

June 9, 1953

R. W. EHLERS
ARMORED GARMENT

2,640,987

Filed June 2, 1952

2 Sheets-Sheet 1

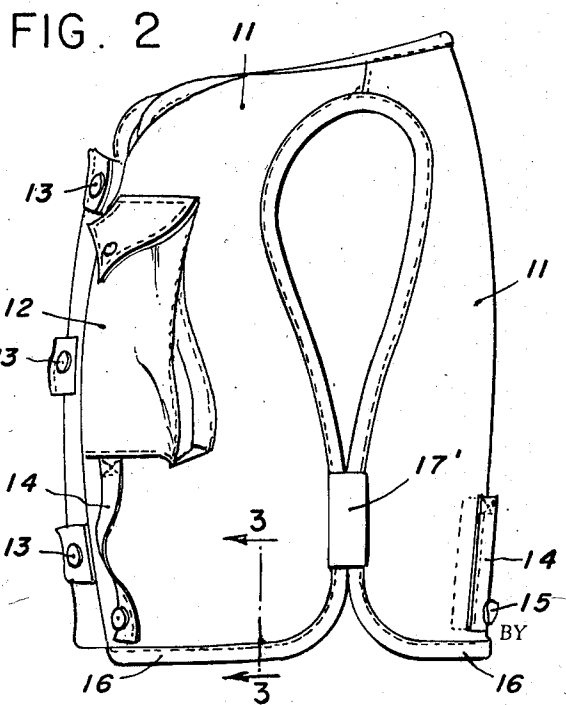
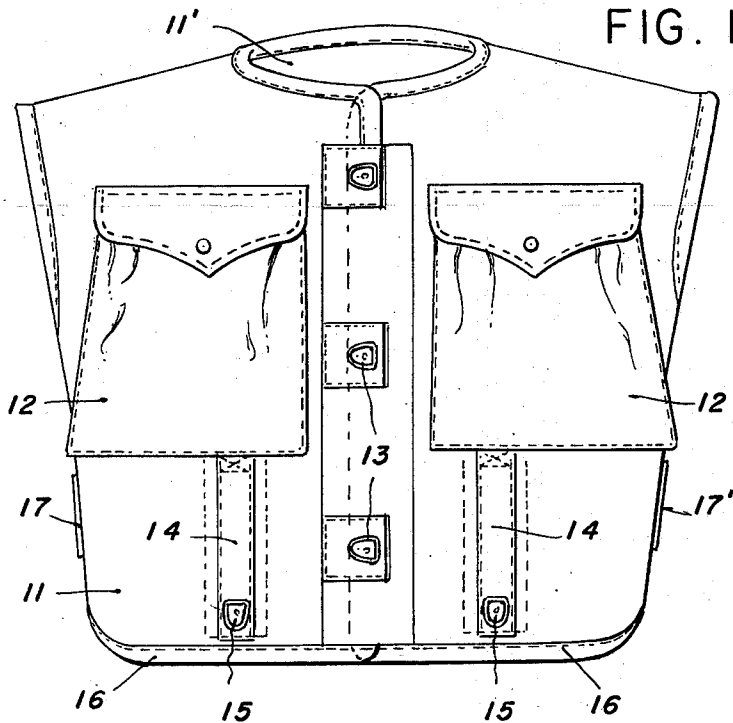
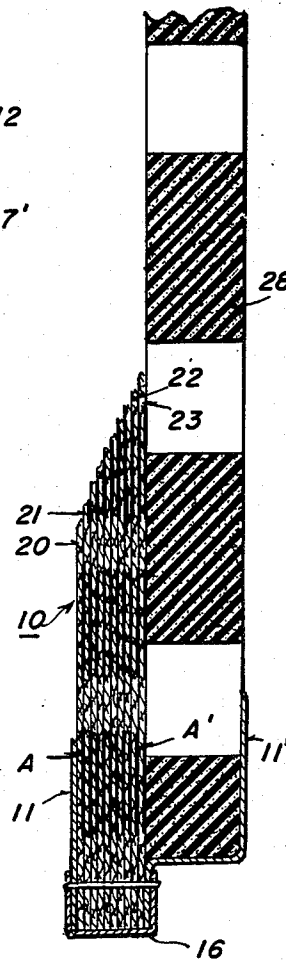


