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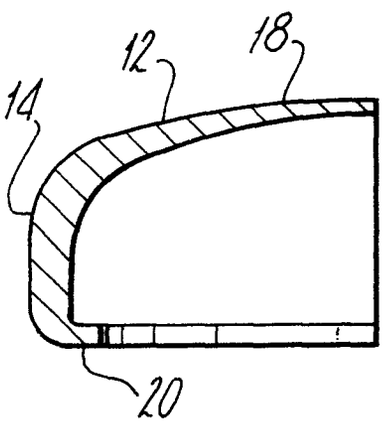
(54) **Protective toe caps.**

(57) A protective toe-cap comprising a domed member adapted to lie over the toes of the wearer and having an open end to receive the toes, said domed member comprising a formable polymeric composition, optionally reinforced with randomly disposed fibres characterised in that the domed member is reinforced with uniaxially aligned continuous fibres bonded to the formable polymer of the dome member.



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PROTECTIVE TOE-CAPS

This invention relates to protective toe-caps for use in safety shoes or boots which are intended to provide the wearer with protection against damage to the toes arising from accidental heavy impact on the toe portion of the shoe or boot.

Conventionally used metal toe-caps have the disadvantage that the resulting shoe is heavy and uncomfortable to wear. In addition the metal insert is subject to corrosion and expensive to manufacture. A toe-cap has now been devised which is lighter and less expensive to manufacture than a metal toe-cap and is not subject to corrosion.

According to the invention there is provided a protective toe-cap comprising a domed member adapted to lie over the toes of the wearer and having an open end to receive the toes, said domed member comprising a formable polymeric composition, optionally reinforced with randomly disposed fibres characterised in that the domed member is reinforced with uniaxially aligned continuous fibres bonded to the formable polymer of the dome member. Optionally the toe-cap may be provided with a flange extending inwardly from at least part of the base of the domed member.

The presence of the aligned continuous fibres in the toe-cap permits substantial improvement in the resistance to impact to be obtained.

The formable polymeric composition used to fabricate the toe-cap may be any polymeric composition which is capable of being formed into the required shape in a mould. For example, it may be a thermoplastics composition which can be melted and injection moulded. Alternatively it may be a dough moulding thermosetting polymer composition which is introduced into the mould in an uncured fluid state and is cured in the mould. Yet

again it may be a thermoplastics composition which is incompletely polymerised when injected into a mould but is cured therein. The latter technique is termed "reaction injection moulding". A preferred method of forming toe-caps from a formable polymer composition is by compression moulding of a blank or sheet of a thermoplastics polymer, preferably containing randomly disposed reinforcing fibres particularly continuous fibres. Sheets of material made by thermoplastic polymer melt impregnation of glass mats containing randomly disposed continuous fibres are particularly suitable.

The essential feature of the invention is the presence of the aligned, continuous reinforcing fibres. Such fibres may be included in the toe-cap by a number of methods. In a first method required lengths of continuous fibres may be positioned and restrained in a mould prior to the introduction of the mouldable polymer composition. Introduction of the mouldable composition into the mould and completion of any additional process steps, for example curing, results in a finished article containing continuous, aligned fibres embedded in a polymer matrix. The aligned fibre reinforcement will be in the required position providing the introduction of the curable composition has not displaced the continuous aligned fibres from the originally chosen position. This method has the potential disadvantages that the continuous, aligned fibres will be displaced from their chosen position during introduction of the mouldable composition. A more important disadvantage is that the fibres may not be adequately wetted when the mouldable polymer is introduced and the maximum benefit of the reinforcement may not be derived.

In a preferred method the continuous, aligned fibres are introduced in the form of preformed reinforced polymer strips which consist of continuous, aligned fibres

embedded in a polymer matrix. A suitable method of forming such a product is described in European patent publication No. 56703. Such a strip can be prepared under conditions which ensure that the fibres are thoroughly wetted by the polymer to ensure that the reinforcement properties are maximised. Strips reinforced with continuous fibres can be readily located in a mould, particularly in a process in which the strip is used in conjunction with a sheet containing randomly dispersed fibres in a compression moulding process to form the toe-cap. The reinforcement may be provided by a single strip or a plurality of strips.

