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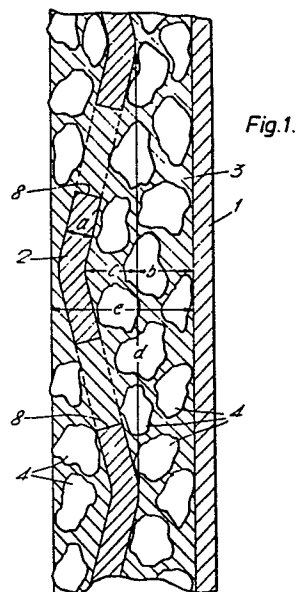
71 Applicant: **Chubb & Son's Lock and Safe Company Limited**
51 Whitfield Street
London W1P 6AA(GB)

72 Inventor: **Sands, Raymond Leonard**
50 Woodlands Lane
Solihull West Midlands(GB)

74 Representative: **Obee, Robert William**
Manor House Manor Lane
Feltham Middlesex TW13 4JQ(GB)

54 **Security barrier structure and method of making the same.**

57 A barrier structure for the walls and/or doors of a safe or other security enclosure comprises a corrugated planar element (2) of copper or other tough and heat-resistant metal disposed in intimate relation within a matrix (3) eg of cast aluminium or concrete containing elements (4) of very hard and refractory material. The corrugations in the element (2) are formed so as to ensure that a cutting tool of selected diameter which is applied to that element (2) will inevitably encounter some of the hard material (4) behind that element (2) so that the tool is blunted before the element (2) can be completely penetrated.



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Security Barrier Structure and Method of Making the Same

The present invention relates to barrier structures for use eg in the walls and/or doors of safes, strongrooms and the like security enclosures. Barrier structures provided for this purpose must have a high degree of resistance to the various forms of burglarious attack to which the enclosure may be subjected and it is an aim of the invention to provide an improved security barrier structure in which materials resistive to different classes of burglary tools can be combined in a particularly effective manner.

There is no known single material which can be employed on a practical basis in the construction of such enclosures to resist all types of tool currently at the disposal of the criminal. Various materials are known which provide excellent resistance to specified classes of tool when used in isolation, but for the same barrier structure to be effective against a range of different tool types a combination of different materials is required. Moreover, these materials should be integrated structurally in such a way as to resist the penetration of the overall barrier by "multiple" attacks, where

- concerted use is made of a range of different tools, but without significant sacrifice to the resistance of the structure to "single-tool" attacks. In particular, it should not be possible readily to penetrate the barrier
- 5 by the successive penetration of each material encountered with appropriately selected tools, as might be the case with a barrier structure made up with simple discrete layers of the different materials.
- 10 In seeking to provide a security barrier structure which is capable of resisting both "single-tool" and "multiple" attacks as aforesaid the invention is characterised by a corrugated planar element of strong, tough, heat-resistant metal generally aligned with the plane of the
- 15 barrier and disposed in intimate relation within a matrix consisting of, or containing elements of, hard and refractory material.

- The invention also provides a method of making a security
- 20 barrier structure which is characterised by the steps of providing a corrugated planar element of strong, tough, heat-resistant metal and casting around that element a matrix consisting of, or containing elements of, hard and refractory material, the corrugated element being
- 25 generally aligned with the plane of the barrier.

- A particularly preferred material from which the aforesaid corrugated element may be made is copper, alternatives including stainless steel, aluminium and
- 30 cast iron.

- The matrix within which the corrugated element is disposed preferably contains, (at least in that portion of the matrix which is behind the corrugated element in
- 35 relation to an attack from outside the enclosure), at least 10% by volume of a material whose hardness is

in excess of 1000 kg/mm². Suitable matrix materials therefore include security-formulation concretes containing hard aggregates such as quartzite, fused alumina or the like (and which may also be reinforced
5 with steel or polypropylene fibres), and composites such as cast aluminium or copper containing nuggets of fused alumina or the like.