FIG. 3



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2 Sheets-Sheet 2

FIG. 4

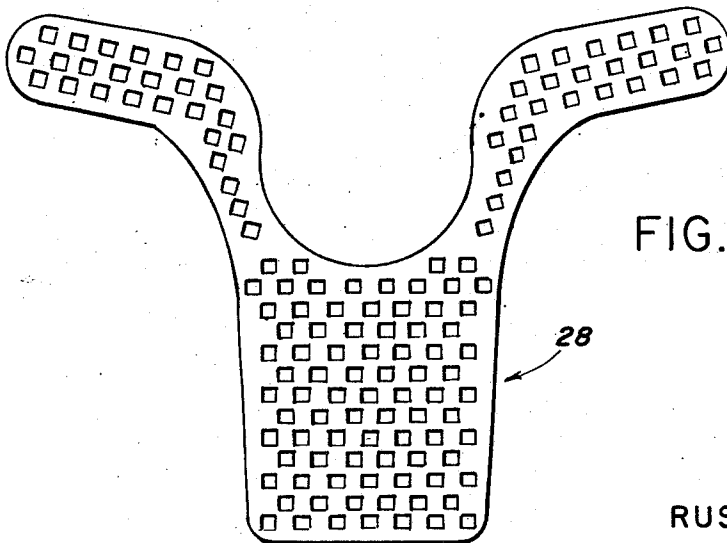
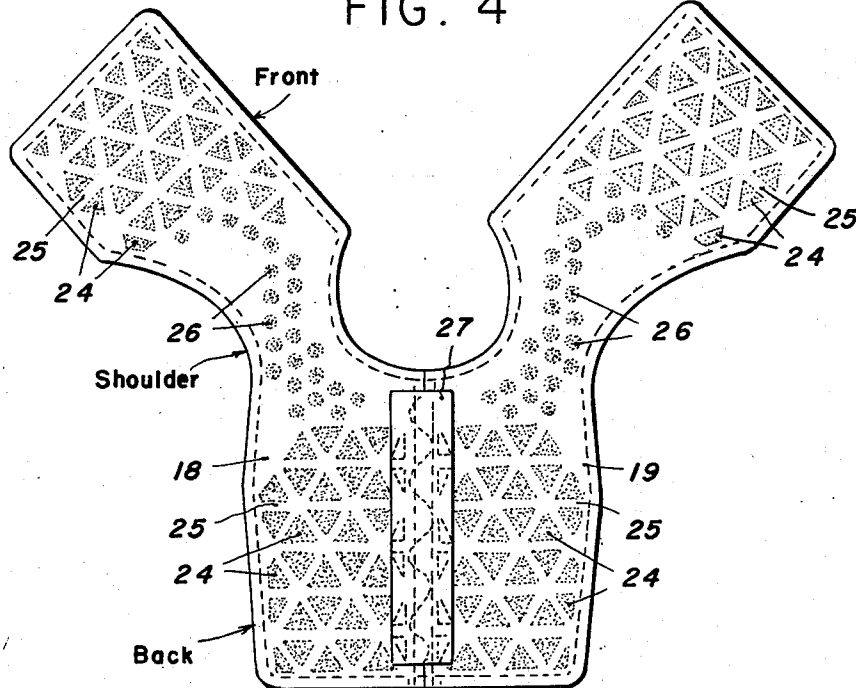


FIG. 5

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ARMORED GARMENT

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the United States of America as represented
by the Secretary of the Army

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29 Claims. (Cl. 2—2.5)

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sec. 266)

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The invention described herein, if patented, may be manufactured and used by or for the Government for governmental purposes, without the payment to me of any royalty thereon.

This invention relates to body armor, and more particularly is a jacket or similar garment equipped with flexible projectile-penetration-resistant spot-laminated armor plates.

Heavy loss of life is often occasioned when military personnel engaged in assault operations is exposed to bursts of artillery fire from the enemy and to small-arms fire from the defender of a position. Similarly, air crews are endangered by fragments from exploding antiaircraft shells. Law-enforcement officers, and to a lesser extent military personnel, are sometimes exposed to fire from pistols and revolvers, which compels them either to endanger their lives or abandon their mission. Protection against such fire has been persistently attempted by the use of steel shields or similar means, which, however, have not been successful as body armor worn on the person, because of the great weight of a steel plate capable of resisting penetration of a projectile. Chiefly, with a view to the protection of personnel against death or injury from artillery and hand weapons, laminated non-metallic armor plates possessing great resistance to penetration by projectiles (shell fragments, as well as small-caliber cartridge and bullets from short-barreled weapons) have been developed during World War II. Examples of such body armor plates are the laminated nylon armor plates described in U. S. Patent No. 2,399,184, Heckert, and the laminated glass fabric armor plate disclosed in U. S. Patent No. 2,562,951, Rose and Merritt. Such plates, while possessing ballistic properties quite adequate for the intended purpose, had the drawback of rigidity and stiffness, which is a source of discomfort to the wearer and, yet more importantly, may prevent him from getting into the proper firing position in difficult terrain during combat. To overcome this drawback of stiffness in body armor plates, it has been suggested, e. g., in Heckert, U. S. Patent No. 2,399,184, at page 4, column 1, and following that "the cementing of the laminae may be limited to one or more of the outer edges or to certain portions of the structure. For example, shell fragment-resisting personal armor can be made by leaving portions free from adhesive where bending is required, as at the knee or elbow." It was found, however, during actual field tests that a multi-layered armor plate of flexible plastic textile material, such as nylon, which is not bonded except at the edges or unbonded over a substantial interior area, puffs up to a bulky mass in the unbonded area; which tends to restrict the movements of the wearer and causes accumulation of water upon exposure to rain during the march or in a water filled foxhole, or as the result of fording a

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stream; the added weight of absorbed water tends to defeat the very purpose of the armored garment in that it either immobilizes the wearer or compels him to discard the garment in order to continue to fight.

