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

(11) Publication number: **0 689 028 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **94401389.5**

(51) Int. Cl.[6]: **F41H 5/007**

(22) Date of filing: **21.06.94**

(43) Date of publication of application:
27.12.95 Bulletin 95/52

(84) Designated Contracting States:
AT BE CH DE DK ES FR GB GR IE IT LI NL PT SE

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(54) Reactive armour effective against normal and skew attack

(57) An ad-on reactive armour element effective against normal and skew attack. The element is a multilayer composite body in which each layer tightly bears against each contiguous layer, which multilayer composite body comprises an outer cover (1), at least one explosive layer (2), at least one intermediary inert body (3) and a base plate (4), the intermediary layer or layers may be, for example, of aluminium, glass or ceramics.

The armour uses the effect of the dynamic collapse of the inert body (13): the explosion of the explosive layer (2) creates compressive stress within the inert body (3). That pressure closes the crater produced by the first part of the jet so that a new barrier is created for the following part of the jet.

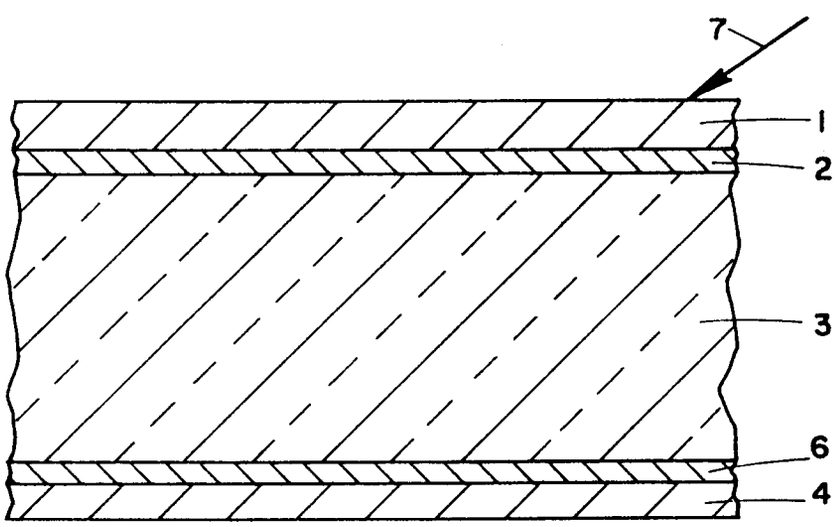

Fig.3

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BACKGROUND OF THE INVENTION AND PRIOR ART

The present invention concerns elements for making a protective reactive armour to be fitted on the outside of an enclosure liable to be exposed to attack by shaped-charge warheads and kinetic energy projectiles. Examples of enclosures protectable by a reactive armour made of elements according to the invention are land vehicles such as battle tanks, armoured personnel carriers, armoured fighting vehicles, armoured, self- propelled guns; armoured static structures such as buildings, above-ground portions of bunkers, container tanks for the storage of fuel and chemicals; etc. A reactive armour element according to the invention may be a basic type armour made integral with a conventional passive armour, or alternatively be of the add-on type.

Warheads with shaped-charge munition, also known as hollow charge munition, are known to pierce armour and thereby destroy the protected object from within. This capacity of a shaped charge results from the fact that upon detonation there forms an energy-rich jet also known as "thorn" or "spike" which advances at very high speed of several thousand meters per second and is thereby capable of piercing even relatively thick armour walls.

In US-A-4,368,660 there is described an arrangement which purports to afford protection against the penetrating effect of an exploding shaped charge. According to that proposal there is provided a continuous wall structure having an explosive layer sandwiched between two wall members of an inert material, e.g. a metal, and being so arranged that the axis of an impinging projectile and of the jet formed upon detonation, includes with the surface of the wall structure an acute angle of say 45°. According to the said U.S. patent, when a jet of a hollow charge warhead penetrates the upper surface of such a protective arrangement, it initiates the explosive layer and in consequence the walls thereof are thrown apart in opposite directions, both essentially normal to their surfaces. Thus one of the wall members moves in the direction of the protected substrate, while the other moves away and in consequence and due to the acute angle included between the jet and the wall member surfaces, the jet is successively intersected by different portions of the moving wall members with the consequence that the energy and mass of the jet are rapidly consumed whereby the jet is attenuated.

