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(54) **Ballistic armour composites.**

(57) A rigid ballistic armour composite (10) which comprises fibre reinforcement in a polymer matrix includes (a) adjacent the back face, a layer (12) containing magnesium aluminosilicate glass fibres fibres in a matrix of a first polymer, and, laminated thereto, (b) adjacent the strike face, a layer (11) containing reinforcing fibres in a matrix of a second polymer, the layer adjacent the strike face having a lower penetration resistance than the layer adjacent the back face. The reinforcing fibres are preferably calcium aluminoborosilicate glass fibres, aliphatic polyamide fibres or aromatic polyester fibres.

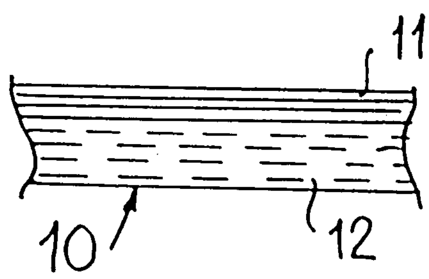

FIG.1

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This invention relates to ballistic armour composites, that is to say rigid composites which comprise reinforcing fibre or fabrics embedded in a polymer matrix.

Polymer composites are gaining importance in ballistic protection for military and civilian personnel, due mainly to the high strength, stiffness, and elongation provided by man-made fibres. Such composites offer many advantages over metal armour, including high durability, light weight and low maintenance costs.

Various composites have been proposed in the past for use in ballistic protection. A commonly used composite comprises a laminated structure consisting of woven or knitted glass fibre structures embedded in various types of polymer matrices such as, for example, epoxy resin, polyester resin and phenolic resin. In the main, prior known composites have comprised a single type of glass fibre as the reinforcement embedded in one or more polymer matrices.

The glass fibre most commonly used for general reinforcement has been that known as E-glass, which is a family of glasses with a calcium aluminoborosilicate composition and a maximum alkali content of 2%. E-glasses are used as a general purpose reinforcement when strength and high electrical resistivity are required. Second types of glass commonly used are that known as S-glass and that known as R-glass. These are a family of glasses which have a magnesium aluminosilicate composition. S-glasses (produced by Owens-Corning Fiberglas Corp.) and R-glasses (produced by Vetrotex Inc) demonstrate higher strength than E-glasses and are therefore used in applications where very high tensile strength is required. R-glass, S-glass and so-called S2-glass fibres have broadly similar glass compositions but have different coatings applied to them. More stringent quality control procedures are necessary with R-glass and S-glass than with E-glasses to meet military specifications, therefore R-glass and S-glass are far more expensive than the E-glasses.

The ballistic performance of various composites may be tested and compared in many different ways. One convenient way, for example, is to fire a known sized projectile at samples of the composite and to record the velocity at which theoretically, 50% of the projectiles penetrate the composite and the other 50% are stopped by the composite. This velocity is often referred to as the V_{50} velocity.

If one carries out ballistic performance tests on a composite comprising solely E-glass fibres embedded in, for example, a phenolic resin, one obtains a much lower V_{50} velocity than one would achieve with a composite made using S2-glass fibres embedded in the same matrix.

The design of ballistic armour is a compromise between the weight, cost, ballistic performance and thickness of the composite, in relation to what the perceived threat is likely to be. In other words, if the threat is likely to be from small arms munitions, then one type of composite may be more suited than another, but if the perceived threat is from for example, artillery shell fragments, then different composites may be more suited than those used for the small arms threat.

Reference to the Articles in International Defense Review July 1, 1989 page 969, Vol.22, No.7 and Jane's Defence Weekly February 6, 1988, page 230, Vol.9, No.5 suggest that the tendency has been to design composite ballistic armour using 100% S2-glass reinforcement instead of the E-glass reinforcement, because of its better ballistic performance, even though the costs are considerably higher. There is therefore a need to produce a composite with at least the same (or nearly the same) ballistic performance as S2-glass, but at a very much more reduced cost.

An object of the present invention is to provide a novel composite ballistic armour which has a similar ballistic performance to that of S2-glass reinforced composites.