The continuous, aligned fibres whether used as untreated fibres or as a preformed strip are positioned in the mould so that their position in the finished toe-cap will give a required level of protection to the wearer. The protection against impact provided by the toe-cap is assessed according to British Standard No. BS 953:1979 which gives levels of performance ranging from a 40 joule drop test up to a 200 joule drop test. The quantity and placement of the continuous, aligned fibres in the domed member will depend on the level of performance required of the toe-cap. The preferred disposition of the fibres is with the fibres lying uniaxially across the toe-cap since this disposition provides the most effective resistance to impact. For maximum effectiveness reinforcement should be provided at least in a band extending up to the edge of the open end of the domed member. The performance improves as the width of the band increases and should extend inwardly from the open end for at least 10 mm and preferably at least 20 mm. Preferably, the continuous fibres should extend across the whole width of the toe-cap, that is from the base of the side wall on one side of the cap to the base of the side wall on the other side of the cap. The fibres may also extend into the flange at

the base of the toe-cap. The toe-cap may be provided with continuous fibres aligned across the whole of the toe-cap but in general such a construction is expensive and is not necessary for providing adequate protection.

Although the preferred disposition of continuous fibres is across the toe-caps, or in other words parallel to the edge of the open end of the toe-cap, other dispositions can be used. The continuous fibres may, at least in part, be disposed along the length of the toe cap, that is lie in a direction along at least an upper part of the domed member from the open end towards the toe end. In particular, woven, continuous, aligned fibre structures may be used for insertion into the mould and may be disposed so that none of the aligned fibre elements making up the woven structure is parallel to the edge of the open end of the toe-cap.

When the reinforcement is introduced as a preformed reinforced polymer strip such strips may be present in side-by-side relationship, indirectly superimposed relationship or as part of a structure woven from the strips.

The essential requirements of the continuous fibres used are that they should be continuous and should be substantially aligned in parallel manner. By the term "continuous" is meant that the fibres should be at least 20 mm long. Preferably the fibres should be at least 50 mm long. The fibres may be of any material which will provide reinforcement, including inorganic fibres and synthetic polymer fibres. Particularly useful for increasing the flexural modulus of the toe-cap are glass fibres and carbon fibres. Although the latter give the better properties their present cost leaves glass fibres as the preferred fibrous reinforcement.

The preferred formable polymer compositions are based on thermoplastic polymers because of the versatility of such materials in being adaptable to a variety of forming processes. The thermoplastic polymer used should have high flexural modulus for optimum performance. Inexpensive polymers such as poly(ethylene terephthalate), nylons and polypropylene are suitable. The compositions may contain additives to improve stiffness and toughness. Randomly disposed glass fibres are a particularly useful additive.

When the continuous, aligned fibres are provided in the form of a preformed reinforced polymer strip the polymer of the strip may be the same or different from the polymer of the formable polymer composition. Where the two materials differ in chemical nature they should nevertheless be compatible so that the preformed strip is strongly bonded to the remainder of the toe-cap after the fabrication process is completed. In general, it is preferred that the chemical nature of the polymers in the preformed strip and the remainder of the toe-cap are the same, although they may differ substantially in average molecular weight.

The toe-caps of the invention may be of substantially uniform thickness or may be of varying thickness, the dimensions and profile of the toe-cap being defined by the mould cavity in which the aligned continuous fibres are incorporated in the toe-cap. For example, in the process of compression moulding a toe-cap male and female moulding tools may define a die cavity of varying thickness as illustrated in Figures 1 to 4 of the accompanying drawings wherein:

Figure 1 is an end elevation of a toe-cap produced in accordance with the invention looking from the open end thereof;

Figure 2 is a top plan view of the toe cap of Figure 1;

Figure 3 is a cross-section on the line A-A of Figure 2; and

Figure 4 is a cross-section on the line B-B of Figure 2.

