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Europäisches Patentamt
European Patent Office
Office européen des brevets

11

Publication number:

**0 188 747
A1**

12

EUROPEAN PATENT APPLICATION

21

Application number: 85115994.7

51

Int. Cl.⁴: F41H 1/04

22

Date of filing: 14.12.85

30

Priority: 23.01.85 IT 1921085

43

Date of publication of application:
30.07.86 Bulletin 86/31

84

Designated Contracting States:
AT BE CH DE FR GB LI LU NL SE

71

Applicant: NOLSA S.r.l.
Via Alberto da Giussano, 15
I-20145 Milano (MI)(IT)

72

Inventor: Nocchi, Marzio
c/o NOLAN S.p.A. Via Capitani di Mozzo 12/16
I-24030 Mozzo BG(IT)
Inventor: Cappa, Arnaldo
c/o LASAR Via Firenze
I-22079 Civello di Villaguardia CO(IT)
Inventor: Argentiero, Pietro
c/o TEXINDUSTRIA SPA Via Firenze
I-22079 Civello di Villaguardia CO(IT)

74

Representative: Ferri, Antonio et al
c/o BREVETTI EUROPA S.r.l. Piazza Bernini 6
I-20133 Milano(IT)

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Caps of composite material for personal protection, such as helmets and the like.

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Shaped cap made of composite material for personal protection, such as helmets and the like, comprising an outer shell of metal material, superimposed onto an inner shell constituted by a fibrous material impregnated with synthetic resin, said two shells being solidly linked to each other by means of a layer of polymeric material interposed between the same shells.

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"CAPS OF COMPOSITE MATERIAL FOR PERSONAL PROTECTION, SUCH AS HELMETS AND THE LIKE"

Field of the invention

The present invention relates to caps made of composite material for personal protection, such as helmets and the like, and more particularly to a composite helmet provided with high resistance to impact energy absorption, as well as with improved properties of resistance to penetration by projectiles, splinters and the like.

Description of the prior art

It is known that ballistic protective helmets (hereinafter also simply denominated as "helmets") are constituted by steel or other metal material. Such helmets have a limit of ballistic protection "V₅₀" of the order of magnitude of 1000-1200 feet/s (i.e., of about 305-366 m/s), wherein V₅₀ is the average of speeds measured for 10 impacts (projectile caliber 0.22, type 2), comprising the five lowest speeds for which the complete projectile penetration occurs, and the five highest speeds for which a partial penetration of projectile occurs, according to known MIL-STD-662B/1971 and MIL-P-46593A(ORD)/1962 (U.S.A.) standards, to which standards reference shall be made in the following disclosure when reference to ballistic characteristics and tests shall be made.

It is known that metal helmets show the drawback of being heavy (relatively to their ballistic characteristics), as well as of being good heat conductors, hence uncomfortable when same helmets are to be borne over long time periods in very hot or very cold places.

Head coverings and helmets also exist (and are known) made of composite material, generally constituted by fiberglass (or of polyamide type) fabric, impregnated with a suitable resin, such as e.g. phenolic resins, thermosetting polyester resins, and others.

French Patent 1,113,396 discloses, e.g., a composite product (useable for protective helmets too) constituted by an assembly (or laminate) of a plurality of sheets of fibrous material (fiberglass) impregnated with a synthetic resin - (polyester), said sheets being linked to each other in a few contact points or areas, only, and wherein some of said sheets may be not resin-impregnated.

U.S. Patent 3,018,210 discloses in its turn a composite helmet (it too of non-metal materials) substantially having a "sandwich" structure, wherein two shells, respectively an inner and an outer shell, are both rigid (by being constituted by a resin-impregnated fibrous material), whilst an intermediate layer, comprised between said two shells, is constituted by a flexible not resin-impregnated ballistic fabric, wherein said layer is mostly free of moving between said outer and inner shells, which shells are solidly linked to each other by means of suitable linking means.