US Patent 2,697,054 (Dietz et al.) describes ballistic composites in which the substances with the greatest resistance to punching shear forces (that is, the better structural properties) are placed on the impact side and the substances which have the greatest properties of tensile strength and elongation (that is, the better ballistic properties) are placed towards the back side. Examples of fibres for use in such composites include nylon, Fortisan (Trade Mark) (saponified cellulose acetate) and spun glass. Different types of nylon may be employed in gradation from fully-drawn nylon on the impact side to undrawn nylon on the inner side.

According to the invention there is provided a rigid ballistic armour composite which comprises fibre reinforcement in a polymer matrix, and which is characterised in that it includes (a) adjacent the back face, a layer containing magnesium aluminosilicate glass fibres in a matrix of a first polymer, and, laminated thereto, (b) adjacent the strike face, a layer containing reinforcing fibres in a matrix of a second polymer, the layer adjacent the strike face having a lower penetration resistance than the layer adjacent the back face. The composites of the invention are asymmetric composites.

Preferably the reinforcing fibres are of calcium aluminoborosilicate glass, although the reinforcing fibres may be selected from the group of polymer materials consisting of: aliphatic polyamide (e.g Nylon 6,6) and aromatic polyester (e.g. poly(ethylene terephthalate)).

Preferably the calcium aluminoborosilicate glass reinforcement is that known as E-glass with an alkali content of less than 2%. Preferably the magnesium aluminosilicate glass reinforcement is that known as S-glass or R-glass. Further preferably the S-glass is that known as S2-glass.

The first and second polymers may be the same polymer material or may be different polymer materials. Each such polymer is preferably selected from the group of polymer materials consisting of the following: phenolic resins, polyester resins, epoxy resins, vinylester resins, polyetheretherketones (PEEK), polyethersulphones (PES), polysulphones, polyetherimides (PEI), polyarylketones (PAK), polyethylene (PE), polypropylene, polycarbonates, polystyrene and polyacrylates.

Whilst the preferred form of fibrous reinforcement in both the layers is a fabric (woven, non-woven or knitted), the fibrous reinforcement may comprise one or more layers of fibres, yarns or threads disposed unidirectionally or multidirectionally.

A composite according to the invention may conveniently be made by lamination of prepregs, that is to say fibre plies impregnated with thermosetting or thermoplastic polymer resin. The areal weight of a prepreg containing a glass fibre fabric is preferably in the range 500 to 1500 grams per square metre. The areal weight of a prepreg containing a synthetic polymer fibre fabric such as an aliphatic polyamide or aromatic polyester is preferably in the range 100 to 400 grams per square metre.

Of the total fibre reinforcement in the composite, the reinforcing fibre in the layer adjacent the strike face may amount to about 20 to about 80 percent, preferably about 20 to about 50 percent, by weight, and the magnesium aluminosilicate glass fibre in the backing layer may correspondingly be about 80 to about 20 percent, preferably about 80 to about 50 percent, by weight.

A composite according to the invention may additionally be provided with a ceramic layer on the strike face.

The areal weight of a composite according to the invention may be in the range 1 to 100 kilograms per square metre. For vehicle protection, the areal weight is preferably in the range 20 to 80 kilograms per square metre. When used for vehicle protection, a composite according to the invention may be used in the manufacture of the vehicle body itself or as a lining inside a conventional vehicle body to prevent injury from spalled fragments. Composites with a ceramic strike face may be preferred in this end-use. For use in personal protection armour, the areal weight is preferably in the range 4 to 20 kilograms per square metre. When used for personal protection, a composite according to the invention may be incorporated as rigid inserts or tiles in pockets in a garment.

The invention further provides a method of making a rigid ballistic armour composite including the steps of:

(1) providing a first prepreg which consists of a ply of magnesium aluminosilicate glass fibres impregnated with a first polymer;
(2) stacking a plurality of the first prepregs to form a stacked backing layer;
(3) providing a second prepreg which consists of a ply of reinforcing fibres impregnated with a second polymer;
(4) stacking a plurality of the second prepregs to form a stacked facing layer;
(5) stacking the stacked facing layer upon the stacked backing layer to form a stacked body; and
(6) subjecting the stacked body to heat and pressure thereby forming the rigid ballistic armour composite wherein the facing layer has a lower penetration resistance than the backing layer.