A similar arrangement is disclosed in GB-A-1,581,125 with the sole difference that in accordance with that disclosure the arrangement of the layer of explosive substance may optionally be covered only on one side by a layer of a non-combustible material.

An improved protective armour is disclosed by the present Applicants in their US-A-4,741,244 and the corresponding EP-B1-O 161,390. This improved protective armour is of the add-on type and consists of a plurality of elements each comprising a cover member having suspended therefrom on the side that faces the substrate at least one explosive insert comprising an explosive layer sandwiched between two metal plates such that when the element is mounted on a substrate the explosive insert remains distant therefrom.

All these prior art reactive armours are based on the mass and energy consuming effects of moving plates and their functioning is conditional on the existence of an acute angle between the jet of an oncoming hollow charge threat and the armour itself, since only in such a case the jet is attenuated by being successively intersected by different portions of the thrown-apart wall members of a hit protective element. Such an acute angle does however not always materialize, typical examples being the roof of an armoured land vehicle which is liable to be hit by a shaped charge projectile such as a cluster bomblet arriving normal or near-normal to the surface, i.e. at an angle of about 90° or close thereto, or bazooka plate liable to be hit by anti-armour warheads which may, i.a. arrive normal to such plates. In such an event conventional reactive armours do not perform their function and the jet generated by an oncoming shaped charge warhead is not significantly attenuated, if at all.

It has already been suggested to overcome this problem by mounting reactive armour elements on the roof or on bazooka plate armour askew with respect to the oncoming jet. However, such a solution is only of very little practical value, because the protection afforded in this way is limited to the case of shaped charge warheads arriving at a narrow range of angles at which the reactive armour is effective.

It is the object of the present invention to provide an element for a protective reactive armour that is suitable for affording protection against shaped charge warheads regardless of the angle of attack, including cases of normal or near-normal hits. It is a further object of the invention to provide an element of the kind specified that is also effective against armour piercing and kinetic energy projectiles.

SUMMARY OF THE INVENTION

In accordance with the invention there is provided an element for making a reactive armour, characterized by being a multilayer composite

body in which each layer tightly bears against each contiguous layer, which multilayer composite body comprises an outer cover, at least one explosive layer, at least one intermediary inert body and a base plate.

A reactive armour element according to the invention may be made integral with a basic armour element or alternatively be of the add-on type.

The invention further provides enclosures fitted with a reactive armour consisting of elements of the kind specified. Enclosures included within the scope of the present invention comprise armoured land vehicles such as battle tanks, armoured personnel carriers, armoured fighting vehicles, armoured, self- propelled guns; armoured marine vessels; armoured static structures such as container tanks for holding fuel and chemicals, armoured buildings and the like.

The protective effect of a reactive armour made of elements in accordance with the invention is based on a new concept by which the moving apart metal plates of conventional reactive armour are replaced by an inert body which functions by way of a so-called dynamic collapse. Thus, a jet generated by an oncoming shaped charge warhead initiates the explosive layer and in consequence a pressure builds up and acts on the inert intermediary body. Such pressure in combination with the action of the jet, sets into operation a chain of successive dynamic collapse cycles each consisting of a first phase at which a crater is produced in the inert intermediary body by the action of the penetrating jet, and a second phase at which said crater is re-closed in consequence of the said pressure. In the course of such succession of cycles the jet progresses across the inert intermediary body with each tailing jet portion encountering a re-closed portion of the body. In this way the mass and energy of the jet are successively consumed and the jet is thus attenuated, deviated and scattered.

As distinct from known reactive armour, the reactive armour according to the invention is highly effective regardless of the angle of attack of a jet produced by an oncoming hollow charge warhead, and thus affords protection also against hollow charge warheads that arrive normal or near-normal to the a reactive armour surface. Accordingly, a reactive armour fitted onto a static or movable enclosure may be made entirely of elements according to the invention. In the alternative, it is possible to produce a reactive armour from elements according to the invention only at those locations such as the roof or a bazooka plate of a battle tank where normal or near-normal hits are expected, and from conventional reactive armour elements at other locations where any shaped charge threat is expected to arrive at an acute angle.