I have found that a comparatively lightweight armored garment, which has the advantages of compactness and water resistance of a resin-bonded structure without the disadvantage of stiffness of a fully laminated armor plate, can be provided by spot-laminating the layers in a regular pattern wherein the laminated areas are transversely aligned and are arranged in spaced rows extending over substantial portions of the area of the armor plate incorporated in the garment. An armored garment which is spot-laminated in this general manner, described in greater detail hereafter, is ballistically at least the equal of an armored garment protected by solidly laminated stiff armor plates, and yet flexible enough to enable the wearer to move freely and to assume the proper firing position, in the prone, kneeling, squatting and standing positions.

A preferred material for an armored garment in accordance with the present invention is tightly woven nylon fabric, resin spot-laminated in from about 9 to about 20 layers, preferably about 12 to 15 layers. However, as will be hereafter more fully appear, my invention is not restricted to the use of nylon material.

It is a principal object of the present invention to provide an armored body garment which affords protection to the wearer against the effects of fragmentation projectiles for some types of small-arms fire, without unduly impeding his movements by reason of excessive weight, stiffness, or bulkiness.

Another object of the present invention is an armored jacket which combines relatively light weight, and good ballistic properties.

A further object of the present invention is a construction of an armored jacket which is protected against waterlogging upon exposure to rain or other sources of water encountered on the battle field.

Still another object of the present invention is a resin-bonded laminated armor plate suitable for use in an armored garment, which is characterized by a regular arrangement of aligned spot laminations disposed in a pattern which insures comparative flexibility throughout its area.

Another object of the present invention is an armored jacket of simple construction, which can be relatively inexpensively manufactured in assorted sizes, and which can be quickly put on or taken off by the wearer as combat conditions may require.

Other objects of my invention will become apparent as the detailed description of a preferred embodiment of the same proceeds.

The accompanying drawings illustrate a pre-

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ferred embodiment of my invention, but should not be deemed to limit the scope of my invention to any particular dimensions, proportions or similar details shown therein.

Figure 1 of the drawings is a front elevation of an armored vest in accordance with my invention;

Figure 2 is a side elevation of the armored vest illustrated in Fig. 1;

Figure 3 is an enlarged sectional view, partly broken away, taken along lines 3—3 of Figure 2, the fabric cover being partly omitted;

Figure 4 is a plan rear view of a spot-laminated armor plate suitable for the armored garment illustrated in Figures 1 to 3; and

Figure 5 is a plan view of a resilient cushioning element for lamination to the armor plate as shown in the detailed view of Fig. 3.

More particularly, the armored garment in accordance with the present invention includes a laminated plate 10 of tightly woven high tenacity elongatable plastic textile material, such as nylon, inclosed in a shell 11, 11' of lightweight water-resistant material, e. g. coated nylon. The shell preferably surrounds the outer and inner surfaces of the armor plate for additional protection against waterlogging; it may be provided with patch pockets 12, fly front tabs provided with quick release snap fasteners 13, and belt loops 14 likewise provided with quick release snap fasteners 15 for the purpose of speedily removing the garment should the wearer find himself in danger of drowning or other reasons for quickly ridding himself of the armored garment. The edges of the shell are preferably provided with a strong water- and tear-resistant binding 16. In the construction shown, a pair of plackets 17, 17' unites the front and back panels of the vest. It will be understood, of course, that the foregoing tailoring details are subject to many modifications and variations; thus, the material and armor plate may be enclosed in a plain waterproof shell, e. g. of nylon or vinyl material, and stitched to the inside of a conventional field jacket (not shown) having a fly front and a conventional slide fastener and button closure.

A preferred armor plate for inclusion in a garment of the type above described consists of about 9 to 20, preferably 12 to 15 plies of tightly woven high tenacity elongatable plastic material; nylon being the preferred material, other strong and elongatable plastic textile materials such as strong fine regenerated cellulose fiber of the "Fortisan" or "Durafil" type are permissible though presently less preferred substitutes. A typical nylon fabric suitable for layers to be laminated in accordance with the present invention is lightweight duck cloth, having the following characteristics:

Weave, plain, two ends woven as one, 2 picks woven as one, weight 13-14 oz. per square yard;

Yarn, 210 denier, high tenacity nylon, 34 filament, minimum tensile strength 7 gm. per denier;

Warp, minimum 40 ends, in the loom, composed of 5 plied threads;

Filling, minimum 37 picks off the loom composed of 5 plied threads;

Breaking strength, minimum 775 lbs. in warp and filling (grab method);

Elongation of finished cloth, minimum 30% in warp and 25% in filling.