The invention further provides a method of making a rigid ballistic armour composite including the steps of:

(1) providing a first prepreg which consists of a ply of magnesium aluminosilicate glass fibres impregnated with a first polymer;
(2) stacking a plurality of the first prepregs to form a stacked backing layer;
(3) subjecting the stacked backing layer to heat and pressure thereby forming a backing laminate;
(4) providing a second prepreg which consists of a ply of reinforcing fibres impregnated with a second polymer;
(5) stacking a plurality of the second prepregs to form a stacked facing layer;
(6) subjecting the stacked facing layer to heat and pressure thereby forming a facing laminate; and
(7) adhering the facing laminate to the backing laminate by means of an adhesive thereby forming the rigid ballistic armour composite wherein the facing layer has a lower penetration resistance than the backing layer.

Suitable types of adhesive are known in the art, for example polysulphide adhesives.

Composites in accordance with the invention are especially suitable for use in ballistic armour intended for protection against bullets and the type of material represented by 1.1 gram fragment-simulating projectiles.

It has surprisingly been found that the ballistic performance of composites in accordance with the invention is markedly superior to that of composites which have magnesium aluminosilicate glass fibre reinforcement in the strike face layer and reinforcing fibres such as polyamide [6,6] or E-glass fibre in the backing layer. One would expect at first sight that better properties would be obtained by placing the fibrous reinforcement of superior ballistic properties in the strike face layer and that of inferior ballistic properties in the backing layer.

The present invention will now be further described, by way of example, with reference to the accompanying drawings in which:-

Figures 1 and 2 show schematically the cross section through two ballistic armour composites constructed in accordance with the present invention, and

Figures 3 and 4 show, respectively, the ballistic performance of the composites shown in Figures 1 and 2.

Referring to Figure 1, a composite constructed in accordance with the present invention comprises a unitary rigid composite 10 comprising two portions 11 and 12. First portion 11 defines the strike face of the composite (that is to say the strike face is the surface which would normally face towards projectiles directed at the composite), and the portion 12 defines a backing portion.

The first portion 11 comprises a stack of glass fibre fabrics (plies) made from E-glass which are pre-impregnated with phenolic resin (i.e. a "prepreg"). The backing portion 12 comprises a stack of S2-glass fabric plies or layers pre-impregnated with phenolic resin. An integral body is formed by laying up the layers 12 on to the back of portion 11 and compression moulding the pre-impregnated layers in portions 11 and 12 to form a unitary body. The method of moulding is conventional and is carried out to allow out-gassing and to achieve consolidation.

The glass fabric prepregs comprised 18±2% by weight of phenolic resin to give a prepreg, prior to consolidation, of 1012 g/m^2 nominal areal weight. A suitable phenolic resin is that manufactured by Borden (UK) Limited under reference No. SC1008P, or that formulated by Courtaulds Aerospace Limited under their reference PH16. The latter of these is a polyvinylbutyral modified phenolic resin.

A typical E-glass composition comprises by weight 52 to 56% silica, 12 to 16% alumina, 16 to 25% calcium oxide, 0 to 5% magnesia, 5 to 10% boron oxide, 0 to 2% sodium oxide, and 0 to 1-5% total of minor oxides, and has an alkali content of less than 2%. Such E-glasses have a Youngs Modulus of Elasticity of approximately 70 to 85 GPa at 20°C (68°F) and an elongation of the order of 3 to 5%. A preferred E-glass is that manufactured by PPG Industries under yarn reference ECR 1472 (2300 tex) with filament diameter K (12-13 micron). This yarn is precoated by the manufacturer with an epoxy compatible size.

The preferred form of the reinforcement is that of a woven fabric comprising a plain weave (manufactured by Courtaulds Aerospace Limited under the reference code Y0224). This fabric comprises 1.97 ends/cm by 1.57 picks/cm with a nominal areal weight of 830 g/m^2. No additional fibre finish was applied during weaving. E-glass fibres of the order of 2-32 micron diameter can be woven to make suitable fabrics having 1-15 picks/cm and 1-15 ends/cm. The E-glass fibre is preferably precoated with a size compatible with the matrix material. Suitable sizes comprise a silane or a thermoplastic or starch oil to achieve a suitable adhesive bonding between the fibres and the polymer matrix.