If desired, it is possible to incorporate in the reactive armour element according to the invention one or more further explosive layer, e.g. between the intermediary body and the base plate and/or within the inert intermediary body so that the element actually comprises two inert intermediary bodies sandwiching between them an explosive layer.

Where in such an embodiment the reactive armour is spaced from the basic armour and a jet produced by an oncoming hollow charge warhead forms an acute angle with the armour surface, the base plate together with the overlaying explosive layer produce a conventional reactive effect additional to the dynamic collapse effect according to the invention, which is an added benefit.

An external fuel or water tank of a land vehicle or marine vessel may, when full, serve as an inert intermediary body in a reactive armour according to the invention. The same also applies to container tanks. Accordingly, by a further aspect of the invention there is also provided a method of furnishing reactive protection to a portion of a structure holding an inert body, comprising applying to the outer face of such structure a covered explosive layer. In this way there is formed in situ a composite body of the kind described hereinbefore.

One of the purposes of the outer cover in a reactive armour according to the invention, is to afford physical protection for the explosive layer. Accordingly the outer cover may optionally either be a metal plate similar to the base plate, such metal plate being instrumental in directing inward the pressure buildup resulting from initiation of the explosive layer; or simply a suitable weather-resistant material, e.g. sheet metal, plastic material, fiberglass and the like. In the latter case the cover does not direct the pressure inward and consequently the explosive layer may have to be thicker.

There are no critical limitations on the material of the intermediary body which may be solid or liquid, metallic, e.g. aluminium, or non-metallic, e.g. glass or a ceramic material. As a rule, such materials will be preferred which on the one hand produce a pronounced dynamic collapse effect, while on the other hand are relatively light so that the reactive armour should not add too much weight to the vehicle.

Where it is desired to provide protection also against armour piercing, kinetic energy projectiles or artillery fragmentations, the material of the intermediary body will be selected accordingly, a typical example being ceramics.

Due to the fact that there is no need for moving plates in the course of operation, reactive armour elements according to the invention need not be

spaced from the basic armour and may be mounted in close proximity thereto whereby the total armour volume is reduced. However, if desired the reactive armour according to the invention may be spaced from the basic armour.

A protective armour according to the invention has the further advantage that there hardly occur ally impacts upon the basic armour of the kind that are usually experienced with conventional protective armours and which are due to the fact that upon detonation the innermost of the two metal plates which between them hold the explosive layer, is hurled onto the main, passive armour of the vehicle. Thus in accordance with the invention the phenomena of spalling, deformation, mechanical shock and vibration, which characterize conventional reactive armour, are practically eliminated.

The invention also provides a method of protecting an enclosure against shaped charge warheads and optionally also against kinetic threats, wherein such enclosure is fitted on the outside with a reactive armour comprising elements of the kind specified.

DESCRIPTION OF THE DRAWINGS

For better understanding the invention will now be described, by way of example only, with reference to the enclosed drawings in which:

Fig. 1 is a fragmentary section across a reactive armour element according to the invention;

Figs. 2a -2d show diagrammatically various operational stages of a reactive armour element according to the invention;

Fig. 3 is a fragmentary section across another embodiment of a reactive armour according to the invention; and

Fig. 4 is a fragmentary section across yet another embodiment of a reactive armour according to the invention.

DESCRIPTION OF SPECIFIC EMBODIMENTS

The protective armour element shown in Fig. 1 is a multilayer body comprising an outer cover plate 1, e.g. of steel, an explosive layer 2, an intermediary inert body 3, e.g. of aluminium, and a base plate 4 which again may be of steel.

The various phases in the operation of a reactive armour element according to the invention are shown in Fig. 2. Fig. 2a shows a jet 5 produced by an oncoming shaped charge warhead and approaching the armour in a direction normal thereto.

In the operational phase shown in Fig. 2b, jet 5 has penetrated into the explosive layer 2 by which an explosion was initiated which resulted in a pressure build-up and exertion of pressure on the intermediary inert body 3, while cover plate 1 is thrown in the opposite direction. In that phase a front portion of jet 5 has already penetrated into inert body 3 and formed a crater therein.

