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Coates(10) **Pub. No.: US 2009/0100578 A1**(43) **Pub. Date: Apr. 23, 2009**(54) **PROTECTIVE CLOTHING****Publication Classification**(76) Inventor: **Nicholas R. Coates**, Crowborough
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BOSTON, MA 02205 (US)(51) **Int. Cl.****A41D 13/00** (2006.01)**A41D 27/00** (2006.01)**A41D 27/28** (2006.01)**A41D 27/26** (2006.01)(52) **U.S. Cl.** **2/455; 2/243.1; 2/267**(57) **ABSTRACT**

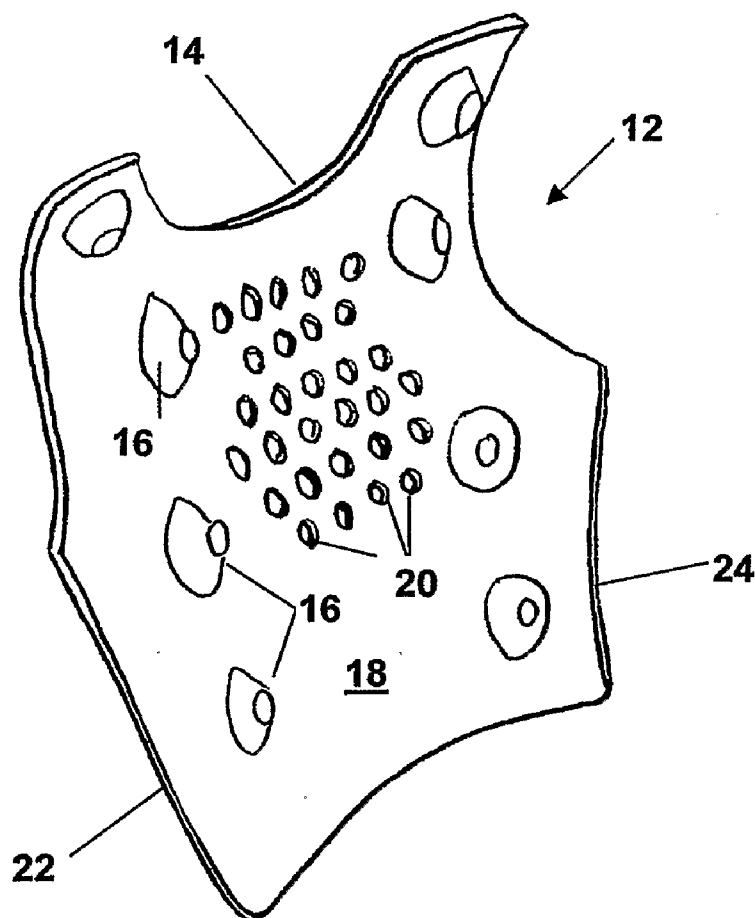
Protective clothing (12) comprising a protective layer (14) for providing protection from blows, and spacer members (16) for spacing the protective layer (14) from that part of a person's body being protected by the protective layer (14); and the protective clothing (12) being such that: (i) the spacer members (16) are made of a resilient material for providing comfort during use of the protective clothing; (ii) the spacer members (16) are 10-25 mm in depth for promoting optimum air flow between the protective clothing and the part of the person's body to be protected; (iii) the spacer members (16) are of a shape which minimises their resistance to the air flow through the spacing; (iv) the protective layer (14) is made of a rigid or semi-rigid material; (v) the protective layer (14) is curved for conforming to that part of the persons body to be protected; and (vi) the protective layer (14) has an inner surface (18) which is formed to minimise resistance to the air flow through the spacing.

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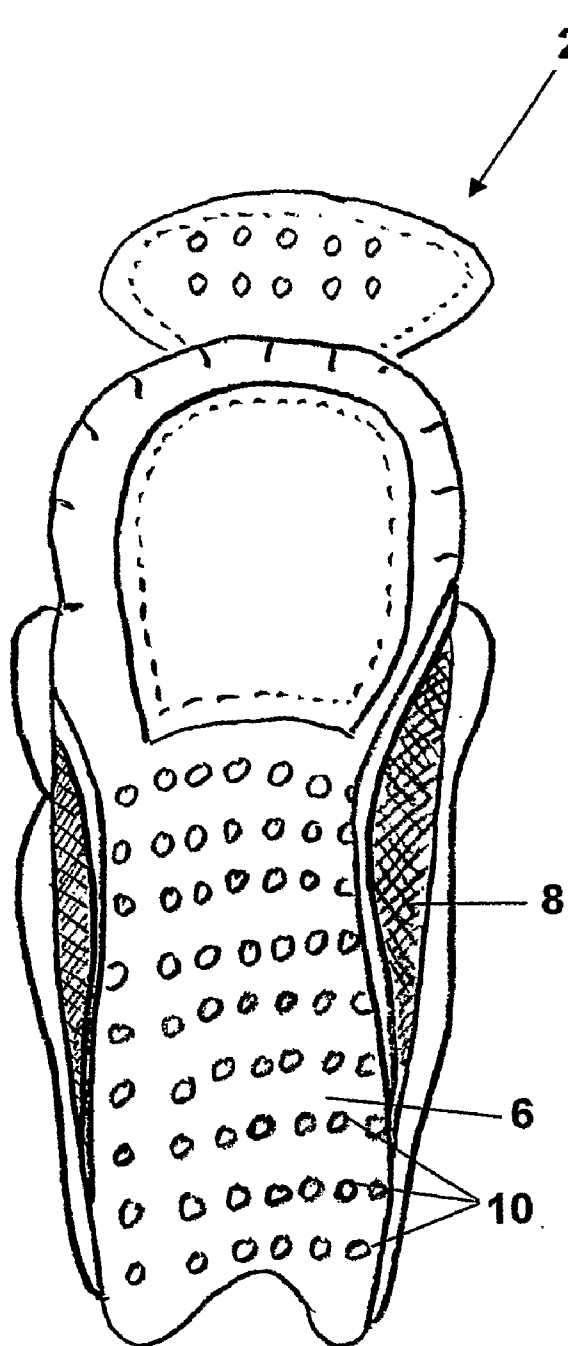