More recently, non-metal helmets have been developed, essentially constituted by fibers with high physical-mechanical characteristics (in particular, aramid fibers, i.e., highly aromatic polyamide fibers), suitably woven, and assembled with synthetic resins. Said helmets are however very expensive, and moreover have ballistic properties (such as those hereinabove defined) around 2000 feet/s - (about 610 m/s).

Summary of the invention

Particular purpose of the present invention is hence to provide an improved composite ballistic helmet, not showing the above said drawbacks of the known art, and which is moreover provided with great resistance to the absorption of impact energy, as well as of greater resistance to penetration by projectiles, splinters, and the like.

Another purpose of the invention is to provide improved composite protective helmets for the most various uses, such as, e.g., helmets for miners, for operators of industrial plants, for firemen, for parachutists and the like.

These and still other purposes, which shall be clear for those skilled in the art from the following detailed disclosure, are achieved according to the present invention by means of a shaped composite product (adaptable, as shape, to cover human head, for the relating protection), comprising, in combination, an outer rigid shell, constituted by a metal material, superimposed to an inner shell constituted by a fibrous material impregnated with synthetic resin, said two shells being solidly linked to each other by means of a layer of polymeric material interposed between the said shells.

Detailed Disclosure of the Invention

Said outer metal shell is accomplished, according to the invention, by preferably using known steels for ballistic protective helmets, or deep-drawable aluminium alloys for ballistic use, whilst the fibrous material of said inner shell is preferably constituted by fabrics of fibers having high physical-mechanical characteristics, in particular polyamide fibers, fiberglass, and the like (the term "polyamide fibers" is intended to comprise also the polyamide fibers of aromatic type known as aramide fibers).

The above said outer metal shell has as its main function the absorbing and dissipating of the most of the impact energy of a projectile or of a splinter or the like, violently striking the same shell; the intermediate layer of polymeric material as above said (besides acting as the bonding agent between the two above said respectively outer and inner shells), cooperates with outer shell in absorbing and dissipating said impact energy, by delamination from the shell itself; finally, the inner shell as already indicated above has the function of absorbing the residual impact energy of the projectile or the like, by inner delamination, and moreover distributing said residual energy on a large surface, said shell being suitable (as a function of the type of fibrous material and of related impregnating resin selected to embody the invention) to delaminate, as well as to make said projectile to move along a trajectory not rectilinear, but tortuous (hence long), hence suitable to absorb much energy and to confer high resistance to penetration by the projectile.

The manufacturing of head coverings and helmets according to the invention is carried out by means of techniques of type known to those skilled in the art, such as cutting, deep drawing, moulding, lamination, polymerization, and the like.

It results evident from the above a complex and very efficacious action of resistance to impact and penetration by hard bodies (in particular, by projectiles) of the various components of composite helmet according to the invention, said action resulting of synergistic type, and however greater than that offered by a comparable helmet of known art, as it shall result more clearly from the Examples disclosed hereinunder.

A preferred, but not exclusive embodiment of the invention envisages that inner shell be constituted by the known "aramide ballistic fabrics" (provided with exceptionally high characteristics of tensile strength), and namely, in practice, e.g. by fabrics of Kevlar yarn (Trade mark of aromatic polyamide fiber by Du Pont de Nemours, E.I. & Co., U.S.A.), said fabrics being in a number of from 10 to about 15, and forming a thickness of about 4-6 mm, same fabrics being solidly assembled with each other by impregnation with a thermoplastic resin, e.g., polyethylene, or with a thermosetting resin, e.g., resins of modified phenol-formaldehyde type, vinyl esters, and polyesters.

The amount of resin represents about 15-35% (by weight, as dry solid matter) of the total of material constituting said inner shell (fibers + resin).

Always according to the said preferred embodiment, the layer of polymeric material interposed between the said outer and inner layers is constituted by a cellulose web of about 12 g/m², bonded with thermally melting adhesive on the basis of SIS (styrene-isoprene-styrene) copolymer.

