

March 31, 1959

A. M. EVANS

2,879,654

ARMORED UNDERGARMENT

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2 Sheets-Sheet 1

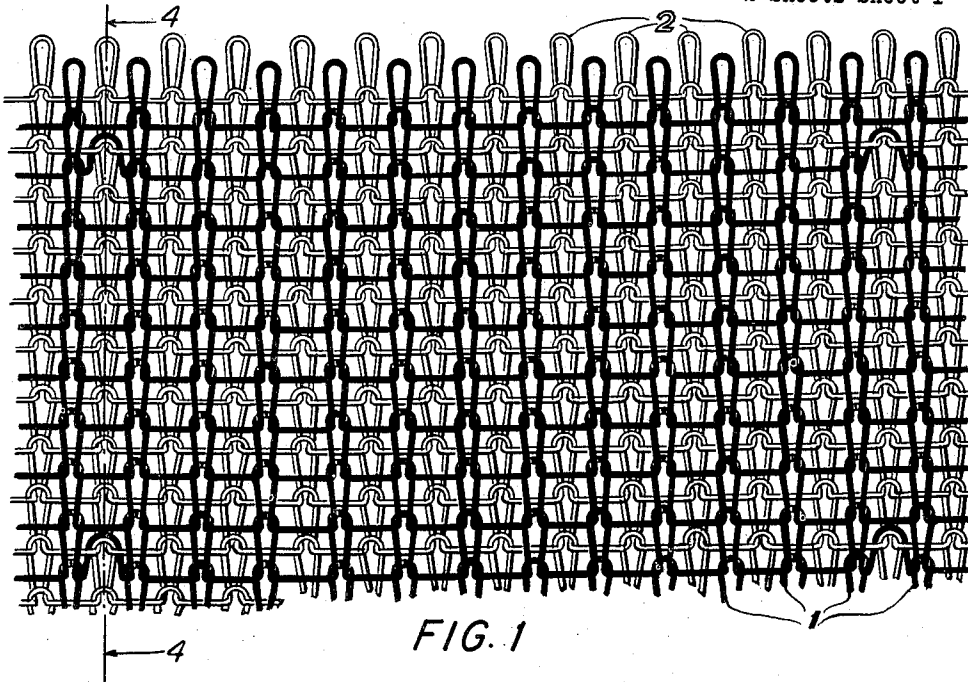


FIG. 1

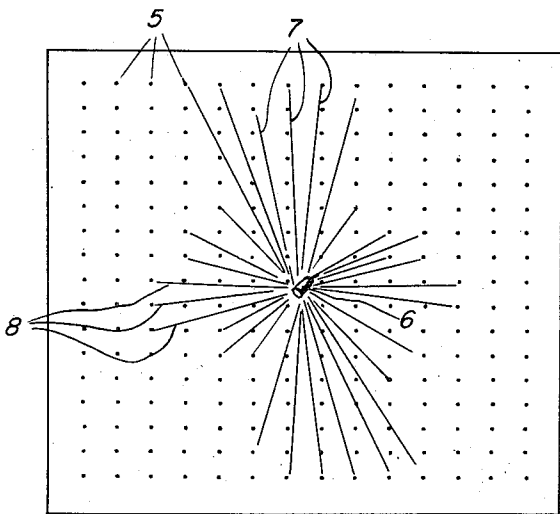


FIG. 2

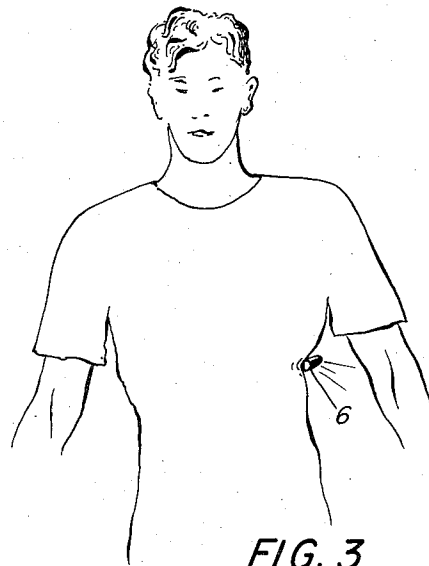


FIG. 3

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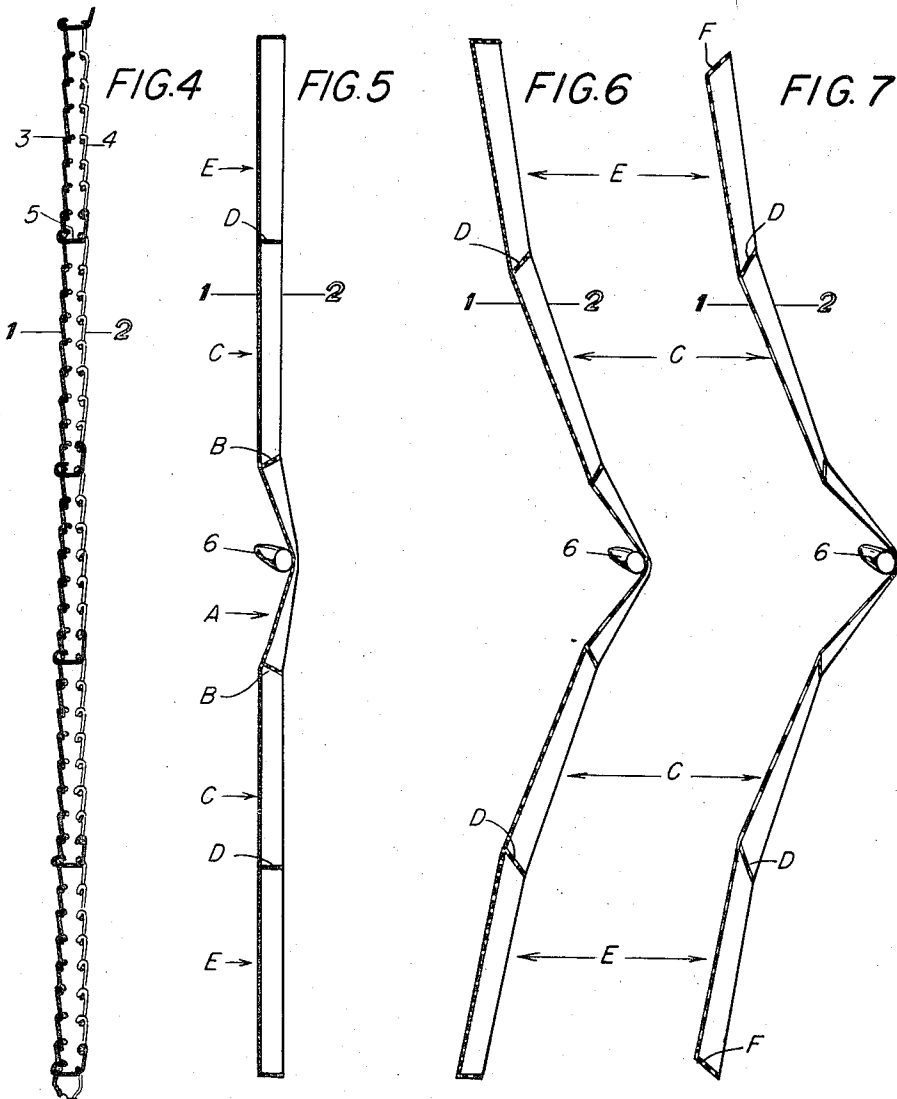
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7 Claims. (Cl. 66—176)

This invention relates to an armored undergarment and more particularly to a two-layer knitted undergarment adapted to give protection against the impact of flying fragments such as spent bullets or shrapnel.

It is known that the majority of injuries in war from enemy fire are due to spent fragments rather than direct hits. It is also true that it is particularly difficult to stop bleeding if an artery under the arm is cut. Furthermore, spent fragments cause shock which frequently incapacitates a man. Effort have heretofore been made to use a multi-layer blanket of high tenacity nylon as an outer garment or suit of armor. This proved too bulky and heavy to be practical. I have found how to construct undergarments to fulfill this armor function without increasing the number or bulk of the wearer's garments. It is characteristic of the two-layer weft knit fabric of the present invention that the two webs or layers are united only at intervals spaced both walewise and coursewise and that the inner layer is composed of substantially inelastic yarn which has absorbent qualities, while the outer layer is of high tenacity yarn of far greater elasticity than the inner layer.

In the drawings:

Fig. 1 is a face view on a large scale of a piece of two-layer weft knit fabric adapted for use in undergarments made in accordance with the present invention.

Fig. 2 is a diagram showing the lateral stresses set up in such fabric by the impact of a spent bullet.

Fig. 3 is an outline of a man wearing a T-shirt made in accordance with the present invention, showing a spent bullet striking under the left arm.

Fig. 4 is a view in transverse section through the fabric of Fig. 1, taken in a walewise direction on the line 4—4 of that figure.

Figs. 5, 6 and 7 are diagrams corresponding to the sectional view of Fig. 4, showing the stretching and tensioning of the various parts of the fabric under impact of a spent bullet. Fig. 5 shows the outer layer of the section at the point of impact slightly stretched. Fig. 6 shows three sections of the fabric pushed out of position on each side of the point of impact and snubbed by the inelastic inner layer. Fig. 7 shows these sections completely stretched and all transmitting the strain to the inner layer for snubbing.

