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New Textile Concepts for Use in Control of Body Environments

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Summary

Double layer, or **three dimensional**, textile constructions have been manufactured for some years by Heathcoat in the form of **spacer** fabrics based on a warp knitted construction and also woven double layer products used in the civil engineering industry. The upper and lower layers of such products are interconnected with common threads during the manufacturing process.

In this paper, I hope to convey the new **functional** products that are becoming available in **double layer constructions** from the John Heathcoat textile company.

The R&D Department at Heathcoat have developed a series of novel composite fabrics based on double layer substrates, categorised for discussion as follows:

Woven:
1. Coated – no spring support
2. Coated with spring support

Warp and Weft Knitted:
3. Spring support, no coating
4. Spring support, coated both faces.

A specific design is chosen for weaving the following Category 1 fabric so that the **single and double layer sections** are formed in **alternating rows**. A specially controlled application of an **impervious coating** is then bonded to one face, as shown in *Figure 1.*

If the **cavities** formed by the double layer sections are sealed at one end and **air is blown into the open ends**, the selected porosity of the non-coated face will allow **inflation** which forms a series of **cylindrical cavities; air** will then issue from the **whole area of the porous face** of the cavities. An application of this concept has been developed with MAFF funding, and demonstrated to be very effective, for the **localised cooling** of food on conveyer lines. In addition to maintaining the chilled state of the food, **bacterial challenge** studies found virtually **no contamination** of the area from a high concentration of **introduced bacteria.**

A major benefit of this system is that it allows the **operative** to work in **ambient temperature** conditions since there is not a need for the current practice of chilling the whole room.

Other areas of application are being pursued where localised control of temperature and bacterial contamination are of interest.

The **limiting characteristic** of this category product however is that, in applications where the localised air delivery product is likely to encounter **points of external pressure** to the surface or **sharp bending** of the fabric, the inflated **cavities will collapse** at those points and **restrict or prevent air-flow** along them. To overcome this, **helically coiled plastic springs** are **inserted** into the double layer cavities.

Paper presented at the RTO HFM Symposium on "Blowing Hot and Cold: Protecting Against Climatic Extremes", held in Dresden, Germany, 8-10 October 2001, and published in RTO-MP-076.

A range of springs, made from **Delrin acetyl resin**, have been investigated with the help of DuPont polymers and *Figure 2* shows just a few of the **profiles** produced. Typical diameters are 5 to 10 mm.

The **modified properties** of the composite, imparted by the springs, are **unique** and open up **new functionalities** for garments and footwear.

Category 2 consists of double layer woven fabric with an **impervious coating** on one face **as before** but now with the **plastic springs inserted** into the cylindrical cavities.

If air is supplied, through a manifold, into the ends of the cavities it will issue from the whole of the porous face of the composite, see *Figure 3.*

This concept is being developed by the **Defence Logistics Organisation** in the UK, who have funding from the MOD for **optimising the design** of a **microclimate garment**. This will incorporate work by **TNO** in the Netherlands, who will continue the human factor studies in their environmental chamber trials, and composite optimisation by Heathcoat. Such a **forced air** system would allow **natural cooling** of the body through **latent heat** of evaporation of sweat and **Hohenstein skin model** studies will also be made by **DLO.**

The use of coiled plastic springs, as opposed to perforated plastic tubes for instance, maintains the **essential textile characteristics in the product** of flexibility, stretch and drape whilst showing, with the springs used so far, a **crush resistance** of greater than 20 tons per square meter. This means that a person can **lie**, **sit** or **stand** on the product without collapse of the air-carrying cavities. Garments containing such panels are **durable** to being washed in a domestic washing machine.

Figure 4 shows the first **demonstrator vest trials by TNO**, in conjunction with **past studies** done by Defence Clothing and Textiles Agency on **air-cooling garment**s, have shown that this composite structure fabric is the **way to proceed** for a **practical microclimate system** which can be worn by the **dismounted infantryman.**

Re-design of a number of features is planned. For instance the **re-chargeable power pack**, which currently weighs a reasonable **800g**, could be **significantly lighter** in weight with the **same power output** if the most modern battery systems are used. The **portable system** would last for **eight hours** in the field before any re-charging of the power pack **at the vehicle** is needed.

The air delivery **manifold system** from the **lightweight plastic pump** and **filter unit** will be **condensed into the garment** probably as a spring supported fabric tube and, if necessary, **replaceable silica gel sachets** will allow **dry air** to be supplied over the skin in conditions of **high ambient humidity.** No problems are expected with air filtration situations since the **rate of air exchange** demanded by this system is **relatively low.**

The **initials trials** by TNO have demonstrated the need for improvement in **ease of escape** of the delivered air **from the skin surface** and this is expected to be achieved by **cutting away** sections of the **coated layer in the fabric;** this would leave **alternating air delivery sections** and **air escape sections**. Such an arrangement would also allow the microclimate garment to be worn **without extra heat stress** if the portable **air pump system fails.** See *Figure 5.*

Figure 6 shows Category 3 composites that consist of **open mesh** warp knitted double layer fabrics **without** an impervious coating but **with springs inserted.** This creates a **very light-weight** separator product with **very high crush resistance** for environments where an air gap has to be **maintained** even when **high external pressure** might be encountered. This type is under development for **aesthetically acceptable impact protection pads**.