By virtue of its rapid heat-dissipating ability the
10 copper or other said corrugated metal element can confer upon a barrier structure according to the invention good resistance to attack by oxy-acetylene, oxy-arc and the like thermal tools, and can also provide good resistance to power percussion tools by virtue of its ability to
15 deform without fragmentation under the action of such tools (ie its toughness). On the other hand, being relatively soft this type of element would be, in isolation, vulnerable to attack by "sharp edge" mechanical cutting tools such as drills, holesaws and
20 chisels, but these can be resisted in a structure according to the invention by the hard material in the surrounding matrix. It is in this respect that the corrugated form of the element is of particular advantage. As more fully discussed below, by appropriate
25 shaping of this element it can be arranged that any such tool adapted to cut a hole of specified diameter which is applied to the corrugated element will inevitably encounter some of the hard material in the matrix behind the corrugated element before that element is completely
30 penetrated. This action will of course rapidly blunt the tool edge, and once blunted cutting tools become very inefficient against ductile metals. In this way the structure can offer high resistance even to multiple attacks which attempt to penetrate the barrier structure
35 firstly by removing a portion of the matrix material in

front of the corrugated element by one class of tool to which the matrix is more vulnerable than the corrugated element, and then attacking the exposed corrugated element with another class of tool to which that element
5 is percieved to be more vulnerable than the matrix. The corrugated shape of the internal metal element may indeed also assist in resisting the first stage of such an attack as considerably more difficulty may be experienced in removing the matrix material which is
10 lodged in the troughs or other depressions in the surface of the corrugated element than in the case of, say, an equivalent material provided as a flat layer.

The copper or like metal element is also of advantage
15 in resisting another class of tool, namely diamond core drills and the like abrasive tools which depend for their operation on the continual wearing down of the tool tip to expose new abrasive particles; when such a tool encounters the corrugated element in a structure
20 according to the invention it will rapidly become clogged by the ductile metal. A structure in accordance with the invention may also offer high resistance to attacks using explosives as the internal metal element can act effectively to retain the integrity of the barrier when
25 subjected to shock loading, and such a structure can furthermore provide the appropriate combination of hard and tough materials for resisting ballistic projectiles and the like.

30 If it is to be ensured that a cutting tool is blunted by the matrix material before penetration of the internal metal element can be completed by that tool then the corrugated form of the internal element must be related to the tool size and direction of advance such as to
35 provide that parts of the tool tip will at one and the

same time encounter a portion of the metal element and a portion of the matrix material. A simple type of corrugation comprising parallel rows of alternate peaks and troughs can be provided by relatively inexpensive sheet or plate forming techniques and can be effective, by appropriate selection of the dimensions of the corrugations, to ensure that the above-mentioned blunting effect takes place for a wide range of the tool sizes and directions of attack that would be likely to be met in practice. In this respect tests indicate that the amplitude of the corrugations (that is the peak-to-trough height measured at the same surface) is preferably 5-15mm more than the thickness of the metal in the corrugated element, so that for an element made from, say, a 10mm thick sheet the amplitude may be about 20mm. Larger amplitudes do not in general detract from security but are likely to be impractical in safes for example where the wall thickness is limited. It has also been found that the pitch of the corrugations (that is the peak-to-peak or trough-to-trough distance) preferably lies in the range between one half and twice the diameter of the typical penetration which the barrier is intended to resist. For resisting a 125mm diameter "handhole" penetration a corrugation pitch of between 60 and 250mm may be best, therefore, or for resisting a 40mm diameter penetration the preferred pitch may be between 20 and 80mm. A pitch of about 70mm might therefore be chosen for optimum resistance to the range of penetration diameters from 40-125mm. The pitch and amplitude will in general be interrelated such that the angle subtended to the plane of the barrier by an imaginary straight line drawn between an adjacent peak and trough is in the range of 5-60°.

However, other more complex corrugated forms may be provided instead of the parallel peak-and-trough form indicated above, for example where there are ridges running in two or more different directions or where
5 there are a plurality of discrete depressions or obtrusions distributed over the surface of the metal element - such an element could be described as being generally of "eggbox" shape - and the term "corrugated" is accordingly to be interpreted broadly. Metal elements
10 of these shapes may be more appropriately produced by casting from the molten metal than by sheet-forming.