FIG. 1

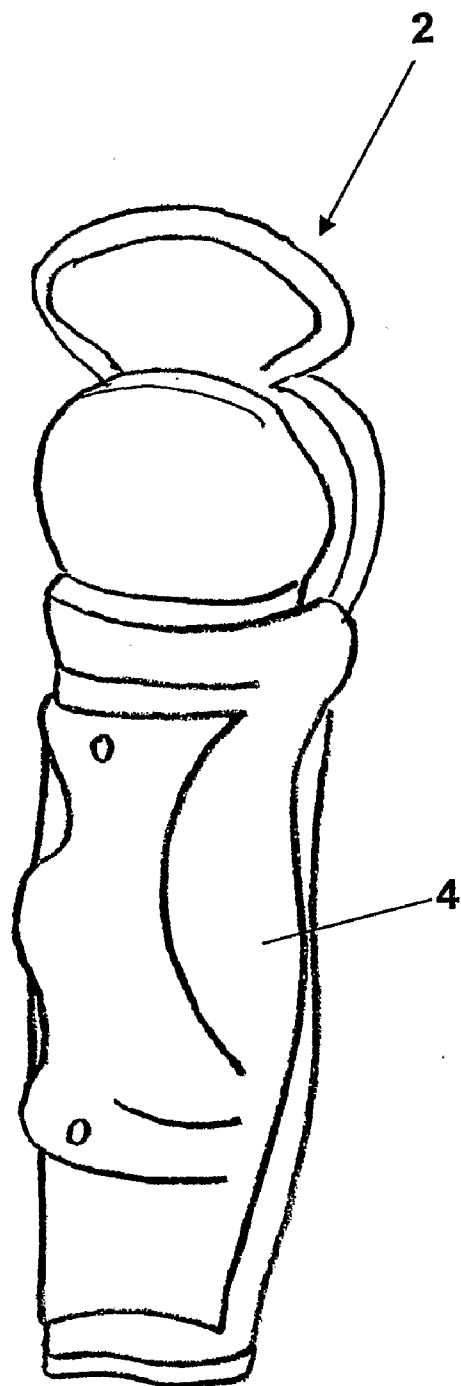
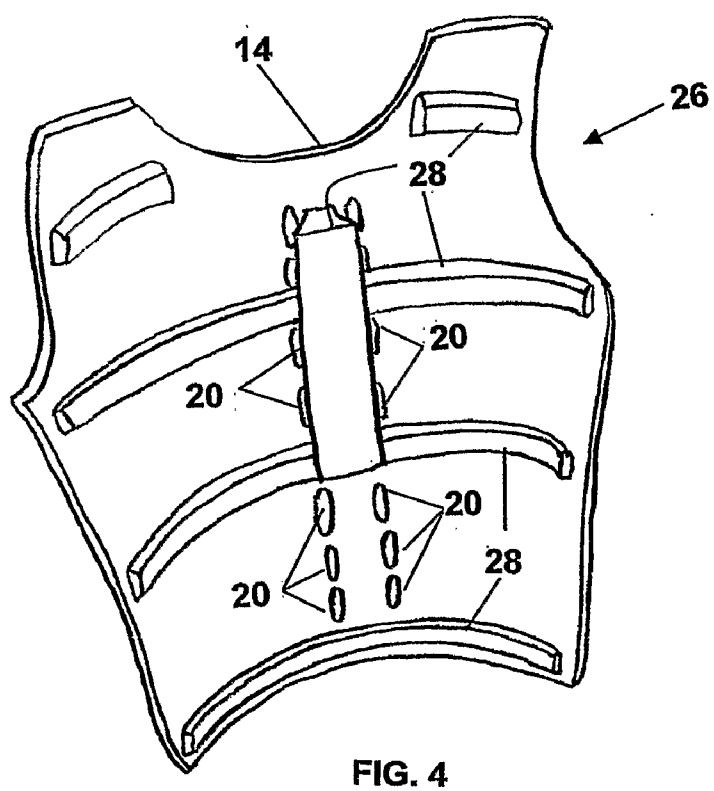