In the operational phase of Fig. 2c, the initial crater in body 3 has closed in consequence of the external pressure resulting from the initiation of explosive layer 2, and two different openings 16, 17 which were successively formed, are shown. This signifies the chain of successive dynamic collapse cycles which occurs in the wake of jet 5 and which consists of rapid succession of openings by the action of jet 5 and reclosures by the action of the external pressure as specified. It is further shown in Fig. 2c that portion of jet 5 which is already within body 3 is deviated, scattered and attenuated.

In the operational phase shown in Fig. 2d, the dynamic collapse effect is in its final stage while the scattered and attenuated segments 18 of the jet have perforated bottom plate 4.

The embodiment of a reactive armour element according to the invention shown in Fig. 3 is basically similar to that of Fig. 1 with the addition, however, of a second explosive layer 6 which is sandwiched between inert body 3 and base plate 4. This addition improves performance in particular in cases of threats that arrive at an acute angle, such as threat 7 in Fig. 3.

If desired the inert body 3 may consist of two or more strata of different inert materials.

In the embodiment of a reactive armour element of Fig. 4 yet another explosive layer is provided. As shown this embodiment comprises a cover plate 8, a first explosive layer 9, a first intermediary body 10 and a second intermediary body 11 which sandwich between them a second explosive layer 12. Intermediary bodies 10 and 11 may be of the same material or of different materials. Underneath body 11 there is provided a third explosive layer 13 and then there follow a baseplate 14.

Claims

1. An element for making a reactive armour, characterized by being a multilayer composite body in which each layer tightly bears against each contiguous layer, which multilayer composite body comprises an outer cover (1), at least one explosive layer (2), at least one intermediary inert body (3) and a base plate (4).

2. An element according to Claim 1 being integral with a basic armour element (14).

3. An element according to Claim 1 being of the add-on type.

4. An element according to any one of Claims 1 to 3 comprising a second explosive layer (6) between the intermediary inert body (3) and base plate (4).

5. An element according to any one of Claims 1 to 4 comprising a third explosive layer (12) sandwiched between two intermediary inert bodies (10,11).

6. An element according to any one of Claims 1 to 5, characterized in that said at least one inert intermediary body is of a single material.

7. An element according to any one of Claims 1 to 5, characterized in that said at least one inert intermediary body comprises two or more strata of different materials.

8. An enclosure fitted with a reactive armour elements according to any one of Claims 1 to 7.

9. An enclosure according to Claim 8 being an armoured land vehicle.

10. An armoured land vehicle according to Claim 9 being a battle tank.

11. An armoured land vehicle according to Claim 10 being a personnel carrier or an armoured fighting vehicle.

12. An armoured land vehicle according to Claim 11 being an armoured, self-propelled gun.

13. An enclosure according to Claim 8 being a marine vessel.

14. An enclosure according to Claim 8 being a container tank.

15. An enclosure according to Claim 8 being a building.

16. A method of protecting an enclosure against shaped charge warheads and optionally against kinetic threats, characterized by fitting the enclosure on the outside with a reactive armour made of elements according to any one of Claims 1 to 7.

17. A modification of the method according to Claim 16, characterized by applying to the outside of an inert body contained within said enclosure a covered explosive layer.

18. A method according to Claim 17 wherein the enclosure is a land vehicle or marine vessel and characterized in that a covered explosive layer is applied to the outside of a liquid holding compartment.