The undergarment of this invention is made of that type of double layer knitted fabric known as bi-knit fabric. By this is meant two independent webs or layers of weft knit plain, i.e., Jersey fabric, united or tied across to each other at intervals spaced in both the walewise and the coursewise directions. A fabric of this general description is found in the old U.S. patent to Bellis No. 709,734, dated Sept. 23, 1902. These garments have generally been knit with the inner layer that lies next to the skin made of cotton and the outer layer of wool. In the example which I have chosen as one illustration of my invention there is a staple yarn composed of a blend of 50% wool and 50% cotton singles for the inner layer and high tenacity nylon of 260 denier

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for the outer layer. It will be noted that the inner layer yarn is a relatively inelastic one. This has the desirable features needed for ventilation and it also can absorb perspiration, blood, etc., as well as provide desirable warmth.

As stated, the outer layer of bi-knit, two-layer fabric has heretofore been knit of wool or similar yarn, but it is found that use of such yarn in the outer layers fails to accomplish the objects of the present invention.

As shown in Figs. 1 and 2, my fabric comprises an outer layer 1 and an inner layer 2 each made of plain weft knit loops 3 and 4 respectively. As shown in Fig. 1, for example, at every eighth course and every twelfth wale, the yarn of the outer layer 1 is interlooped with a stitch of the inner layer 2. Such tying-in loops are marked with the numeral 5 in Figs. 1, 2 and 4. The spacing of the looped wales or courses can be varied. It will be understood that these tying-in loops may be formed out of the outer or face layer yarn or of the inner or back layer yarn. I prefer to use the outer layer yarn. The fabric as described thus far in this paragraph resembles generally the fabrics of the Bellis patent above mentioned.

I find that by using bi-knit fabric with a relatively inelastic yarn for the inner layer and a heavy relatively elastic yarn of high tenacity for the outer layer, it is possible to get the coordination of resilience and snubbing which gives the undergarment a valuable armored characteristic.

It has further been found that by using an undergarment for body armor it is possible, by means of the construction about to be described, to coordinate the snubbing effect of the human body with the snubbing of the garment.

I have found that the garment must create a preliminary snubbing and cushioning effect by a coordination of the spaced tying-in or interlocked stitches with layers of different characteristics as to resilience and preferably also as to strength. I use a yarn of extremely high strength in the outer layer. This yarn must also be of higher resilience than the yarn of the inner layer. One example of such a yarn is high tenacity nylon. A yarn with a dull finish and a monofilament is preferred, though this is not essential. High tenacity nylon has less elasticity than ordinary nylon but still it is very elastic compared to ordinary yarns such as cotton or wool. On the other hand, it provides almost unbreakable strength; and yet, the outer layer can "give" resiliently without breaking. Such a yarn can be said to have "high residual strength" after it is stretched. (By "residual strength" is meant the tensile strength of the yarn when stretched.) It is possible to use any natural or man-made fibers in the outer layer of my fabric, the requirements being merely that the outer layer be more resilient and the yarn strong, and that the inner layer be substantially inelastic. The yarn used in the nylon layer should be yarn of higher tenacity and greater elasticity, and should be relatively heavier, than the cotton and wool yarns used so as to have the highest snubbing effect possible.

In all of the fabrics shown in the drawings the courses and the wales of the two layers are actually behind each other, viewed from the face, the offsetting of the courses and wales in Fig. 1 being merely to show the interlooping more clearly. The tying-in loops 5 therefore are between an adjacent wale in each of the layers of the fabric. The cross-connecting stitches can come from either or both layers of webs but I find it preferable to have them made of the resilient high-residual-strength yarn of the outer layer.

Like other plain weft knit fabric, the knitted stitches themselves have some elasticity by virtue of their looped

structure. However, the fabric as a whole has very little stretch in the walewise direction but has more stretch in the coursewise direction. This extensibility due to the looped structure is practically the only extensibility of the inner web or layer of my fabric.

Fig. 2 is a diagram of the outer face of a piece of bi-knit fabric such as shown in Fig. 1 in which the dots represent the tying-in loops 5 that interlock with the back or inner fabric layer 2. A spent bullet 6 is represented hitting the fabric, and the radiating lines 7, 8 represent the radial pulls on the cloth due to the impact. It will be noted that the strains going to the tying-in loops 5 are represented. This is done because it is at these points that the moderately resilient and high-residual-strength nylon is concatenated with the relatively inelastic inner layer. The sequence and coordination of resilience and snubbing that brings the flying fragments to a stop without breaking any of the stitches apparently are follows.