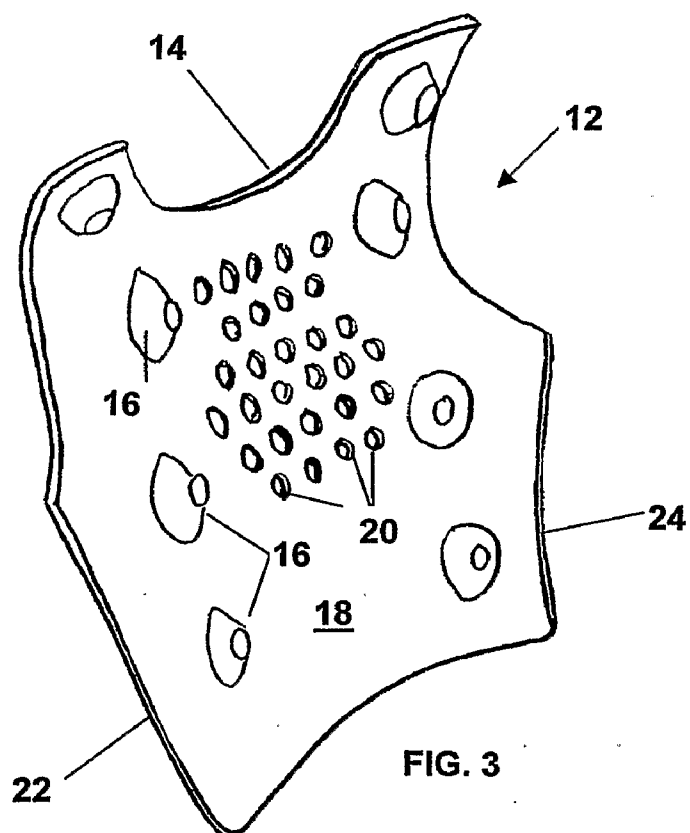
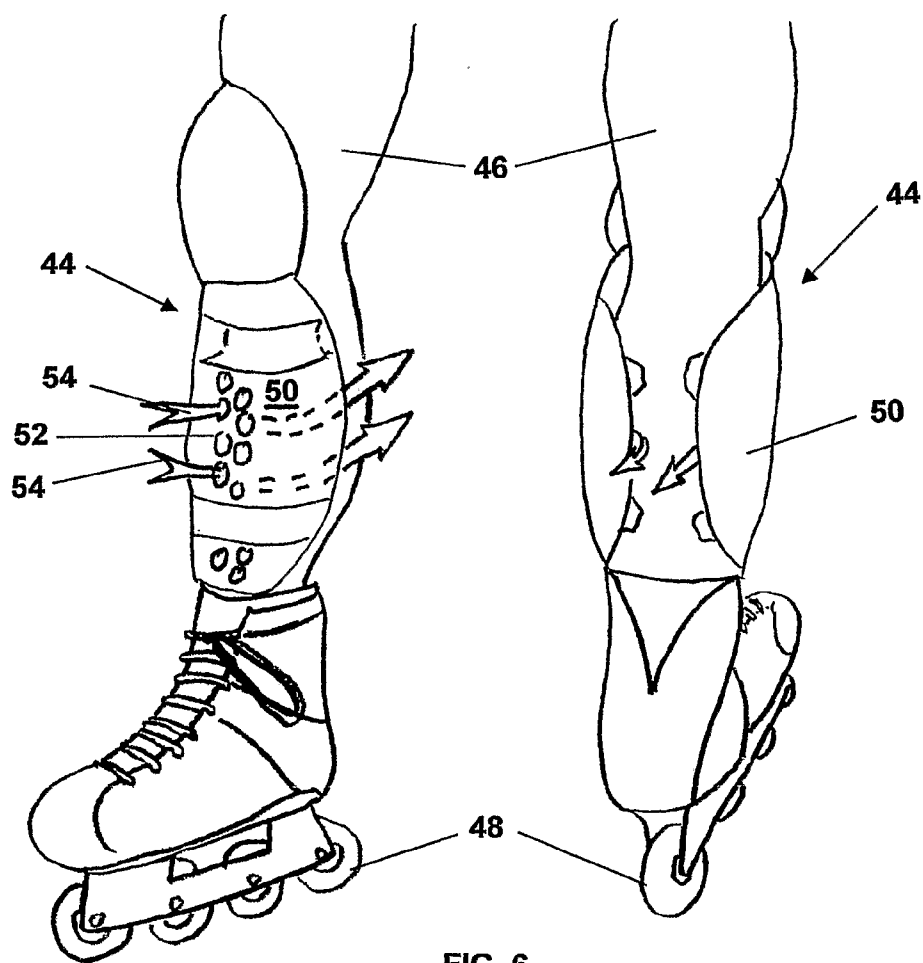
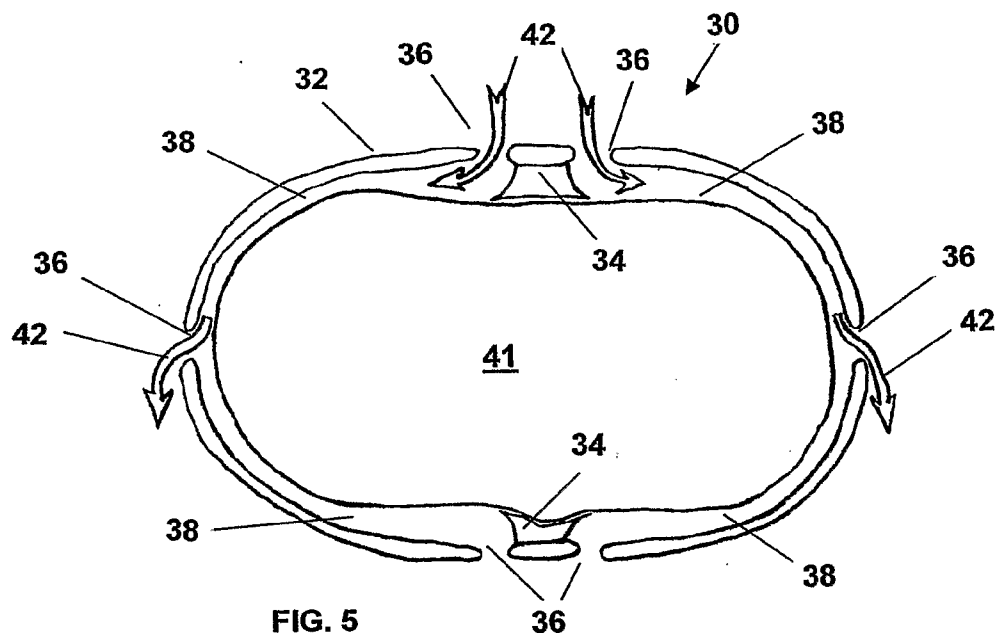


