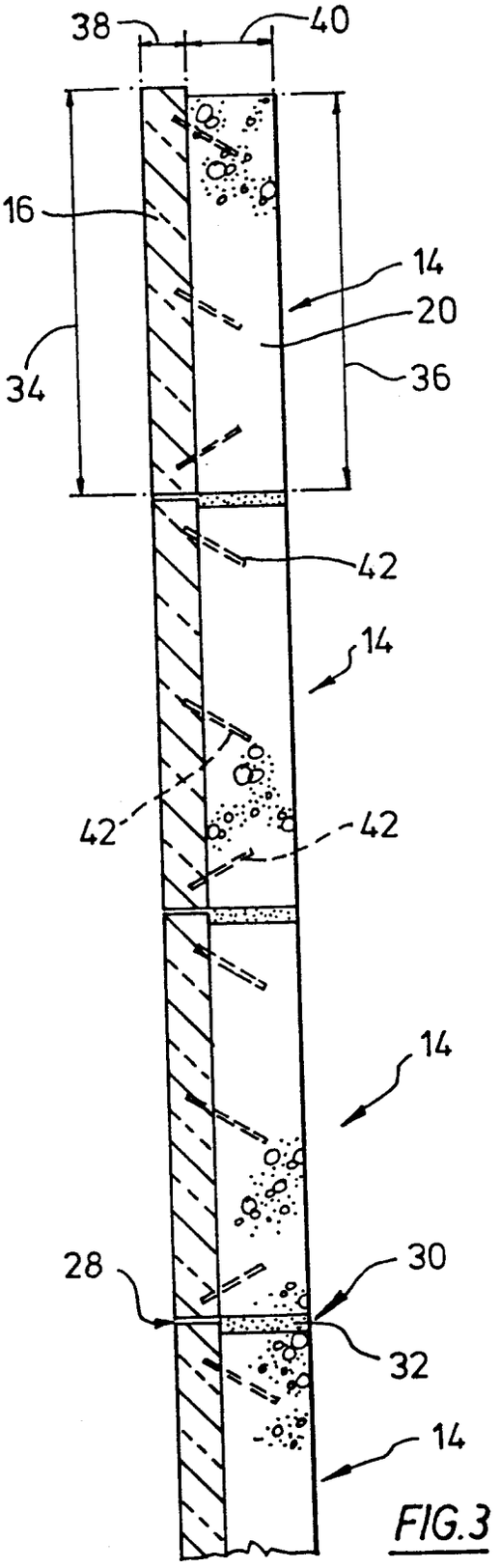

FIG.3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 30 9795

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	WO-A-9 112 393 (LAPIN MARMORI OY) * Whole document *	1	B 28 B 19/00 B 28 D 1/00 E 04 F 13/14
A	US-A-3 694 533 (P.S. KELSEY) * Whole document *	1	
A	US-A-4 522 003 (S. AKIHAMA) * Column 2, lines 54-68; column 3; column 4, lines 1-4; figures 4-10 *	1,4	
A	GB-A- 938 901 (E. GREGSON) * Whole document *	2	
A,D	GB-A-2 197 005 (C.N. BATEMAN) * Whole document *	3	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

B 28 B
B 32 B
B 28 D
E 04 F

~~The present search report has been drawn up for all claims~~

Place of search	Date of completion of the search	Examiner
THE HAGUE	11-06-1992	GOURIER P.A.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

☐ All claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for all claims.

☐ Only part of the claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid,

namely claims:

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions,

namely:

see sheet -B-

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid,

namely claims:

☒ None of the further search fees has been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims,

namely claims: 1-5

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claims 1-5: Method of keying a moulded layer to a solid layer

2. Claims 6-11: Method of making a composite building element