Said layer can also be constituted by the same resin used to impregnate the inner layer. Other types of resin of known type which can be advantageously used are: modified melamine resins, polyester resins, vinyl resins, olefinic polymers and copolymers, as well as other known thermosetting resins and thermoplastic polymers.

The said intermediate layer of polymeric material (interposed between said two shells) can be accomplished, according to the invention, both as continuous layer (a cap, in particular a helmet, of "monolithic structure", being thus formed), as well as in other forms, as, e.g., a foam, a honeycomb structure, and the like, in that case a cap being formed with so-called "sandwich structure".

According to another embodiment, the invention envisages that inner shell be constituted by polyethylene sheets alternated to aramidic fiber fabrics; the polyethylene sheets forming (by partial bonding with each other through the interstices of said fabrics) an elastic matrix with alveolar structure, with function of tridimensional support, into the alveoli of which the filaments of aramidic fabrics are contained, freely encapsulated (see European Patent Application N° 0049014 A2, published), said polyethylene sheets and said fabrics being assembled with each other in the said alveolar mode by high-temperature pressing (e.g., under a pressure of about 5 kg/cm² at a temperature of about 165°C, and over a time of about 15 minutes).

The alveolar structure as above said reacts elastically to projectile impact, as the filaments of aramidic fabrics cooperate harmonically in a very efficacious way in the impact area and in its surroundings, slightly sliding (by "controlled delamination") inside related alveoli, when said polyethylene alveolar structure is elastically deformed by the projectile.

The following Examples of invention embodiments, given to illustrative only and not limitative purposes, shall serve to better illustrate the same invention.

5 Example 1

Ballistic helmet, so constituted:

10 - Outer shell: of steel sheet, type helmet M33 of Esercito Italiano (Italian Army), average thickness 1.1 mm;

15 - Inner shell: composite laminate constituted by 9 fabrics "TEXILAR", of 220 g/m² KEVLAR 49 fibers (TEXILAR = Trademark for fabrics by TEXINDUSTRIA S.p.a., Como), impregnated with a thermosetting resin of fire-proofed vinyl ester type;

20 - inner layer, interposed between the two said shells: made in form of cellulose web of 12 g/m² bonded with thermomelting adhesive on the basis of SIS (styrene-isoprene-styrene).

25 The weight per surface area unit of composite helmet - (reported in plane) is of 10.8 kg/m² (of which, 8.8 kg/cm² the outer steel shell, and 2 kg/m² the inner shell + the intermediate layer).

30 The same helmet, submitted to the ballistic test according to the modalities already indicated at the beginning of the present disclosure, gives a value $V_{50} = 2350$ feet/s - (716 m/s).

35 The data of this example and of subsequent Examples are reported in Table 1 enclosed, in which to comparison purposes also the analogous data relating to known commercial helmets, of the type on the basis of Kevlar only and of steel only are reported.

Example 2

40 Ballistic helmet constituted as that of Example 1, with the difference that the outer shell is of deep-drawable aluminium

45 TABLE 1

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Sample	Type of helmet (outer shell/inner shell)	Outer shell	Inner shell (+ interme- diate lay- er)	Total	Weight (kg/cm ²)	feet/s	V ₅₀
1	Steel/aramidic composite with thermosetting resin	8.8	2.0	10.8		2350	716
2	Aluminium alloy/aramidic composite with thermoset- ting resin	6.5	4.3	10.8		2400	732
3	Steel/aramidic composite	8.8	2.0	10.8		2350	716
=	Steel (known)	=	=	8.8		1150	403
=	Aramidic composite with thermosetting resin (known)	10.8	=	10.8		2000	610

alloys for ballistic use, average thickness 2.5 mm.