FIG. 2





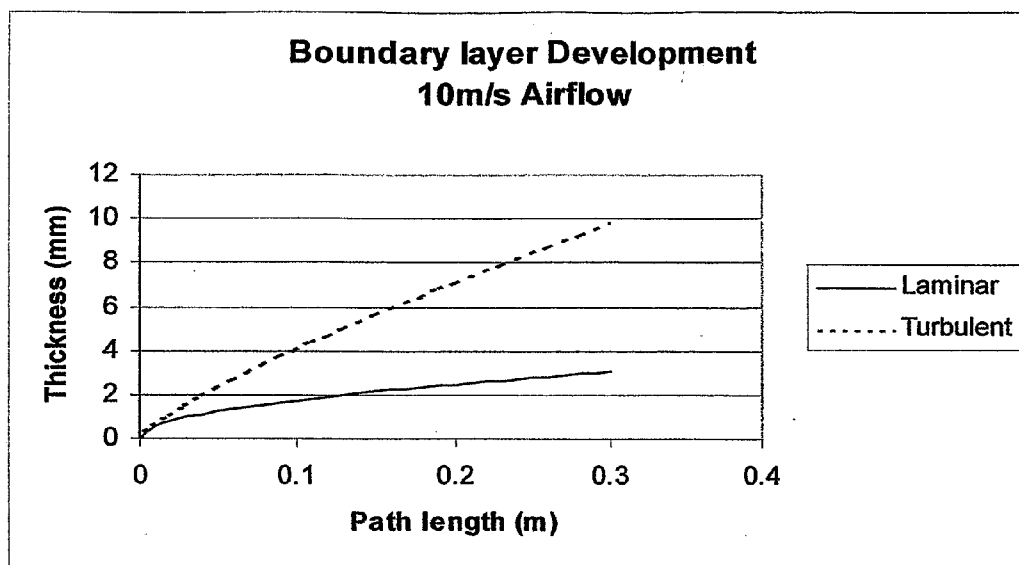


FIG. 7

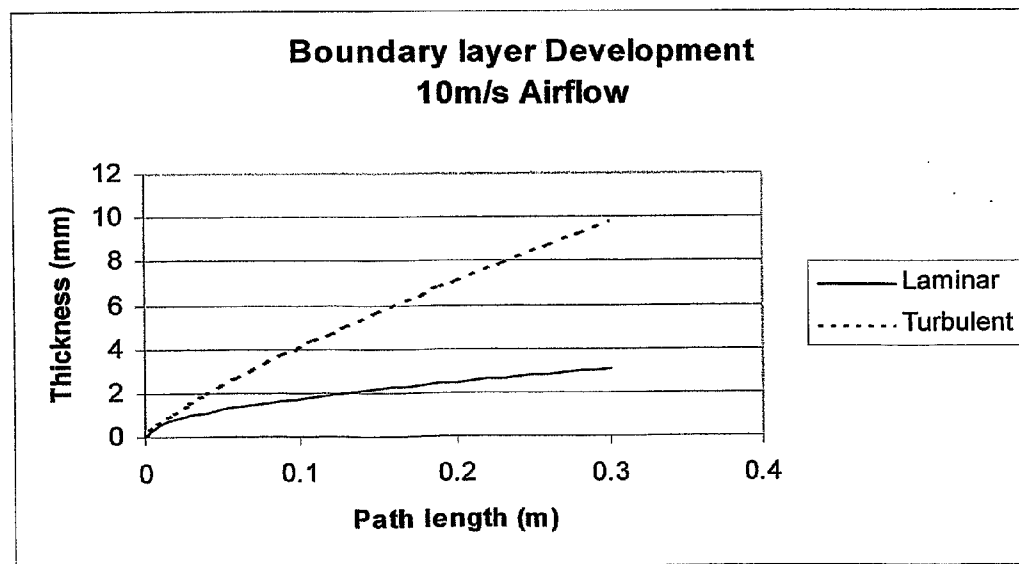


FIG. 8

PROTECTIVE CLOTHING

[0001] This invention relates to protective clothing, for example for use in sport, industry, the police, or the armed services.

[0002] There are a number of areas where it is desirable or essential for persons to wear protective clothing. The protective clothing may protect one or more of the head, body and limbs of the person from impact with the ground, collisions or blows. The collisions may be with other persons, vehicles or parts of buildings or other structures. In sport, the blows may be from clubs, rackets, sticks or projectiles such for example as balls or pucks.

[0003] During the playing of different games of sport, the players indulge in vigorous exercises which causes the body to produce approximately 3 watts of heat for every watt of useful output. The organs in the human body, notably the brain, must operate within a very small temperature range. It is thus vital that player's body is able to shed the extra heat generated during the playing of a game. Two mechanisms are employed for this purpose. The first mechanism is the dilation of blood vessels near the surface of the skin. This allows the blood to transfer heat to the surface of the skin, from where it can be transferred to the surrounding air. The second mechanism which augments the first mechanism, is the sweat mechanism whereby sweat, which is mostly water with some salt, is released from the surface of the skin. The sweat evaporates into the air, taking an amount of heat equivalent to the latent heat of evaporation of the sweat. The sweating mechanism is activated by signals from the brain, and these signals are generated in response to a rise in body core temperature. The fact that a player is sweating is an indication that the player's body core temperature is above optimum.

[0004] When an area of the player's skin is covered in close fitting protective clothing, the sweat is still produced and it soaks into the protective clothing. This means that the sweat does not have its intended cooling effect and the protective clothing, for example padding, becomes soaked with the sweat. The sweat then adds significantly to the weight of the protective clothing. The player's body, having failed to cool itself, then produces more sweat.

[0005] There are several mechanisms which reduce the performance of a player as a result of inadequate body cooling. As the blood supply is diverted for use as a coolant, there is reduced cardiovascular capacity available for transferring oxygen to the player's muscles. As sweat is lost, the hydration of the body moves away from the ideal at a rate which cannot be made good by drinking during breaks in play. The amount of salt in the player's body must also remain within narrow limits or muscle cramps can occur.

