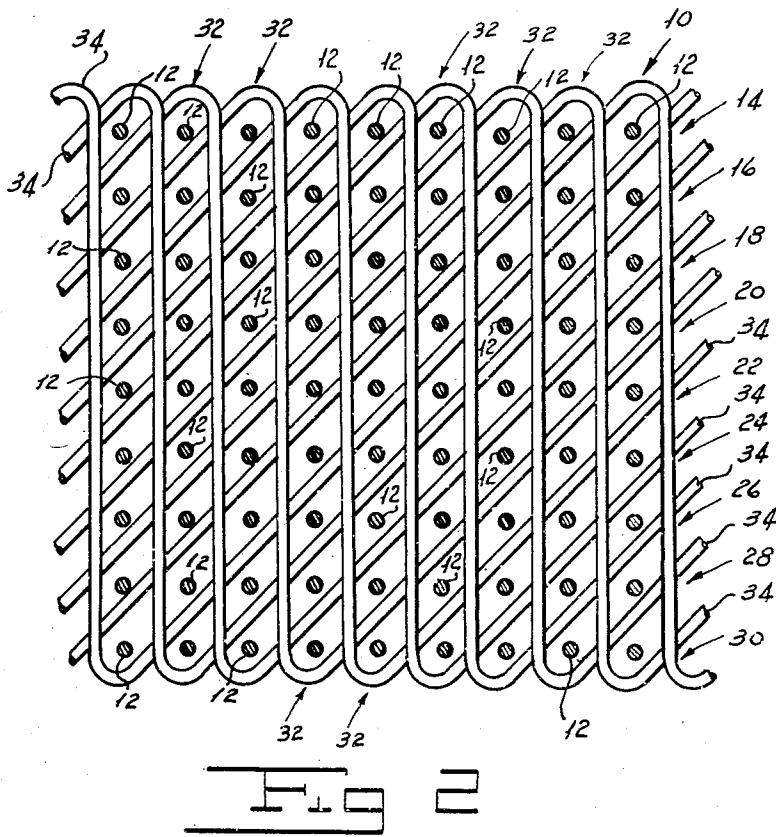
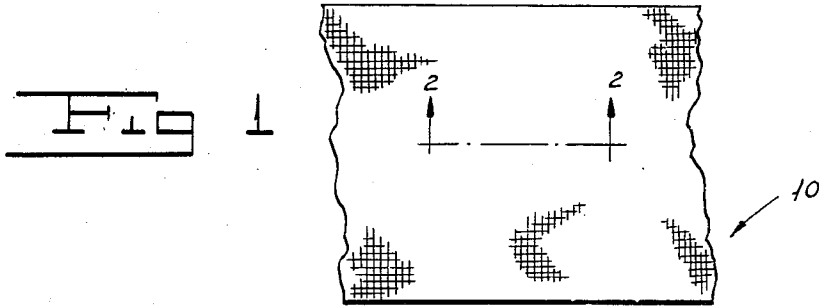


Aug. 18, 1959

W. S. FINKEN ET AL
UNITARY BALLISTIC FABRIC

2,899,987

Filed May 19, 1955



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2,899,987

UNITARY BALLISTIC FABRIC

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Application May 19, 1955, Serial No. 509,455

8 Claims. (Cl. 139—408)

Our invention relates to a unitary ballistic fabric and more particularly to a unitary ballistic fabric which is homogeneous and which has a high degree of resistance to penetration by flying fragments, missiles or other projectiles.