In one aspect, the shape of the corrugated element can be defined as being such that, for substantially all
15 positions within at least a major portion of the projected area of that element, an imaginary cylindrical core of selected diameter taken through the barrier structure generally perpendicular to the plane thereof will have at least one transverse section at one part of
20 the periphery whereof there is a portion of the corrugated element and at another part of the periphery whereof there is a portion of the matrix material which is located behind the corrugated element, especially where the said selected diameter is in the range of 40-
25 125mm.

Structures according to the invention may be produced eg in the form of flat slabs for incorporation into the walls and doors of safes or strongrooms. Alternatively,
30 in the construction of safe bodies it is of advantage if the barrier structure is of "monolithic" form including a suitably interconnected series of the metal elements (eg one each for the back, top, bottom and two side walls of the safe) disposed within a single "bell" of cast matrix
35 material. In addition to the main corrugated metal

element(s) in any such structure it is also possible to incorporate specially formed strips or plates of the same or similar metal into the same matrix to give even greater resistance to penetration in particularly
5 important areas of a security enclosure door or body.

In practice the barrier structure will generally be built up on a backing plate which supports and locates the structure in relation to the completed enclosure, (that
10 is the backing plate is located behind the aforesaid matrix and corrugated element, and may define the inner skin of a safe body for example). The overall structure may then comprise anchors secured to the backing plate and extending into the mass of the matrix material to
15 secure the latter to the plate. Preferably such anchors extend through apertures in the corrugated element and are interconnected in front of that element by a network of rods or the like. The combination of these rods and anchors, (which will resist the corrugated element being
20 pulled away from the backing plate), and the disposition of that element within the matrix can offer excellent resistance to "delamination" of the barrier structure as a whole from the plate, which might be attempted eg through use of explosives or other gross force.

25

As a further feature of a barrier structure according to the invention it may be of advantage to have the internal metal element coated with an electrically insulating and/or fume-generating substance; one substance which
30 could provide both properties is bitumen, for example, but others are possible. If the internal metal element can be electrically insulated in this way from the usual steel skins or other metal constituents of the security enclosure then it will be very difficult to penetrate the
35 barrier using tools - such as the oxy-arc torch - which

depend for their operation on striking an arc. The ability of such a coating to produce fumes when heated will be of value in hindering thermal attacks in general.

5

Illustrative embodiments of the present invention will now be more particularly described, by way of example, with reference to the accompanying drawings, in which:-

10 Figure 1 is a section through part of a slab or "bell" barrier structure according to one embodiment of the invention;

Figure 2 shows a detail of the structure of Figure 1;

15

Figure 3 is a horizontal section through the door/body junction of a safe incorporating barrier structures according to the invention; and

20 Figure 4 is a view similar to Figure 1 of a further embodiment of the invention.

Referring to Figure 1 there is shown a high strength steel backing plate 1 to which is secured an integral
25 barrier structure comprising a corrugated wrought copper plate 2 disposed in intimate relation within a matrix of cast aluminium alloy 3 containing also nuggets of fused alumina 4 (eg ALOXITE - Registered Trade Mark) or the like very hard, refractory material. In one specific
30 example of a structure as shown in Figure 1 the thickness a of the copper plate was 13mm, the minimum thickness b of matrix material between the copper plate 2 and backing plate 1 was 25mm, the amplitude c of the corrugations in plate 2 was 24mm, the pitch d of the corrugations was in
35 the region of 100-150mm, and the overall thickness e of

the integral barrier was 65mm. As explained previously, a structure of this type has a high resistance to attack by a wide range of thermal and mechanical tools, and the corrugated form of the copper plate 2 in this embodiment is such as to ensure that the tip of any mechanical cutting tool which is adapted to form a "handhole" size aperture in the plate and which is advanced through the barrier from the outside (that is the side remote from the plate 1) will encounter hard elements 4 in the matrix behind the plate 2 before that plate can be completely penetrated.