[0006] As the player's body temperature approaches the upper limit, a variety of unpleasant symptoms occur including discomfort, loss of concentration, headaches, nausea, and loss of consciousness. Even the mildest of these unpleasant symptoms will degrade the performance, competitiveness and enjoyment of the player. In the extreme, the symptoms can be dangerous, or in rare cases fatal.

[0007] A further consequence of the problem is that sweat soaked playing equipment is difficult to wash when a player is involved in a busy schedule of training and match play. This is generally because the washed equipment takes several days to dry. There is thus a tendency for players not wash their

equipment as frequently as it should be, so that the equipment can smell and give offense to other players.

[0008] Some players will opt to wear the minimum of protective clothing allowed by the rules if the protective clothing reduces their performance. In competitive sports, this in turn puts pressure on other players to wear less protective clothing.

[0009] Some manufacturers of protective clothing for use in sport have acknowledged that cooling is a problem. Thus some known protective clothing has marketing features such for example as perforated foam, or systems for wicking moisture away from the player's skin. The perforated foam tends to be ineffective because the air holes are blocked at one end by the proximity of the body, and the resultant cavities are too small to permit a significant flow of air to develop. This is because, although moving air can be used to effect cooling, static or very slowly moving air is an excellent heat insulator. Therefore creating small holes through a layer to the skin uncovers a negligible area and may have little or no effect on the cooling of the skin. The wicking of the sweat away uses fabric to create a path from the skin to the top surface of foam. Here the sweat may evaporate causing a drop in temperature on the outside of the protective clothing. However this top surface layer of the foam is separated from the skin by a material which has very poor heat conduction. There is therefore some reduction in the discomfort due to the Wetness of the skin, but little cooling effect.

[0010] The above observations and problems in relation to protective clothing for use in sport are also applicable to protective clothing for use in other areas, for example in industry, the police, or the armed services.

[0011] U.S. Pat. No. 6,654,960 discloses the use of protective clothing which comprises a protective layer for providing protection from blows, an apertured foam layer co-extensive with the protective layer, and projections on the foam layer. The projections are of unspecified dimensions. The protective clothing, which is in the form of a shin pad, is unable to provide a good air flow between the protective clothing and the player's skin.

[0012] It is an aim of the present invention to obviate or reduce the above mentioned problems.