Referring to the drawings, the toe-cap 10 has a generally curved shape for conforming to the toe part of a safety boot or shoe so that, in use, it will bridge the toes in front of and to the side of the toes. The toe cap is in the form of a single continuous curve in three dimensions and is produced from a formable polymeric composition, optionally reinforced with randomly disposed fibres, and a reinforcement of uniaxially aligned continuous fibres bonded to the formable polymer as hereinbefore described.

The main area 12 of the toe-cap is of substantially uniform thickness but the front part 14 and the forward part of the sides 16 are of increased thickness relative to the main area 12 as will be seen from Figure 3. These thickened parts 14 and the forward part of the sides 16 taper into and merge smoothly with the main area 12 as shown in Figure 4 and taper further back to the edge area 18 at the open end of the toe-cap. The sides 16 are also of increased thickness at the base of the toe-cap and taper upwardly therefrom into the main area 12 as is clearly illustrated in Figure 1.

A flange 20 extends inwardly around the toe-cap 10 around the base thereof. As illustrated, this flange 20 will provide additional stiffness to the toe-cap but it is not essential. It may be necessary however to provide at least a small inwardly extending edge to the base of the toe-cap for use in locating and securing the toe-cap in position in the safety boot or shoe.

It will be appreciated that different relative thicknesses of the parts of the toe-cap may be provided according to the size of the footwear within which it is

to be secured. For example, in a typical man's safety boot, the main area 12 of the toe-cap 10 may be of the order of 3.5 millimetres thickness tapering down to 2.5 millimetres at the edge area 18. The thickened front part 14 may be of the order of 6 millimetres thickness whilst the sides 16 may be of the order of 4 millimetres thickness at their base tapering into the main area 12.

This gradual merging and tapering of the thickness around the front-end of the toe-cap helps to strengthen the whole of the toe-cap and thereby allows an acceptably thin main area 12 to be utilised. It is important to avoid excessive thickness in the main area 12 because this would adversely affect the appearance of the boot or shoe which, for commercial reasons, may well have to be styled into a fashion product to some extent as well as functioning as safety footwear. The limited thickening and gradual taper of the front part of the toe-cap merely adds a requirement for a small increase in length and does not detract significantly from the appearance of the footwear.

A further feature which may be provided as an improvement in the appearance of the footwear, the ease of building the toe-cap into a boot or shoe, and the comfort of the wearer, is that the rear edge area 18 of the toe-cap may be provided with a lip tapered in thickness relative to the main area 12 to facilitate a smooth transition of the toe-cap with the remainder of the boot or shoe. The decreased thickness in this lip extending beyond edge area 18 does not significantly affect the strength of the toe-cap as a whole. This lip will normally comprise a material which does not include significant amounts of uniaxially disposed fibres.

The invention is further described with reference to the following example.

EXAMPLE 1

Samples of a glass mat reinforced polypropylene sheet (supplied as 'Symalit' GM40PP, containing 40% by weight of glass fibres) having a thickness of 3 mm were cut into blanks having dimensions 13 cm x 7 cm. Samples of uniaxially glass-reinforced polypropylene pultrusion prepared according to the disclosure of Example 7 of European Patent Publication No. 56703 having a cross-section of 12.5 mm x 2 mm, were cut to lengths of 13 mm. The polypropylene used had a low molecular weight, exhibiting a melt viscosity of 5 Ns/m^2 at 260°C. Both the reinforced sheet and the reinforced pultrusions were placed in an infra-red preheat oven, maintained at 300°C, for 1 minute. A toe-cap was moulded from the heat softened components using a toe-cap mould comprising male and female moulding tools defining a cavity of uniform thickness. The male and female components of the toe-cap mould were bolted to opposite platens of a press to provide mating engagement when the press was closed. The press platens were maintained at 70°C. Two pultruded strips were removed from the oven and located in superimposed relationship in the male tool of a toe-cap mould so that in the finished moulding they would be located around that part of the toe-cap defining the open end of the toe-cap. The sample of sheet was placed in the female tool of the mould. The press was closed to give a pressure of 30 kg/cm^2 of platen and was maintained for 1 minute. The operation produced a smooth surfaced toe-cap with the pultrusion strips embedded in the toe-cap. When using other polymeric materials in the uniaxially reinforced insert or the randomly reinforced sheet the conditions of temperature and pressures used should be sufficient to unite the uniaxially reinforced member with the randomly reinforced member.