Typical S2-glass fibres have a composition by weight of 64% silica, 25% alumina, 10% magnesia, 0.3% sodium oxide, and 0.7% total of other minor oxides. Such S2-glasses have a Youngs Modulus of Elasticity of approximately 80 to 95 GPa at 20°C (68°F) and an elongation of 3 to 7%. A preferred S-glass is an S2-glass manufactured by Owens-Corning Fiberglas Corp. under yarn reference 463 AA-250 (nominal 244 yds/lb (1984 tex)). This yarn has filament size G (9 micron) and is coated by the manufacturer with an epoxy compatible size which has the manufacturer's code reference 463. The yarn was woven by Courtaulds Aerospace Limited to give a fabric (Ref.Y0554) comprising 1.96 ends/cm by 1.97 picks/cm plain weave. The fabric had a nominal areal weight of 830 g/m^2. No additional fibre finish was applied during weaving.

From Figure 1 it will be seen that the ballistic armour composite 10 comprises a first portion 11 providing the strike face which portion has a lower ballistic performance than that of the S2-glass reinforced backing portion 12. Normally this is the reverse of what one would expect in order to achieve an optimum ballistic performance. Normally one would expect to use the high performance material at the strike face and to back the high performance material with a lower performance material on the basis that the lower performance material will arrest any projectile or fragments which manage to get through the high performance material. However, we have surprisingly found that by reversing the positions of the high performance and low performance materials, we can achieve a ballistic performance far better than that achieved with the S2-glass at the first portion 11 defining the strike face and the lower performance ballistic material in the backing portion 12.

Fragment V_{50} testing was carried out in accordance with the UK Specification UK/SC/4697 using 1.1 g fragment-simulating projectiles. Bullet V_{50} testing was carried out in accordance with UK/SC/4697 except that 5.56 mm calibre FN SS92 rounds were used instead of fragments, and only two complete penetrations and two partial penetrations of each target over a velocity range of 40 m/s were used to calculate V_{50} values.

Referring to Figure 3, the fragment V_{50} velocities (in metres per second) for a composite having an areal weight of approximately 8 kg/m^2 are plotted against the percentage by weight in the fibrous reinforcement of S2-glass (the balance of the fibre being E-glass) in the total thickness of the composite. The line of the curve E represents the V_{50} velocities for a composite constructed in accordance with the present invention with the

E-glass at the strike face. The line S represents the V_{50} velocities for a composite not according to the invention in which the S2-glass is placed at the strike face and is backed by a layer which includes the E-glass reinforcement.

From Figure 3 it will be seen, for example, that in a composite where 50% of the total glass content is E-glass adjacent the strike face, the fragment V_{50} velocity is of the order of 400 metres per second, whereas for the same composite reversed so that the S2 reinforced layer is at the strike surface, the fragment V_{50} velocity is of the order of 350 metres per second. In Figure 3 the data represented by the cross, (I), is the V_{50} velocity for a composite (not according to the invention) which comprised alternate layers of E-glass reinforced phenolic resin and S2-glass reinforced phenolic resin (the reinforcement in the composite comprising approximately 50% S2-glass and 50% E-glass). It can be seen that the composites of the invention had superior ballistic properties to this comparative example.

The 5.56 mm bullet V_{50} data for a composite of the type shown in Figure 1 having an areal weight of 22.6±0.4 kg/m^2 is shown in Table 1.

Table 1

S2-glass/E-glass			
S2-glass (%wt)	E-glass (%wt)	Strikeface	V_{50} (m/s)
100	-	S2-glass	691
74	26	E-glass	691
49	51	E-glass	670

It can be seen that the composite which contained 26% E-glass had the same V_{50} as the one containing 0% E-glass. The composite containing 51% E-glass had a lower but nevertheless acceptable V_{50}.

Referring now to Figure 2 there is shown a second composite 20 which comprises the same S2-glass reinforced phenolic backing layer 22 as that used at 12 in the composite 10 of Figure 1. In the Figure 2 composite, a strike portion 21 comprises fabrics which are woven from aliphatic polyamide fibres such as nylon 6,6 embedded in a phenolic resin matrix. Here again the prepregs for both portions 21 and 22 are laid up in a mould and compression moulded to form a rigid composite.