[0013] Accordingly, in one non-limiting embodiment of the present invention there is provided protective clothing comprising a protective layer for providing protection from blows, and spacer members for spacing the protective layer from that part of a person's body being protected by the protective layer: and the protective clothing being such that:

[0014] (i) the spacer members are made of a resilient material for providing comfort during use of the protective clothing;

[0015] (ii) the spacer members are 10-25 mm in depth for promoting optimum air flow between the protective clothing and the part of the person's body to be protected;

[0016] (iii) the spacer members are of a shape which minimises their resistance to the air flow through the spacing;

[0017] (iv) the protective layer is made of a rigid or semi-rigid material;

[0018] (v) the protective layer is curved for conforming to that part of the person's body to be protected; and

[0019] (vi) the protective layer has an inner surface which is formed to minimise resistance to the air flow through the spacing.

[0020] The protective clothing of the present invention is advantageous in that it permits a good air flow to be achieved between the protective clothing and the person's body. This is so irrespective of whether the protective clothing is worn directly against the person's skin or against other material being worn by the player such for example as a t-shirt or socks. Because of the air flow, sweat from the person generated during the use of the protective clothing is able to evaporate and thus the player is able to maintain a cooler body temperature. This in turn leads to better performance, for example better competitiveness, comfort and enjoyment for a player in the case of protective clothing for use in sport.

[0021] The protective layer may have apertures which enable air to pass through the protective layer and provide air for the air flow through the spacing.

[0022] The protective clothing may be one in which the spacer members are in the form of pads. In this case, the protective clothing may be one in which the pads extend in a line near to opposed edges of the protective layer, and in which the apertures are centrally positioned between the two lines of pads. The pads may be circular in plan. Other aerodynamic shapes for the pads may be employed.

[0023] Alternatively, the protective clothing may be one in which the spacer members are in the form of strips. In this case, the protective clothing may be one in which the strips comprise a longitudinally extending strip which is centrally positioned on the protective layer, and a plurality of transversely extending strips.

[0024] Alternatively, the protective clothing may be one in which the spacer members form air ducts, and in which the air ducts receive the air flow through the spacing.

[0025] In all embodiments of the invention, the protective clothing may be one in which the spacer members have a area in contact with the skin or underclothing of the person which is less than 25% of the area of the protective layer.

[0026] In all embodiments of the invention, the spacer members may be made of a closed cell foam. The closed cell foam does not soak up sweat and it is thus easily cleaned.

[0027] In all embodiments of the invention, the protective layer may be made of a rigid material. Alternatively, the protective layer may be made of a semi-rigid material, for example where a degree of flexibility of the protective layer is required. The choice of material for the protective layer needs to achieve required rigidity and toughness. This is especially so where the protective layer is only supported intermittently by pads or ribs and/or where the protective layer has apertures formed in its surface. Forming stiffening ribs in the protective material is not acceptable where the inner surface is smooth to minimise retardation of the airflow. Excellent results may be obtained with a cross-linked polyethylene foam and especially a cross-linked polyethylene foam with a density between 70 and 115 Kg/M³. This material uses nitrogen as the foaming agent. It is manufactured by allowing nitrogen to diffuse into the material by a high-pressure thermal process. This has an advantage over other foams where the foaming agent is a volatile organic material or a gas produced by a chemical reaction in that no residue from the foaming process remains in the material which can impair the properties of the polymer. It also has a minimal environmental impact. As the material is an order of magnitude less dense than solid plastics, a shin pad with a 10 mm thick protective layer may be a third of the weight of a comparable prior art shin pad. The material may be produced with varying degrees of cross-linking, which results in various degrees of rigidity.

[0028] The protective clothing may include at least one battery powered fan. The use of one or more fans may be used to create or augment the air flow. The battery may be a dry cell battery or rechargeable battery. Battery powered fans would not normally be employed for persons who are frequently in motion. However persons such for example as net minders in roller skate hockey, inline skate hockey and ice hockey are very heavily padded with protective clothing and they have little opportunity to skate at speed. Thus they get extremely hot and would benefit from the use of one or more battery powered fans.

[0029] The protective clothing may be used in a wide variety of areas. In sport, the sport may be ice hockey, roller skate hockey, inline skate hockey, field hockey, football, American football, cricket and rugby. In industry, the protective clothing may be used in factories and warehouses. In the police, the protective clothing may be of special use where the police have to control demonstrations. The protective clothing may thus, for example, be in the form of one or more of body armor, padded shorts, leg protectors, elbow protectors, gloves or helmets. The body armour may be for covering the shoulders and the upper torso of the person. The padded shorts may be for covering the waist of the person and the person's kidneys down to just above the knee. The leg protectors may be simple shin pads or shin pads combined with knee pads. The elbow protectors may be designed to cover part of the upper and lower arms. The protective clothing will usually be different for different areas of use.