To produce a structure of the type shown in Figure 1 the following procedure may be adopted. Rows of "L" anchors 5 (Figure 2) are welded to the backing plate 1 and the preformed plate 2 is fitted over these anchors, the plate 2 first having been prepared with appropriately spaced holes 6 in the troughs of selected corrugations (as illustrated), or elsewhere, for this purpose. Cross rods 7 are introduced to run over the surface of the plate 2 and beneath the respective anchors 5 in each row, and the assembly of rods 7 and anchors 5 is welded together. The rods 7 and anchors 5 serve accurately to define the position of the plate 2 in relation to the remainder of the structure during the subsequent steps of manufacture and, most importantly, offer high resistance to separation of the completed security barrier from the backing plate.

After welding up the rods and anchors the plate 1 is assembled with a re-usable mould structure to define an appropriate mould cavity around the plate 2, and the ALOXITE or like nuggets 4 are introduced into the resulting volume. The whole is then preheated and molten aluminium alloy is poured into the cavity to form the

matrix 3, the aluminium completely filling the interstices between the nuggets 4 and plates 1 and 2. The aluminium flows around both sides of the copper plate 2 and through the holes 6 and further prepared holes 8 in the plate so that the plate is intimately embedded in the resultant matrix. Finally, when the casting has cooled the plate 1 is removed from the mould structure to leave a security barrier of the form shown in Figures 1 and 2.

10 Turning now to Figure 3 this shows one example of the practical application to a security enclosure of barrier structures according to the invention. In this, the door 9 and body 10 of a safe incorporate, respectively, slab and "bell" type barrier structures comprising copper
15 plates 2 in aluminium/alumina matrices 3/4 as previously described, the corrugations in the door plate 2 being shown running vertically and the corrugations in the body plate 2 being shown running horizontally. In addition, wrought copper strips 11 and 12 are integrated into the
20 respective barrier structures at positions adjacent to the junction between the door edge and safe body. These strips 11 and 12 are especially useful in protecting against a torch attack on the door bolts 13 and their detentions 14 in the safe body - in particular they will
25 resist attempts to widen the gap 15 between the door and body in an effort to direct a torch at the bolts 13/detentions 14 at a favourable angle through that gap.

In Figure 4 there is shown another embodiment of a
30 barrier structure in accordance with the invention. There is a corrugated wrought copper plate 2' anchored to a backing plate 1' generally as described before, but in this case the plate 2' is disposed within a matrix 3' of hard security concrete of a total thickness of, say,
35 150mm. The plate 2' is secured to the plate 1' by

anchors 5' and rods 7' functionally equivalent to the anchors 5 and rods 7 previously described, additional anchors 16 and rods 17 also being provided to increase resistance to separation of the concrete 3' from the
5 plate 2'. An outer finishing skin is indicated at 18. The concrete 3' is preferably a fibre-reinforced concrete and contains a high proportion of quartzite or other selected very hard aggregate.

Claims

1. A security barrier structure characterised by a corrugated planar element (2,2') of strong, tough, heat-resistant metal generally aligned with the plane of the barrier and disposed in intimate relation within a matrix (3,3') consisting of, or containing elements (4) of, hard and refractory material.
2. A structure according to claim 1 wherein said metal is selected from the group comprising copper, stainless steel, aluminium and cast iron.
3. A structure according to claim 1 or claim 2 wherein at least that portion of the matrix (3,3') which is disposed behind the corrugated element (2,2') contains at least 10% by volume of a material (4) whose hardness is in excess of 1000kg/mm^2 .
4. A structure according to any preceding claim wherein the material of said matrix (3,3') is selected from the group comprising concrete of which the aggregate includes quartzite or fused alumina, and cast aluminium or copper containing nuggets of fused alumina.
5. A structure according to any preceding claim wherein said corrugated element (2,2') is formed with parallel rows of alternate peaks and troughs.
6. A structure according to claim 5 wherein the amplitude (c) of the corrugations in said element (2,2') is 5-15mm greater than the thickness (a) of the metal therein.