At first the impact is received by the high tenacity nylon alone. The nylon stretches somewhat, as indicated by the small breaks in the solid line showing of the nylon at the center fabric section A (Fig. 5). It will be seen that the resulting tension is transmitted to the inner layer at the tying-in loop B on each side of the point of impact. Almost immediately after this stretch at section A the outer layer 1 begins to push on the inner layer 2 and the resilience of the stitches of cotton and wool permits the inner layer between the two tying-in loops at B to stretch slightly. This takes up all the stretch in this section of the inner fabric, and snubbing begins.

In Fig. 6 the nylon at section A has received its full stretch and will pass on the pull to the fabric at a greater distance from the point of impact. It does this mostly to the inner layer in the adjacent section C on each side of the point of impact through the tying-in loops at B. However, some of the pull goes to the nylon in the sections C. This nylon stretches. The inner layer in section C takes up a little of the shock with the resilience of its loops and then snubs by passing on to the next section E. In the meantime the nylon in section C transmits most of the pull on it to the inner layer of section E by means of the tying-in loops at D location between sections C and E.

Fig. 7 shows the effect of the impact spreading further in a walewise direction. Here the nylon in section C has become stretched to the full and the nylon in section E is partly stretched. This brings in the tying-in loops at F beyond section E.

Thus it will be seen that each extension of the resilience of the nylon is followed by a transfer of a major part of the pull to the inner layer. In addition to the taking up of the resilience of the stitches of cotton and wool followed by the solid snub of the inner layer, there is the relation to the body. If the impact is great enough, the inner layer of the fabric will move frictionally with relation to the skin, i.e., toward the point of impact. The stretching of the fabric out of line, as in Figs. 6 and 7, may be due in part to the resilience of the nylon yarn, in part to the resilience of the stitches in both layers of the fabric, and in part to frictional sliding of the inner layer 2 on the human skin. At the same time that the strain lines 7 are extending in a generally walewise direction (see Fig. 2), the strain lines 8 are spreading in a coursewise direction. They do not spread in a coursewise direction as fast as in a walewise direction because the fabric has greater elasticity in the coursewise direc-

tion and the strain as such does not begin until the resilience has been expended. Thus in Fig. 2 I have shown walewise strains 7 of a maximum of eight sections or eight tying-in loops on each side of the point of impact but the coursewise strains 8 of a maximum of five sections or tying-in loops. The dislocation of the fabric also occurs in a coursewise direction to whatever extent is necessary. Thus a much larger area of the inner layer 2 is involved in the snubbing than of the outer layer 1. The sequence of resilience and snubbing snubs the spent bullet to the point where the flesh can finish the snubbing without breaking the nylon.

I prefer to make an undershirt with quarter sleeves, as shown in Fig. 3, to protect the under-arm area.

What I claim is:

1. An armored undergarment comprising two separate layers of knitted plain fabric united only at spaced wales and spaced courses by loops of yarn from one layer tied to loops in the other, in which the inner layer is composed of substantially inelastic yarn and the outer layer of yarn of higher tenacity, greater elasticity and relatively heavier than the inner layer yarn; whereby a spent missile hitting the outer layer will be retarded and snubbed without yarn breakage.

2. An armored undergarment comprising two separate layers of weft knit plain fabric united only at spaced wales and spaced courses by loops of yarn from the outer layer tied to loops in the inner layer, in which the inner layer is composed of substantially inelastic yarn and the outer layer of yarn of higher tenacity and of greater elasticity and heavier than the inner layer yarn, the outer layer being nylon yarn of at least 260 denier; whereby a spent missile hitting the outer layer will be retarded and snubbed without yarn breakage.

3. An armored undergarment comprising two separate layers of weft knit plain fabric united only at spaced wales and spaced courses by loops of yarn from one layer tied to loops in the other, in which the inner layer is composed of substantially inelastic cotton and wool yarn and the outer layer of high tenacity yarn of greater elasticity than the inner layer yarn; whereby a spent missile hitting the outer layer will be retarded and snubbed without yarn breakage.

4. An armored undergarment according to claim 3 in which the outer layer is composed of high tenacity monofilament nylon having greater elasticity than the inner layer yarn.

5. An armored undergarment according to claim 4 in which the inner layer yarn is substantially half cotton and half wool, and the nylon is dull finish and heavier than the cotton and wool yarn.

6. An armored undergarment according to claim 4 in which there are sleeves covering the underarm area.

7. An armored undergarment according to claim 4 in which the loops of yarn uniting the layers are of the high tenacity monofilament nylon from the outer layer.

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