[0030] Embodiments of the invention will now be described solely by way of example and with reference to the accompanying drawings in which:

[0031] FIG. 1 is a rear perspective view of a known inline hockey knee and shin guard;

[0032] FIG. 2 is a front perspective view of the shin guard shown in FIG. 1;

[0033] FIG. 3 is a rear view of first protective clothing of the present invention;

[0034] FIG. 4 is a rear view of second protective clothing of the present invention;

[0035] FIG. 5 is a sectional view through a torso with third protective clothing of the present invention in place;

[0036] FIG. 6 shows front and back views of a pair of inline skate hockey knee and shin guards as worn; and

[0037] FIGS. 7 and 8 illustrate laminar flows and turbulent flows plotted against air gap thickness and air gap length.

[0038] Referring to FIGS. 1 and 2, there is shown known protective clothing 2 in the form of an inline skating hockey knee and shin guard. The protective clothing 2 has a rigid 2.7 mm thick plastics protective layer 4. The protective layer 4 is curved for additional rigidity. The protective layer 4 is separated from the player's leg by a layer 6 of perforated foam polymer material. The layer 6 has a sewn on fabric cover 8. The fabric cover 8 on the outer surface has an open weave. In use, all the holes 10 in the layer 6 are blocked at the inner end by the player's leg. Most of the holes 10 are blocked at the outer end by the protective layer 4. The protective clothing 2 shown in FIGS. 1 and 2 is always soaked in sweat after play, this being testimony to the fact that the design of the protective clothing 2 is not able to remove sweat, which causes the problems mentioned above. For simplicity of illustration in FIGS. 1 and 2, elastic straps which are usually used to secure the protective clothing 2 to the player's leg have not been shown.

[0039] The present invention utilises the realisation that when air flows through a passage, the air flow is retarded by form friction and skin friction. Form friction is caused when the air encounters bluff shapes, edges and sudden changes of cross section. The kinetic energy of the flow is converted into eddies and random movement. Skin friction is a consequence of the viscous drag of the air on air passage walls. The layer of air next to the walls of the passage where this occurs is a boundary layer. Further from the wall, the flow is a free stream flow. In a narrow air flow passage, the boundary layer on each side of the passage will meet the middle, permitting no free air stream flow. This is why material structure such as open cell foams, knitted woolen fabric and rock wool, which are by no means impervious to the flow of air, are none the less capable of reducing the motion of the air sufficiently to act as very effective heat insulators.

[0040] In the following Figures, which are given as examples of the present invention, the illustrated protective clothing has been designed to allow a good air flow, and thereby a good cooling effect. More specifically, the protective clothing is designed to permit a significant air flow next to the player's skin. This improves cooling, and thereby improves the performance and comfort of the player. For a given output, the player will produce less sweat, because the sweat will largely be able to evaporate into the air flow, giving the required cooling. In the following Figures, it will be appreciated that the protective layer is held at a required distance from the player's skin by spacer members. The spacer members and the inner surface of the protective layer are designed to provide minimum resistance to the air flow in the spacing between the protective layer and the player.

[0041] Referring now to FIG. 3, there is shown protective clothing 12 in the form of a breast plate which extends over the player's shoulders. The protective clothing 12 comprises a protective layer 14 for providing protection from blows. The protective clothing 12 also comprises spacer members 16 for spacing the protective layer 14 from that part of a player's body (i.e. the chest) being protected by the protective layer 14.

[0042] The protective clothing 12 is such that the spacer members 16 are made of a resilient material for providing player comfort during use of the protective clothing. The resilient material may be, for example, a foamed plastics material. The spacer members 16 are 10-25 mm in depth for promoting optimum air flow between the protective clothing 12 and the part of the player's body to be protected. The spacer members are of a circular shape in plan which minimises their resistance to air flow through the spacing.

[0043] The protective layer 14 is made from a rigid or semi-rigid material. This material is only supported at intervals by the spacer members 16 and must be rigid enough to resist deformation under impact and tough enough not to fracture despite the presence of apertures 20. Forming stiffening ribs or corrugations as with prior art solutions is not possible as the inner surface 18 must be smooth. In one non-limiting embodiment the protective layer 14 is made from cross-linked polyethylene foam with a density of 70 to 115 Kg/M³ between 5 mm and 15 mm in thickness. The degree of cross-linking can be varied to render the material rigid or semi-rigid. The protective layer 14 has apertures 20 which enable air to pass through the protective layer 14 and provide the air for the air flow through the spacing.

[0044] The spacer members 16 are in the form of pads. The spacer members 16 extend in a line as shown along opposed

edges 22, 24 of the protective layer 14. The apertures 20 are centrally positioned between the two lines of the spacer members 16. The spacer members 16 in the form of the pads are circular in plan as shown.

[0045] Referring now to FIG. 4, there is shown protective clothing 26 which is in the form of a shield of the same shape as shown in FIG. 3. Similar parts have been given the same reference numerals for ease of comparison and understanding. In the shield 26, the apertures 20 are centrally positioned as shown. The protective clothing 26 has spacer members 28 in the form of strips. As shown, there are one longitudinally extending strip which is centrally positioned on the protective layer 14 and a plurality of transversely extending strips.