19. A method according to Claim 18, characterized in that said compartment holds fuel.

20. A method according to Claim 18, characterized in that said compartment holds water.

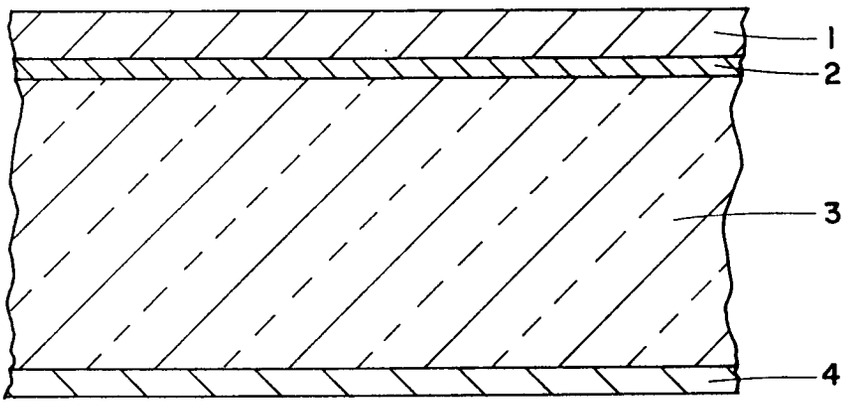


Fig.1

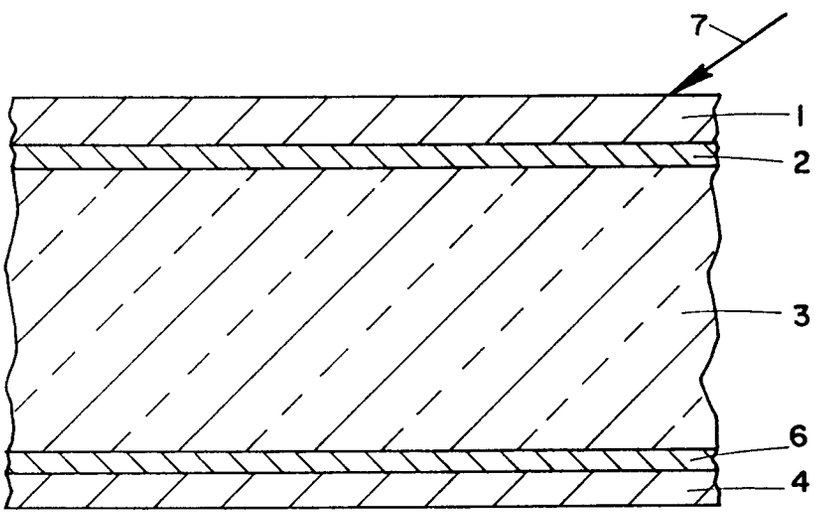


Fig.3

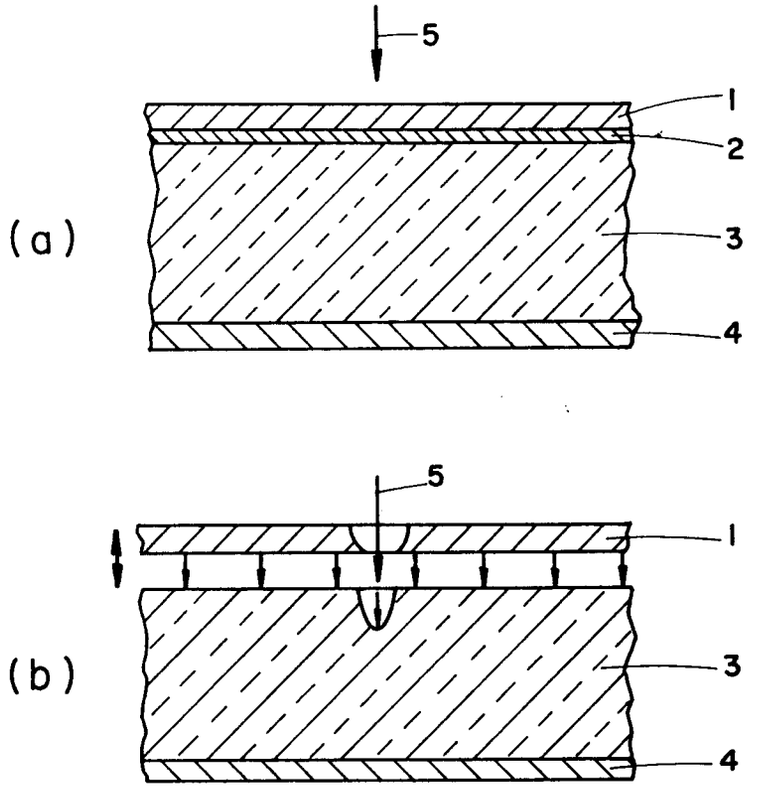
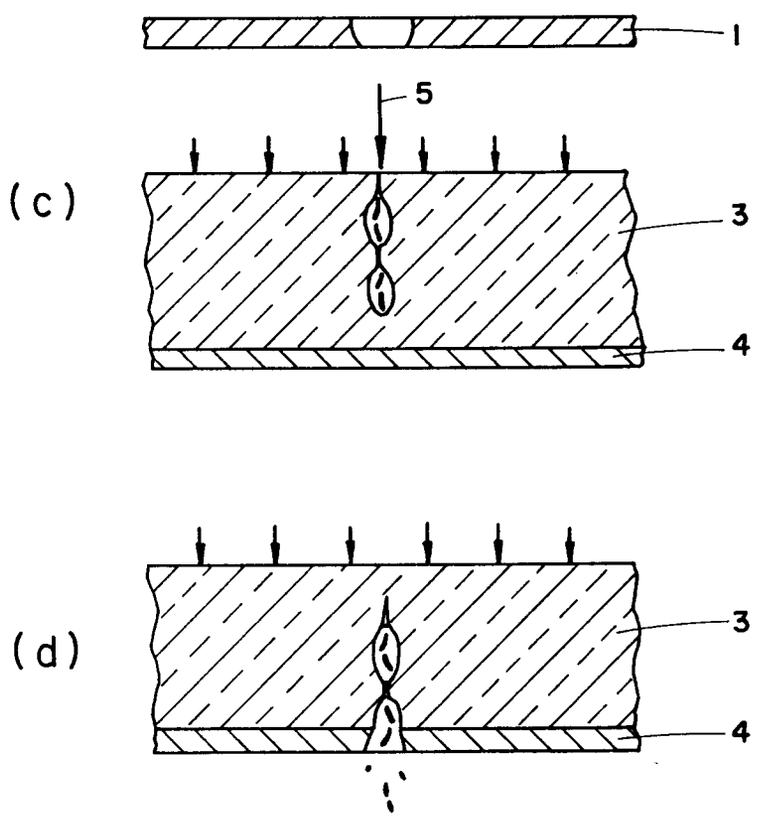


Fig. 2



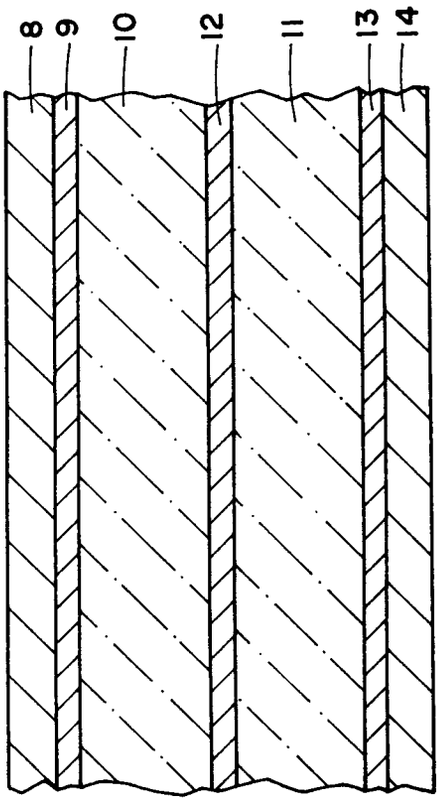


Fig. 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 40 1389

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.6)
X	FR-A-2 632 059 (ETAT FRANÇAIS) * page 2, line 1-18; figures 1-4 * * page 3, line 13 - page 4, line 7 * * page 4, line 21 - page 5, line 10 * * page 6, line 7-35 *	1-17	F41H5/007
X	GB-A-2 191 277 (ROYAL ORDNANCE) * page 1, line 108 - page 2, line 52; figure 1 *	1-3,6-17	
A	DE-A-20 31 658 (KRAUSS-MAFFEI)	1-5,7	
A	GB-A-2 191 276 (ROYAL ORDNANCE)		
A	WO-A-87 05994 (AFFÄRSVERKET FFV)		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

F41H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10 August 1994	Van der Plas, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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