In the manufacture of protective armor for wearing apparel and the like, plastic material or synthetic resin material is rapidly replacing metal as a material from which the armor is formed. Plastic material armor is more flexible, lighter, and more easily formed into a suitable shape than is metal armor. Various forms of plastic armor have been suggested in the prior art. The copending application of Leonard P. Frieder et al., Serial No. 362,338, filed June 17, 1953, now Patent No. 2,816,578, discloses a ballistic cloth or textile armor including a plurality of fabric laminates bonded by yarns passing from laminate to laminate at spaced points. Each of the fabric laminates of the ballistic cloth disclosed in the said copending application includes a plurality of entwined warp and weft yarns. We have discovered that while the ballistic cloth has superior penetration resisting qualities to the plastic armors disclosed in the prior art, the entwined warp and weft yarns of an individual fabric laminate tend to shear each other under the force of impact of a missile, flying fragment or the like. As is pointed out in the said copending application, the ballistic cloth relies in part on the tensile strength of the bonding yarns to resist the force of penetration of a flying fragment or missile.

We have invented a unitary ballistic fabric having a different construction than the ballistic cloth disclosed in the said copending application. The warp and weft yarns of our unitary ballistic fabric are not entwined in the manner of a conventional fabric of the prior art but are held together in a manner which reduces the shearing action between entwined yarns. The warp yarns of our unitary ballistic fabric which pass through a number of layers of weft yarns are subject to compression rather than tension when the fabric is struck by a missile, with the result that the desirable features of our fabric are enhanced in a manner to be described more fully hereinafter.

One object of our invention is to provide a unitary ballistic fabric which has a high degree of resistance to penetration by flying fragments, missiles or like projectiles.

Another object of our invention is to provide a unitary ballistic fabric which is homogeneous.

A further object of our invention is to provide a unitary ballistic fabric in which the warp and weft yarns are not entwined in the conventional manner of fabrics of the prior art.

Other and further objects of our invention will appear from the following description.

In general, our invention contemplates the provision

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of a unitary ballistic fabric including a plurality of superimposed layers of substantially straight, vertically aligned, weft yarns. The warp yarns of the fabric alternately pass substantially perpendicularly through the layers between a pair of adjacent columns of weft yarns from top to bottom of the fabric and then pass diagonally upwardly through the weft yarn layers from bottom to top of the fabric. Advantageously, we form the yarns of our fabric from synthetic resin, continuous filament threads spun to a predetermined number of convolutions per unit length.

In the accompanying drawings which form part of the instant specification and which are to be read in conjunction therewith and in which like reference numerals are used to indicate like parts in the various views:

Figure 1 is a fragmentary plan view of our unitary ballistic fabric.

Figure 2 is a fragmentary sectional view, drawn on an enlarged scale, of our unitary ballistic fabric, taken along the line 2—2 of Figure 1.

More particularly referring now to the drawings, our unitary ballistic fabric, indicated generally by the reference character 10, includes a plurality of superimposed layers of weft yarns 12. In the form of our invention shown in the drawings, the fabric includes nine layers of weft yarns 12, the respective layers being indicated generally by the reference characters 14, 16, 18, 20, 22, 24, 26, 28 and 30. The layers of the fabric are vertically aligned so that a plurality of wefts 12, each of which is taken from one of the respective layers of the fabric, form substantially straight columns, indicated generally by the reference character 32, from top to bottom of the fabric as viewed in Figure 2.

Our fabric includes a plurality of warp yarns 34. In forming our fabric, we first pass each of the warp yarns 34 substantially vertically downwardly, as viewed in Figures 2, between a pair of adjacent weft yarn columns 32 to the bottom of the fabric. We then pass the warp yarn 34 around the lowest weft 12 in a column 32 and direct it diagonally upwardly to the top of the fabric. After passing around the uppermost weft yarn 12 of a column 32, the warp again passes substantially vertically downwardly between another pair of adjacent columns 32. In order that there be a minimum of entwinement between the warp yarns 34 and the weft yarns 12, we dispose the diagonally extending portions of the warp yarns 34 at an angle of approximately forty-five degrees to the plane of the surface of the fabric. While we have shown a fabric including only nine layers of weft yarns 12, it will readily be understood that we may employ any convenient number of layers.