[0046] FIG. 5 shows protective clothing 30 which is generally elliptical. The protective clothing 30 comprises a protective layer 32 and spacer members 34. The protective layer 32 has apertures 36. The spacer members 34 form air ducts 38 which allow air flow through the spacing 40. The spacing 40 is formed between the protective clothing 30 and a player's torso 41. The air flow is shown by the arrows 42. FIG. 5 shows the use of a combined breast plate which might be of the type shown in FIGS. 3 and 4, and a similar back plate. In FIG. 5, the spacer members 34 are ribs extending to the torso 41.

[0047] FIG. 6 shows protective clothing 44 in the form of a pair of inline skating knee and shin pads. The protective clothing 44 is shown being worn on the legs 46 of a player wearing inline skates 48. The protective clothing 44 has a protective layer 50. The protective layer 50 has apertures 52 for enabling the passage of air shown by arrows 54. Although not shown in FIG. 6, the protective layer 50 is spaced from the player's legs 46 by spacer members which may be in the form of pads, strips or other configurations.

[0048] The spacer members used in the embodiment of the invention such as those illustrated in FIGS. 3 and 4 are preferably such that they have a smooth texture. If the spacer members are in the form of tapering pads or other tapering formations, then the spacer members preferably taper smoothly down to the inner surface of the protective layer. The spacer members may be truncated conical pads.

[0049] FIGS. 7 and 8 are charts showing the development of the boundary layer on each wall of an air passage at a low speed (1 m/s in FIG. 7) and a high speed (10 m/s in FIG. 8). It can be seen that the boundary layer increases in thickness along the length of the passage and that a turbulent boundary layer is thicker than a laminar boundary layer. It can also be seen that the low-speed boundary layers are generally thicker than the equivalent high-speed boundary layer. Fortunately, the laminar boundary layer will tend to predominate at the low speed because the flow is well below the critical Reynolds number at which transition to turbulent flow occurs. At the high speed, the boundary layer may become turbulent because although the Reynolds number is still sub critical the entry conditions and smoothness of the walls (one of which may be the skin of the wearer) mitigate against laminar flow. It can be seen therefore that the thickness of the boundary layer will be approximately the same in either case. Because a boundary layer develops on each wall, in order to maintain some free stream flow in the passage, the separation between the wall should be a little more than double the boundary layer thickness for the required path length. For example in the case of a breastplate as in FIG. 4 where the path length is approximately 0.3 m the separation should be between 20 and 25 mm. For a leg pad where the path length may be 0.16 m a separation of 15 mm would be adequate.

[0050] It is to be appreciated that the embodiments of the invention described above with reference to FIGS. 3-8 of the accompanying drawings have been given by way of example only and that modifications may be effected. Thus, for example, the shape of the apertures 20, 52 may be other than circular. The protective clothing may be used by persons who require protection other than in sport. In FIGS. 4 and 5, the central rib is shown to be tapered in towards the protective layer. This is to provide a fillet to guide the air flow into the passage. This might prove to be unnecessary. The other transverse ribs might with benefit taper in the opposite sense to give the maximum area for adhesion to the protective layer and the minimum area on contact with the skin. The resilience of the rib would then ensure that the area in contact with the skin would naturally increase to spread the load in the event of an impact.

1. Protective clothing comprising a protective layer for providing protection from blows, and spacer members for spacing the protective layer from that part of a person's body being protected by the protective layer: and the protective clothing being such that:

- (i) the spacer members are made of a resilient material for providing comfort during use of the protective clothing;
- (ii) the spacer members are 10-25 mm in depth for promoting optimum air flow between the protective clothing and the part of the person's body to be protected;
- (iii) the spacer members are of a shape which minimises their resistance to the air flow through the spacing;
- (iv) the protective layer is made of a rigid or semi-rigid material;
- (v) the protective layer is curved for conforming to that part of the person's body to be protected; and
- (vi) the protective layer has an inner surface which is formed to minimise resistance to the air flow through the spacing.

2. Protective clothing according to claim 1 in which the protective layer has apertures which enable air to pass through the protective layer and provide air for the air flow through the spacing.

3. Protective clothing according to claim 1 in which the spacer members are in the form of pads.

4. Protective clothing according to claim 3 in which the pads extend in a line along opposed edges of the protective layer, and in which the apertures are centrally positioned between the two lines of pads.

5. Protective clothing according to claim 3 in which the pads are circular in plan.

6. Protective clothing according to claim 1 in which the spacer members are in the form of strips.

7. Protective clothing according to claim 6 in which the strips comprise a longitudinally extending strip which is centrally positioned on the protective layer, and a plurality of transversely extending strips.

8. Protective clothing according to claim 1 in which the spacer members form air ducts, and in which the air ducts receive the air flow through the spacing.

9. Protective clothing according to any one of the preceding claims in which the spacer members have an area in contact with the skin or underclothing of the person which is less than 25% of the area of the protective layer.

10. Protective clothing according to claim 1 in which the spacer members are made of a closed cell polymer foam.

11. Protective clothing according to claim 1 in which the protective layer is made of a rigid material.

12. Protective clothing according to claim 1 in which the protective layer is made of a semi-rigid material.

13. Protective clothing according to claim 1 in which the protective layer is made from cross-linked polyethylene foam.

14. Protective clothing according to claim 1 further including at least one battery powered fan.

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