The weight per surface area unit of composite helmet - (reported in plane) is of 10.8 kg/m² (of which, 6.5 kg/m² the shell of aluminium alloy, and 4.3 kg/m² the inner shell + the intermediate layer).

The limit of ballistic protection V_{50} results equal to 2400 feet/s (732 m/s).

Example 3

Ballistic helmet as that of Example 1, with the variant that the inner shell is constituted by a Kevlar-polyethylene laminate, with polyethylene formed according to an alveolar structure (as hereinabove disclosed), said laminate comprising 9 polyethylene films and 9 Texilar fabrics of 220 g/m² KEVLAR 49 fiber.

The weight per surface area unit of helmet (reported in plane) is of 10.8 kg/m² (of which, 8.8 kg/m² the steel shell, and 2 kg/m² the outer shell + the intermediate layer).

The limit of ballistic protection V_{50} is equal to 2350 feet/s (716 m/s).

The above examples relate to helmets with outer shell respectively of steel and of aluminium alloy, but as already above said, such outer shell may be constituted, according to the invention, by any suitable metal material, such as e.g., titanium.

The present invention has been disclosed with particular reference to caps of composite material shaped for the protection of human head, but the protection area of the same invention is intended to enclose also caps shaped in different fashion, i.e., as shapes suitable to protect other parts of human body.

Claims

1. Cap of composite material, shaped for the protection of human body's head, provided with high characteristics of resistance to the absorption of impact energy and to the dynamic penetration by hard bodies, characterized in that it comprises, in combination, an outer shell constituted by a metal material superimposed to an inner shell constituted by a fibrous material impregnated with synthetic resin, said two shells being solidly linked to each other by means of a layer of polymeric material interposed between the same shells.

2. Cap of composite according to claim 1, characterized in that said metal material is constituted by steel of ballistic type.

3. Cap of composite according to claim 1, characterized in that said metal material is constituted by a deep-drawable aluminum alloy for ballistic use.

4. Cap of composite according to claim 1, characterized in that said metal material is constituted by titanium.

5. Cap of composite according to claim 1, characterized in that the fibrous material with which said inner shell is constituted, consists of a plurality of fabrics of fibers provided with high physical-mechanical characteristics, said fibers being selected among fibers of polyamide type and fiberglass.

6. Cap of composite according to claim 1, characterized in that said synthetic resin impregnating the inner fibrous layer is constituted by a thermosetting resin.

7. Cap of composite according to claim 1, characterized in that said synthetic resin impregnating the inner shell of fibrous material is constituted by polyethylene film, said fibrous material being constituted by fabrics of aramidic fibers, and said polyethylene having an alveolar structure.

8. Cap of composite according to claim 1, characterized in that said intermediate layer of polymeric material is constituted by a cellulose web bonded with thermomelting adhesive on the basis of styrene-isoprene-styrene copolymer.

9. Cap of composite according to claim 1, characterized in that said intermediate layer of polymeric material is constituted by the same synthetic resin impregnating the inner shell.

10. Cap of composite according to claim 1, for use as ballistic protective helmet, as protective helmet for miners, for operators of industrial plants, for firemen, for parachutists, and the like.

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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.4)
X	FR-A-2 425 046 (CHANTERET) * Claims 1,3,4; figure *	1,2	F 41 H 1/04
X	FR-A-2 431 674 (FONTANTO) * Claims 1-4; figure 1 *	1,5	
A	US-A-3 722 355 (KING) * Column 2, lines 50-60 and table 1 *	1-5	
A	EP-A-0 089 537 (HARPELL) * Claim 5 *	7	
A	GB-A-1 367 403 (DALY) * Page 1, lines 9-10; page 3, line 106 *	8	
A	GB-A-3 018 210 (FRIEDER)		
A	US-A-3 867 239 (ALESI)		TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			F 41 H
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 22-04-1986	Examiner RODOLAUSSE P.E.C.C.
CATEGORY OF CITED DOCUMENTS		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	
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			