When a flying fragment, missile or like projectile strikes the surface of our fabric 10, the warp yarns are subjected to a compressive force. The substantially vertically extending strands of these yarns 34 between adjacent columns 32 compress along their lengths to fill the voids between the columns 32. This action maintains the vertical alignment of the weft yarns 12 of the columns 32. The compressive force exerted on the diagonal strands of the warp yarns also maintains the horizontal alignment of weft yarns 12 in a layer. It will be seen that under the impact of a missile, or the like, the warp yarns of our fabric compress to fill the voids and eliminate open spots in the fabric to present a compact mass to the missile. This compression of the warp yarns contributes to the elimination of the shearing action under impact present in conventionally woven fabrics in which warp and weft yarns are entwined.

Advantageously, we form both the weft yarns 12

and warp yarns 34 of our fabric from synthetic resin continuous filament threads spun to a predetermined number of convolutions per unit length. As is disclosed in the said copending application, preferably we employ a material such as nylon, polyester filaments, polyvinyl filaments or the like, and spin the threads to a predetermined number of convolutions per unit length corresponding to a tension which produces an elongation of the filaments which is between fifty percent and ninety percent of the ultimate elongation of the filamentary material being used.

In use of our unitary ballistic fabric, it may be formed to any suitable shape for use as an article of wearing apparel, or the like. As many layers of the fabric as desired may be used. It may form a fabric laminate of a laminated ballistic cloth bonded at spaced intervals over the surface of adjacent laminates by any convenient means. A missile, flying fragment, or the like, impinging on the surface of our fabric compresses warp yarns 34. As they are compressed these yarns deform radially to fill voids in the fabric and thus resist penetration. Our fabric eliminates the danger of shearing of entwined warp or weft yarns when struck by a missile or the like. It presents a solid, substantially homogeneous mass to the missile, fragment or like projectile to resist penetration.

It will be seen that we have accomplished the objects of our invention. We have provided a unitary ballistic fabric which has a high degree of resistance to penetration by flying fragments, missiles and the like. Our fabric minimizes the shearing action under tension between entwined warp and weft yarns in fabrics of the prior art. Our ballistic fabric is substantially homogeneous. Since the warp yarns are compressed when a missile impinges on the surface of the fabric, the fabric acts similar to a solid, multiply structure in resisting penetration. Our ballistic fabric is light, flexible and easily formed into and especially suitable for manufacture of articles such as wearing apparel and the like. We are able to retain flexibility yet approach or surpass the efficacy of plastic impregnated glass fiber laminated armor.

It will be understood that certain features and sub-combinations are of utility and may be employed without reference to other features and sub-combinations. This is contemplated by and is within the scope of our claims. It is further obvious that various changes may be made in detail within the scope of our claims without departing from the spirit of our invention. It is therefore to be understood that our invention is not to be limited to the specific details shown and described.

Having thus described our invention, what we claim is:

1. A unitary ballistic fabric including in combination a plurality of superimposed layers of first yarns including a top layer and a bottom layer, the yarns of each of said layers being substantially vertically aligned with respective yarns of the remainder of said layers to form a plurality of columns of said first yarns, each pair of adjacent columns of yarns including a pair of adjacent yarns from each of said layers, and a plurality of second yarns, at least one of said second yarns alternately passing downwardly from said top layer between a pair of adjacent columns between the yarns of each one of said pairs of layer yarns making up said adjacent columns to said bottom layer and diagonally upwardly from said bottom layer to said top layer, said one of said second yarns traversing a plurality of columns in its passage from the bottom layer to the top layer.

2. A unitary ballistic fabric including in combination a plurality of superimposed layers of weft yarns including a top layer and a bottom layer, the weft yarns of each of said layers being substantially vertically aligned with respective weft yarns of the remainder of said layers to form a plurality of columns of weft yarns, each pair of adjacent columns of weft yarns including a pair of adjacent weft yarns from each of said layers, and a plu-

rality of warp yarns, at least one of said yarns alternately passing downwardly from said top layer to said bottom layer between a pair of adjacent columns of weft yarns between the yarns of each one of said pairs of layer weft yarns making up said adjacent columns and passing diagonally upwardly from said bottom layer to said top layer, said one of said warp yarns traversing a plurality of columns in its passage from the bottom layer to the top layer.