The nylon prepreg comprised 18±2% by weight of phenolic resin, to give a prepreg, prior to consolidation, of 317 g/m^2 nominal areal weight. A nylon 6,6 yarn (made by ICI Limited under ICI reference T1142) was used for the warp threads of the prepreg. This yarn was 940 decitex, and comprised 140 filaments. For the weft yarn, an ICI yarn reference T126 was used. This yarn was 950 decitex, and also comprised 140 filaments. The approximate filament diameter of both yarns was 27 micron. The yarns were woven by Courtaulds Aerospace Limited (their ref. D0594) to produce a woven fabric comprising 13.7 ends/cm and 13.0 picks/cm having a nominal areal weight of 260 g/m^2. The fabric was scoured after weaving.

The ballistic performance of the composite shown in Figure 2 is shown in Figure 4.

Referring to Figure 4, the ballistic performance of the composite 20 of Figure 2 is shown by the line of the curve N which is a plot of the fragment V_{50} velocity against percentage of S2-glass in the total composite. The line of the curve S shows the ballistic performance of composites not according to the invention with the S2-glass reinforcement at the strike face and the nylon reinforcement at the back face. One significant result which we have found is that the composite which contains 25% of the total reinforcement as nylon reinforcement at the strike face and 75% S2-glass reinforcement in the backing portion 22 has a similar ballistic performance to a composite having S2-glass as the sole reinforcement fibre. Furthermore, Figure 4 shows that the ballistic performance of the composite with nylon at the strike face is far better than if the composite is reversed and the S2-glass is employed at the strike face. Again on Figure 4 the cross, (I), represents the data for a composite comprising interleaved equal mass of alternate layers of nylon reinforcement and S2-glass reinforcement in a phenolic resin matrix, which again had inferior ballistic properties to the composites of the invention.

In the above examples the polymer matrix is the same in the strike face and backing portions, and the preferred material is phenolic resin. If desired the matrix of the backing portion may be different from that of the first portion defining the strike face. It is believed that similar advantages of ballistic performance as demonstrated above can be achieved with other matrix materials. The matrices may be selected from one or more of the following group of polymer materials, namely: phenolic resins, polyester resins, epoxy resins, vinylester resins, polyetheretherketones (PEEK), polyethersulphones (PES), polysulphones, polyetherimides (PEI), polyarylketones (PAK), polyethylene (PE), polypropylene, polycarbonates, polystyrene and polyacrylates.

In the above examples E-glass or nylon has been used in the strike face portion. It is to be understood that reinforcement made of other types of fibres may be used in the strike face portion. For example, an aromatic polyester (e.g. poly(ethylene terephthalate)) may be used.

The preferred form of the reinforcement is a woven fabric. However, the reinforcement may be a knitted or nonwoven fabric. Furthermore, each prepreg layer could be in the form of unidirectional or multi-directional fibres. Indeed each prepreg could comprise a plurality of layers of fabric, unidirectional fibres or multi-directional fibres. The unidirectional fibres in one layer may lie at an angle to those in adjacent layers. The lay up of such reinforcements is well known in the art of making composite materials.

Claims

1. A rigid ballistic armour composite which comprises fibre reinforcement in a polymer matrix, characterised in that it includes (a) adjacent the back face, a layer (12) containing magnesium aluminosilicate glass fibres in a matrix of a first polymer, and, laminated thereto, (b) adjacent the strike face, a layer (11) containing reinforcing fibres in a matrix of a second polymer, the layer adjacent the strike face having a lower penetration resistance than the layer adjacent the back face.

2. A composite according to claim 1, characterised in that the magnesium aluminosilicate fibres are S-glass, S2-glass or R-glass fibres.

3. A composite according to claim 1, characterised in that the reinforcing fibres are calcium aluminoborosilicate glass fibres.

4. A composite according to claim 3, characterised in that the calcium aluminoborosilicate glass fibres are E-glass fibres.

5. A composite according to claim 1, characterised in that the reinforcing fibres are aliphatic polyamide fibres or aromatic polyester fibres.

6. A composite according to claim 5, characterised in that the reinforcing fibres are polyamide [6,6] fibres.

7. A composite according to any preceding claim, characterised in that the first polymer and the second polymer are the same material.

8. A composite according to any of claims 1 to 6, characterised in that the first polymer and the second polymer are different materials.