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7. A structure according to claim 5 or claim 6 wherein the pitch (d) of the corrugations in said element (2,2') lies in the range of 60-250mm.
8. A structure according to claim 5 or claim 6 wherein the pitch (d) of the corrugations in said element (2,2') lies in the range of 20-80mm.
9. A structure according to any one of claims 5 to 8 wherein an imaginary straight line drawn between an adjacent peak and trough of said element (2,2') subtends an angle in the range of 5-60° to the plane of the barrier.
10. A structure according to any one of claims 1 to 4 wherein said corrugated element is formed with a plurality of discrete depressions or obtrusions distributed over its surface.
11. A structure according to any preceding claim wherein the shape of said corrugated element (2,2') is such that, for substantially all positions within at least a major portion of the projected area of that element, an imaginary cylindrical core of selected diameter taken through the structure generally perpendicular to the plane thereof will have at least one transverse section at one part of the periphery whereof there is a portion of the corrugated element (2,2') and at another part of the periphery whereof there is a portion of the matrix material (3,3'/4) which is located behind the corrugated element (2,2'), where the said selected diameter is in the range of 40-125mm.

12. A structure according to any preceding claim which is secured to a backing plate (1,1'), there being anchors (5,5') extending from the backing plate (1,1') into the mass of the matrix (3,3').
13. A structure according to claim 12 wherein said anchors (5,5') extend through apertures (6,6') in the corrugated element (2,2') and are interconnected in front of that element (2,2') by a network of rods (7,7') or the like.
14. A structure according to any preceding claim wherein the corrugated element (2,2') is coated with an electrically insulating and/or fume-generating substance.
15. A security enclosure characterised in that the door (9) and/or body (10) thereof incorporates a security barrier structure (2/3/4) in accordance with any preceding claim.
16. A method of making a security barrier structure which is characterised by the steps of providing a corrugated planar element (2,2') of strong, heat-resistant metal and casting around that element (2,2') a matrix (3,3') consisting of, or containing elements (4) of, hard and refractory material, the corrugated element (2,2') being generally aligned with the plane of the barrier.
17. A method according to claim 16 wherein said corrugated element (2,2') is made by deforming a sheet or plate of the said metal or by casting the said metal in the molten state.
18. A method according to claim 16 or claim 17 wherein the structure has the characteristics of any one of claims 2 to 14.