3. A unitary ballistic fabric including in combination a plurality of superimposed layers of weft yarns including a top layer and a bottom layer, the weft yarns of each of said layers being substantially vertically aligned with respective weft yarns of the remainder of said layers to form a plurality of columns of weft yarns, each pair of adjacent columns of weft yarns including a pair of adjacent weft yarns from each of said layers, and a plurality of warp yarns, at least one of said warp yarns passing downwardly from said top layer between a pair of adjacent columns between the yarns of each one of said pairs of layer weft yarns making up said adjacent columns to said bottom layer and around a yarn of said bottom layer and diagonally upwardly through said layers to said top layer and around a yarn of said top layer, said one of said warp yarns traversing a plurality of columns in its passage from the bottom layer to the top layer.

4. A unitary ballistic fabric including in combination a plurality of superimposed layers of weft yarns including a top layer and a bottom layer, the weft yarns of each of said layers being substantially vertically aligned with respective weft yarns of the remainder of said layers to form a plurality of columns of weft yarns, each pair of adjacent columns of weft yarns including a pair of adjacent weft yarns from each of said layers, and a plurality of warp yarns, at least one of said warp yarns including a first length extending from said top layer to said bottom layer between a pair of adjacent columns between the yarns of each one of said pairs of layer weft yarns making up said adjacent columns and a second length extending diagonally from the bottom layer to the top layer tangent to respective weft yarns of said layers, said second length traversing a plurality of columns in its passage from the bottom layer to the top layer.

5. A unitary ballistic fabric including in combination a plurality of superimposed layers of weft yarns including a top layer and a bottom layer, the weft yarns of each of said layers being substantially vertically aligned with respective weft yarns of the remainder of said layers to form a plurality of columns of weft yarns, each pair of adjacent columns of weft yarns including a pair of adjacent weft yarns from each of said layers, and a plurality of warp yarns, each of said warp yarns alternately passing downwardly from said top layer to said bottom layer between a pair of adjacent columns between the yarns of each one of said pairs of layer weft yarns making up said adjacent columns and diagonally upwardly from said bottom layer to said top layer, each of said warp yarns traversing a plurality of columns in its passage from the bottom layer to the top layer.

6. A unitary ballistic fabric as in claim 5 in which said warp yarns make an angle of approximately forty-five degrees with the planes of said layers in passing from said bottom layer to said top layer.

7. A unitary ballistic fabric as in claim 5 in which each of said weft and warp yarns is formed from synthetic resin continuous filament threads spun to a predetermined number of convolutions per unit length.

8. A unitary ballistic fabric including in combination a plurality of superimposed layers of weft yarns including a top layer and a bottom layer, the weft yarns of each of said layers being substantially vertically aligned with respective weft yarns of the remainder of said layers to form a plurality of columns of weft yarns, each pair of adjacent columns of weft yarns including a pair of ad-

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jacent weft yarns from each of said layers, a plurality
 of warp yarns, each of said warp yarns including first
 lengths extending from the top layer to the bottom layer
 between a pair of adjacent columns between the yarns
 of each one of said pairs of layer weft yarns making up 5
 said adjacent columns and intermediate lengths extending
 diagonally between a pair of adjacent first lengths tangent
 to respective weft yarns of said layers, each of said
 intermediate lengths traversing a plurality of columns in
 its passage from the bottom layer to the top layer. 10

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,899,987

August 18, 1959

Walter S. Finken et al.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 1, after "said" insert -- warp --; line 14, for "levers" read -- layers --.

Signed and sealed this 9th day of February 1960.

(SEAL)

Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents

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