EXAMPLE 2

The procedure of Example 1 was repeated except in that the toe-cap was formed from a glass mat reinforced polypropylene sheet containing 50% by weight of glass fibres (supplied as 'Symalit' GM50PP). The same pultrusion was used as in Example 1 and all other conditions remained the same.

CLAIMS

1. A protective toe cap for use in safety foot wear comprising a domed member adapted to lie over the toes of the wearer and having an open end to receive the toes, said domed member comprising a formable polymeric composition optionally reinforced with randomly disposed fibres characterised in that the domed member is reinforced with uniaxially aligned continuous fibres bonded to the formable polymer of the domed member.

2. A protective toe cap as claimed in Claim 1 wherein the said uniaxially aligned continuous fibres are present in a polymer matrix in a pre-formed strip bonded to the formable polymer of the domed member.

3. A protective toe cap as claimed in Claim 2 wherein the formable polymer is a sheet of randomly disposed continuous reinforced fibres.

4. A protective toe cap as claimed in any one of Claims 1 to 3 wherein said uniaxially aligned continuous fibres are bonded to the domed member at or adjacent the said open end thereof.

5. A protective toe cap as claimed in any one of the preceding claims wherein said uniaxially aligned continuous fibres lie in a direction across at least an upper part of the domed member from side to side thereof.

6. A protective toe cap as claimed in any one of Claims 1 to 4 wherein said uniaxially aligned continuous fibres lie in a direction along at least an upper part of the domed member from the said open end thereof towards the toe end.

7. A method of manufacturing a protective toe cap for use in safety foot wear wherein the toe cap comprises a domed member adapted to receive the toes of the wearer and having an open end to receive the toes comprising the steps of moulding said domed member from a formable polymeric composition optionally reinforced with randomly

disposed fibres between male and female moulding tools characterised in that uniaxially aligned continuous fibre reinforcement is located between the moulding tools prior to the moulding of the domed member and is bonded to the polymeric compositions during the moulding operation.

8. A method as claimed in Claim 7 wherein said uniaxially aligned continuous fibre reinforcement is in the form of a preformed polymer matrix strip.

9. A method as claimed in Claim 8 wherein the polymeric composition comprises a sheet thereof and the polymer matrix strip is bonded to said sheet during the moulding of the domed member from said sheet.

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Fig.1.

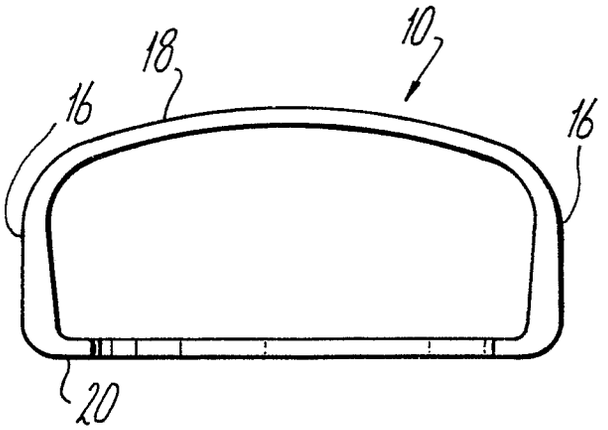


Fig.3.