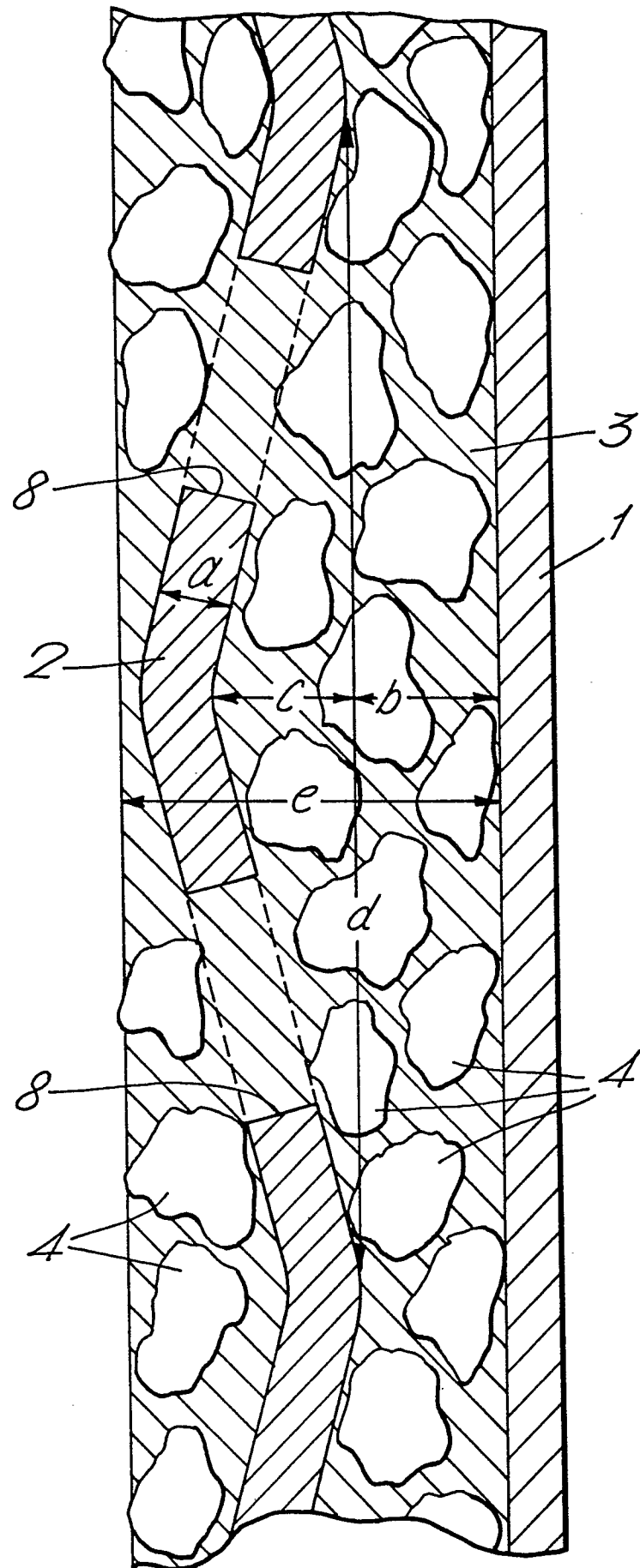


Fig. 1.

Fig.2.

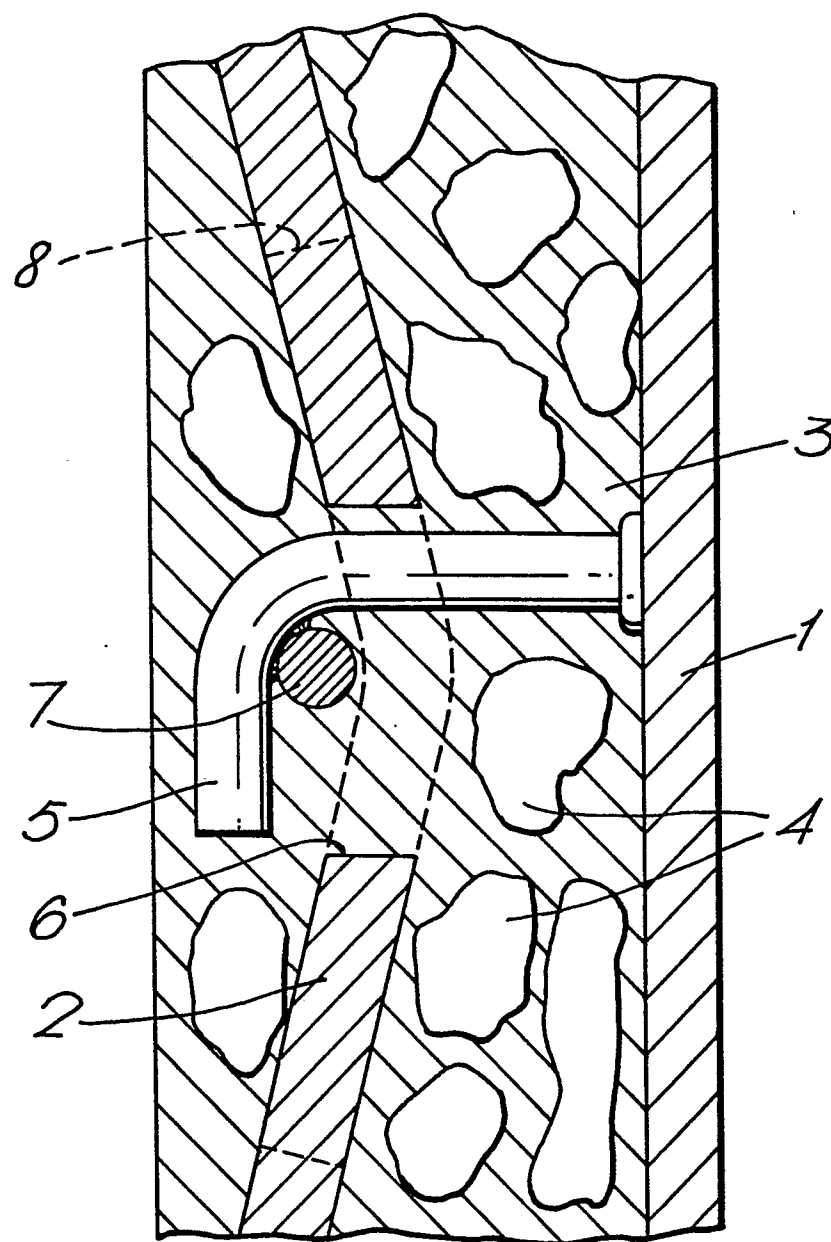


Fig.3.