Category 4 development (see *Figure 7*) incorporates the Category 3 product shown on the previous slide. **Gas impermeable membrane** such as butyl rubber, is bonded to **both faces** and **sealed** round the edges except for a **one way valve.** Air is withdrawn from the **whole enclosed cavity layer** to create a high vacuum. **Total vacuum** is easily possible without the springs collapsing and since the **material volume content** in the cavity is **less than 5%**, there is more than **95% vacuum space**. With the presence of an

aluminised outer surface for **reflecting** heat, the opportunity for **heat penetration** through the composite is **minimised.**

The product offers a **unique**, very **flexible**, **wrap round vacuum layer** for **heat** and **sound insulation** and has potential application in **preventing heat loss** or heat **gain** in **blanket** or **garment** type products.

Further **concepts** covered by this series of **patents** involve effects from **rotating the springs** in the fabric cavities in **two different modes**. Textile fabric constructions are possible whereby very **open surface cover sections alternate** in the double layer cylindrical cavities with **more solid cover areas**. If the springs are designed to **coordinate in their shape** with this arrangement of the fabric, **rotation** of the springs in a **non-**screw manner will **open and close the windows** in the fabric, shown in *Figure 8*. If the rotation of the springs is **controlled by temperature sensors**, an **intelligent** fabric will result which has a **variable climate and would** react to **prevailing climatic conditions.**

An **intelligent chameleon effect** can also be produced using springs which have **stripes of three different colours** around their circumference. Rotation of the springs in **a screw fashion** will present a new colour impression to the windows with each **one third revolution** of the springs in the fabric.

Other novel functionalities with these constructions are in **skin surfac**e, or other surface, **vacuum effect** and also for **fluid drainage** from the body.

These concepts are covered by the following Heathcoat patents:

•Gas Delivery Device: EU App. No. 97308535.0

•Fabric with Helical Support: EU App. No. 99309484.6

•Adaptive Material: EU App. No. 00301728.2

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•Claude Maat: Bobet, Rouen, France - Specialist Coating

•Neil Dennis-Purves: John Heathcoat & Co. Ltd. - Research Assistance.

FIGURE 1

CATEGORY 1: WOVEN - COATED

NO SPRINGS SUPPORT

Air inflates the tubes and issues from the whole porous face

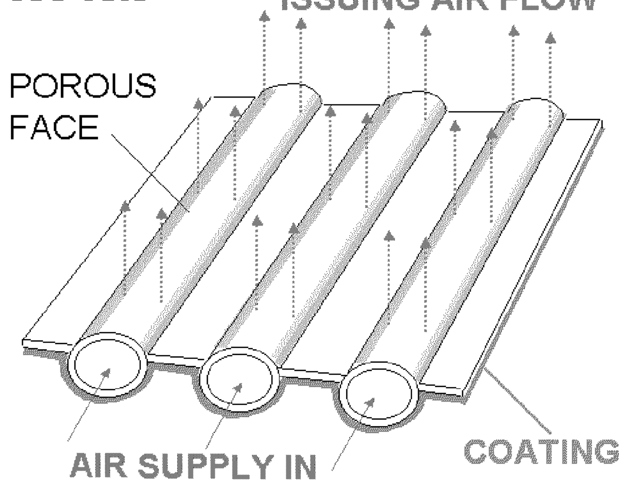


FIGURE 2

SELECTION OF SPRINGS

8 mm

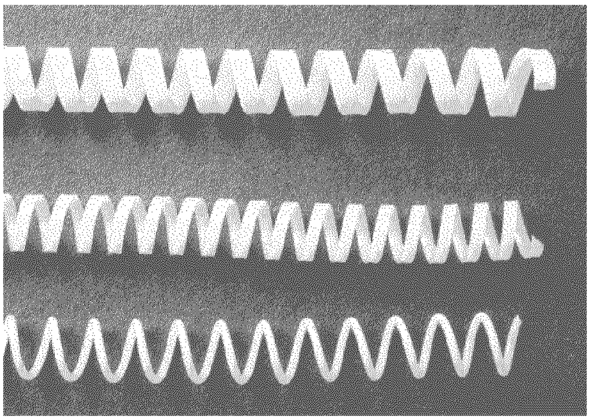
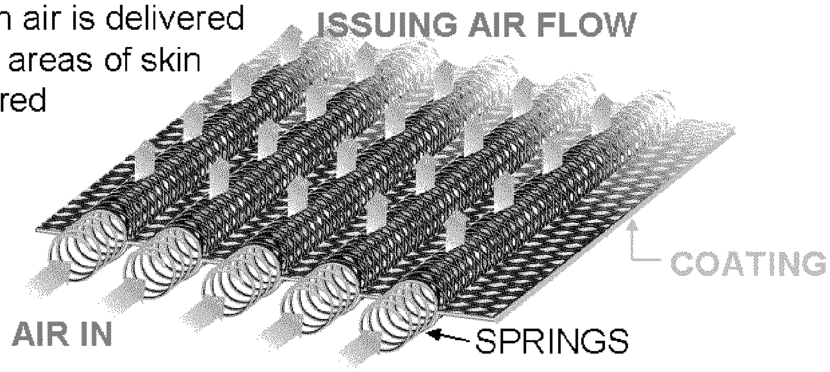