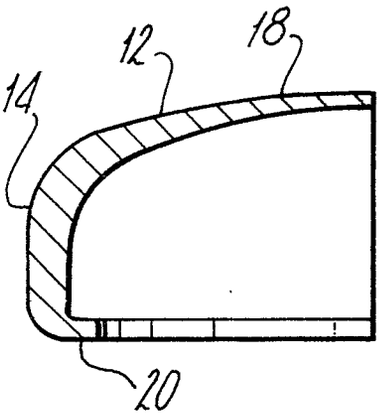


Fig.2.

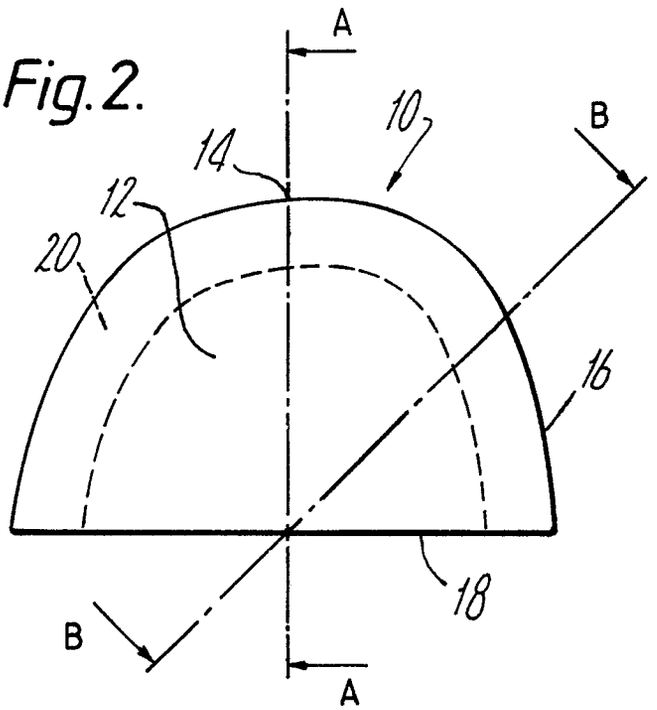
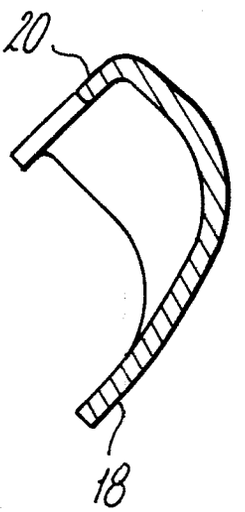


Fig.4.



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EUROPEAN SEARCH REPORT

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Application number

EP 83304046.2

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. ³)
X Y	EP - A1 - 0 021 612 (FIRTH CLEVELAND ENGINEERING) * Page 1, line 26 - page 2, line 3; page 3, lines 1-6 *	1 2,3,4, 5,7,8	A 43 B 7/32
Y	US - A - 3 829 351 (CLOSSON) * Especially column 2, lines 4-72 *	2,4,5, 8	
Y	US - A - 3 918 182 (COOPER) * Especially column 1, lines 44-48; column 9, lines 12-22 *	2,3,7	
X	AT - B - 305 085 (RESNER) * Especially fig. 1,2; page 2, lines 9-21 *	1	TECHNICAL FIELDS SEARCHED (Int. Cl. ³)
A	DE - A - 1 911 436 (DEUTSCHE SEMPERIT) * Especially fig. 1; page 2, lines 17-20 *		A 43 B
A	DE - A1 - 2 549 498 (PHOENIX GUMMIWERKE) * Especially page 2, lines 22-26 *		
X	GB - A - 2 050 144 (LSB ORTHOPAEDICS) * Especially page 1, lines 60-86 *	1	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	05-10-1983	SAMSEGGER

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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