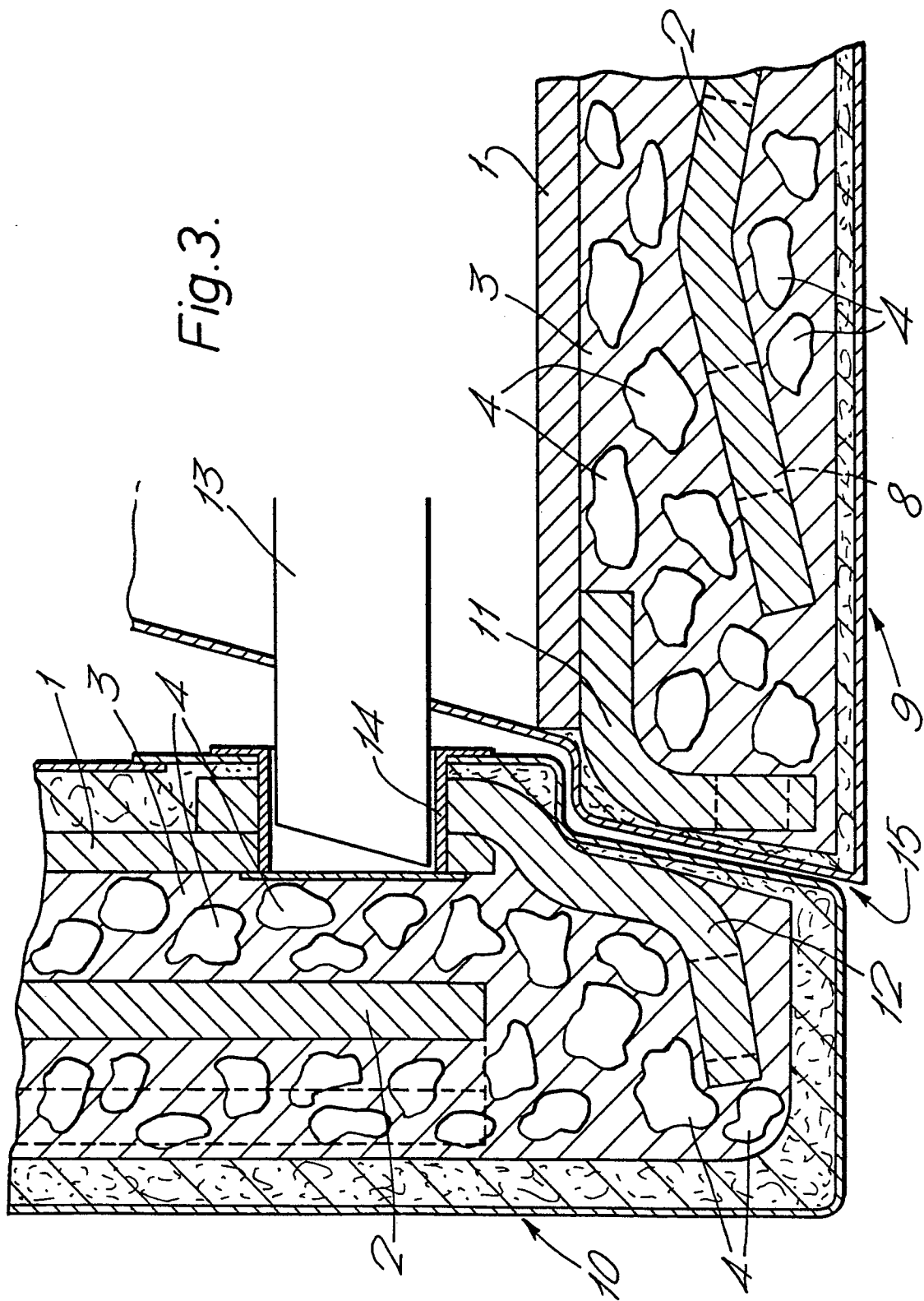


Fig.4.