FIGURE 3

CATEGORY 2: WOVEN - COATED

SPRINGS SUPPORT

Fresh air is delivered to all areas of skin covered



The spirals maintain air flow by preventing crushing of the cavities

The material is totally flexible

FIGURE 4

MICROCLIMATE VEST

FIGURE 5 CATEGORY 2 WITH SOME COATED SECTIONS CUT AWAY

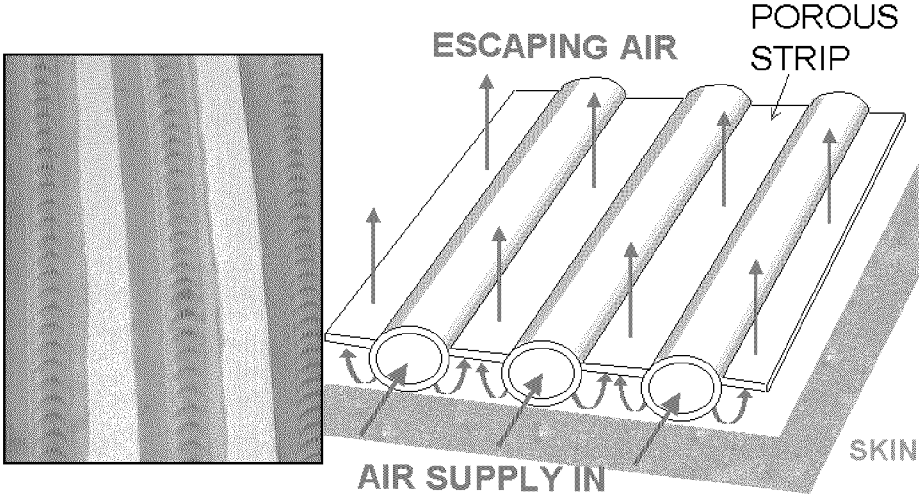


FIGURE 6

CATEGORY 3: KNITTED WITH SPRINGS

NO COATING

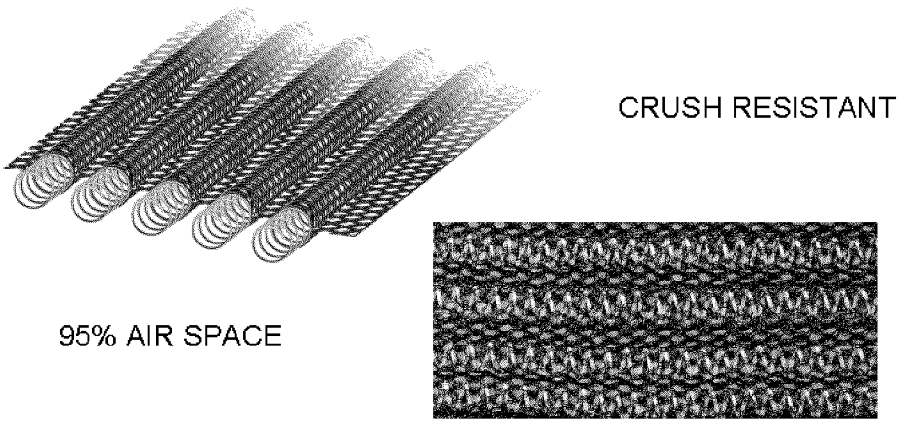


FIGURE 7

CATEGORY 4: VACUUM LAYER EFFECT

IMPERVIOUS BUTYL COATING ON BOTH FACES

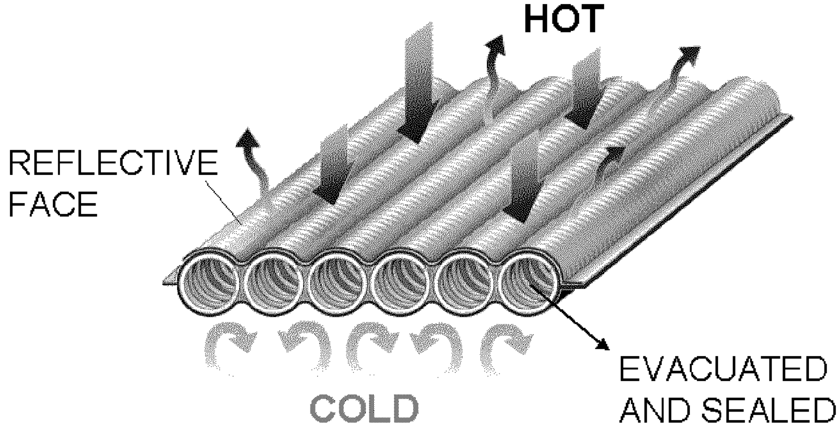


FIGURE 8

VARIABLE CLIMATE FABRIC

SEQUENCE OF ROTATION OF SPRINGS