9. A composite according to any preceding claim, characterised in that the first and second polymers are each selected from the group consisting of phenolic resins, polyester resins, epoxy resins, vinylester resins, polyetheretherketones (PEEK), polyethersulphones (PES), polysulphones, polyetherimides (PEI), polyarylketones (PAK), polyethylene (PE), polypropylene, polycarbonates, polystyrene and polyacrylates.

10. A composite according to any preceding claim, characterised in that layer (a) contains a plurality of plies of the magnesium aluminosilicate glass fibres.

11. A composite according to claim 10, characterised in that the plies of magnesium aluminosilicate glass fibres comprise woven, knitted or non-woven fabrics.

12. A composite according to claim 10 or claim 11, characterised in that the areal weight of each such ply together with the matrix of first polymer associated therewith is in the range 500 to 1500 grams per square metre.

13. A composite according to any preceding claim, characterised in that layer (b) contains a plurality of plies of the reinforcing fibres.

14. A composite according to claim 13, characterised in that the plies of reinforcing fibres comprise woven, knitted or non-woven fabrics.

15. A composite according to claim 13 or claim 14 as dependent on claim 3 or claim 4, characterised in that

the areal weight of each such ply of reinforcing fibres together with the matrix of the second polymer associated therewith is in the range 500 to 1500 grams per square metre.

16. A composite according to claim 13 or claim 14 as dependent on claim 5 or claim 6, characterised in that the areal weight of each such ply of reinforcing fibres together with the matrix of the second polymer associated therewith is in the range 100 to 400 grams per square metre.

17. A composite according to any preceding claim, characterised in that its areal weight is in the range 1 to 100 kilograms per square metre.

18. A composite according to claim 17, characterised in that its areal weight is in the range 20 to 80 kilograms per square metre.

19. A composite according to claim 17, characterised in that its areal weight is in the range 4 to 20 kilograms per square metre.

20. A composite according to any preceding claim, characterised in that it additionally comprises a ceramic layer upon the strike face.

21. A method of making a rigid ballistic armour composite including the steps of:
(1) providing a first prepreg which consists of a ply of magnesium aluminosilicate fibres impregnated with a first polymer;
(2) stacking a plurality of the first prepregs to form a stacked backing layer (12,22);
(3) providing a second prepreg which consists of a ply of reinforcing fibres impregnated with a second polymer;
(4) stacking a plurality of the second prepregs to form a stacked facing layer (11,21);
(5) stacking the stacked facing layer upon the stacked backing layer to form a stacked body; and
(6) subjecting the stacked body to heat and pressure thereby forming the rigid ballistic armour composite wherein the facing layer has a lower penetration resistance than the backing layer.

22. A method of making a rigid ballistic armour composite including the steps of:
providing a first prepreg which consists of a ply of magnesium aluminosilicate glass fibres impregnated with a first polymer;
stacking a plurality of the first prepregs to form a stacked backing layer;
subjecting the stacked backing layer to heat and pressure thereby forming a backing laminate (12, 22);
providing a second prepreg which consists of a ply of reinforcing fibres impregnated with a second polymer;
stacking a plurality of the second prepregs to form a stacked facing layer;
subjecting the stacked facing layer to heat and pressure thereby forming a facing laminate (11, 21); and
adhering the facing laminate to the backing laminate by means of an adhesive thereby forming the rigid ballistic armour composite wherein the facing layer has a lower penetration resistance than the backing layer.

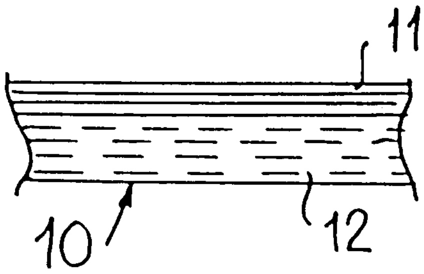

FIG.1

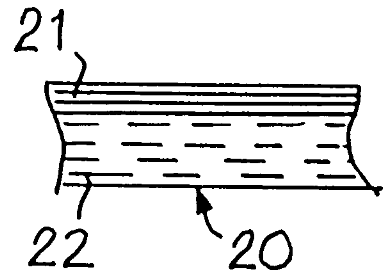

FIG.2

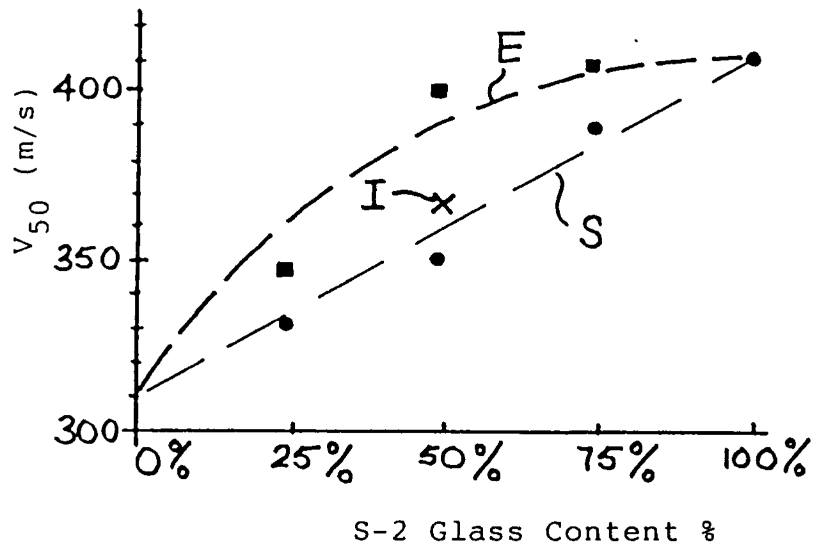

FIG.3

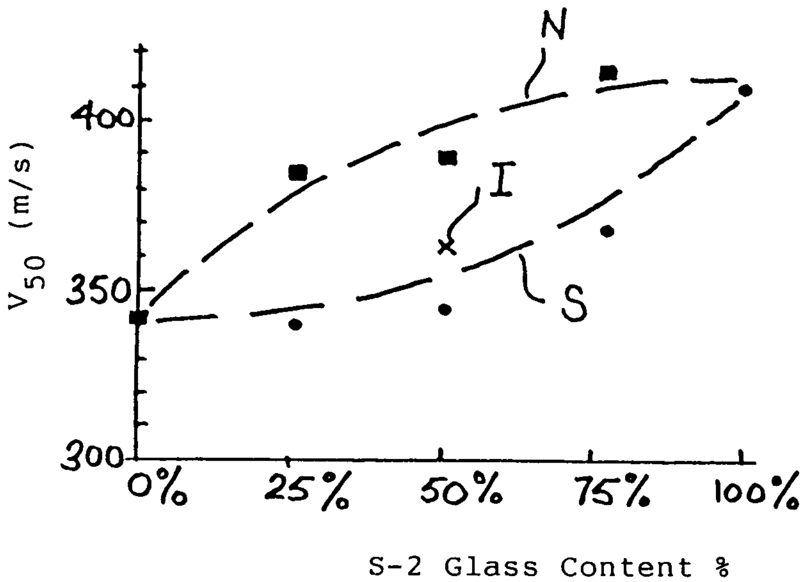

FIG.4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 30 2402

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)
Y	FR-A-2 398 607 (CONCEPCION VALLCORBA TURA) * page 2, line 20 - page 3, line 38 * * page 5 * ---	1-22	F41H5/04
Y	WO-A-89 01124 (OWENS-CORNING FIBERGLAS CORPORATION) * abstract * * page 5, line 7 - line 37 * ---	1-22	
A	WO-A-92 08095 (ALLIED-SIGNAL INC.) * page 10, line 23 - page 16, line 17 * * page 34, line 31 - line 38 * ---	1-22	
A,D	INTERNAT. DEFENCE REVIEW, vol.22, no.7, 1 July 1989 pages 969 - 970 OGORKIEWICZ 'Armoured vehicles of composite materials' ---	1-22	
A,D	JANE'S DEFENCE WEEKLY, vol.9, no.5, 6 February 1988 pages 230 - 232 'Latest developments in main battle tank armour' ---		TECHNICAL FIELDS SEARCHED (Int.Cl.5) F41H
A,D	US-A-2 697 054 (DIETZ & MOONEY) -----		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	3 August 1994	Olsson, B

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
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