This cloth, in the preferred form of the present invention, is then cut into sheets or panels of the configuration shown in Fig. 4 of the drawings; each panel includes a generally rectangu-

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lar front portion, a generally rectangular back portion, and a shoulder portion, the front portion being disposed at an obtuse angle relative to the back portion. For greater flexibility, I prefer to have "left" panels 18 and "right" panels 19, hinged together along the back in a manner about to be described in greater detail. However, it will be understood that the panels may also be cut in the general form of a Y, in a configuration generally corresponding to the outline of Figure 4, but without the center back hinge.

As heretofore indicated, the plies which make up the armored plate are joined together by resin in spot-laminations, with the laminated areas of the front and back portions being disposed in a regular pattern which insures flexibility. As shown in Figure 3 of the drawings, the laminated areas are transversely aligned, i. e. the resin-bonded area A between the outer layer 20 and the second layer 21 is in alignment with the resin-bonded areas underneath, including the resin-bonded area A' between next-to-last layer 22 and innermost layer 23. I have found that best results are obtained by an equilateral triangular configuration of the spot laminations, e. g. of a side length of 2". These triangular spot laminations extend over the areas of the front and back portions of each panel in spaced rows, as shown in detail in Fig. 4, with the sides of the triangles 24 aligned in straight lines, thereby enabling the armor plate to be flexed transversely and along lines intersecting at a 60° angle. The spaces or "gutters" 25 between the rows should be of substantial width, say 5/8", to insure flexibility; however, the interstices will be less than the maximum linear dimensions of adjacent spot laminations (e. g., less than the 2" side length of the triangular spot laminations specifically set forth herein). It also appears from the arrangement shown in Fig. 4 that the triangles 24 are disposed in regular clusters, wherein at the intersections between any three "gutters" 25, the tips of six triangles 24 are assembled in contiguity.

The shoulder portion is preferably laminated in a different pattern from that of the front and back portion, e. g., in a pattern of small circular spots 26, so that the plate may be bent sharply at the shoulder portion to enable the front and back portions to be joined in vest or jacket form as shown in Figure 2 of the drawings. It is necessary that the individual resin spots 26 between the fabric layers be transversely aligned throughout the depth of the plate, as otherwise the plate would be stiff.

The lamination resin is preferably applied to the plies by means of a stencil or printing roll. While I do not wish to limit the scope of the present invention to any particular resin, I wish to point out that I have obtained highly satisfactory ballistic results by the use of a mixture of approximately equal parts of a phenol formaldehyde resin and polyvinyl butyral resin (safety glass grade) in a solvent of alcohol and toluene. Such an adhesive resin is sold by Bakelite Corporation as Resin BJ-16320, and by Industrial Tape Corporation as Permaceal 1500; the resin solids content of this adhesive is about 33-37%. With the spot-lamination pattern arrangement, as above described, the addition of about 10 parts by weight of resin to each 100 parts by weight of textile material is sufficient to produce good ballistic results. Other resin binders, some of which are enumerated in Heckert, Patent No.

2,398,184, may also be employed, though probably with less favorable ballistic results.

In my preferred construction, wherein "left" and "right" panels are provided, they are joined by a back center hinge strip, e. g. a long narrow two-ply nylon strip 27, which may be resin bonded to the innermost layer 23 of each panel, and/or sewn thereto prior to the bonding together of the plate.

Even though an armored garment incorporating a properly constructed armor plate such as the one herein disclosed will arrest a projectile having a considerable velocity, and thereby protect the wearer from death or injury, it nevertheless transmits a painful blow to his body, when struck. In order to cushion this blow, I prefer to cement or otherwise join to the inner layer 23 of the armor plate a thick resilient layer, preferably of unicellular rubber or plastic (e. g., neoprene or vinyl) material. In order to save weight and add to the shock absorption, a large number of squares or other geometric figures is cut away from the resilient layer, as shown in Fig. 5. The unicellular material, which is now commercially sold under several trade names, such as "Rubatex" or "Ensolute," does not take up appreciable quantities of water, because the cells do not intercommunicate.

A typical 12-ply armor plate in accordance with the present invention has a thickness of about $\frac{1}{4}$ to $\frac{5}{8}$ inch measured from outer to inner nylon layer, to which is added an extra about $\frac{1}{4}$ inch thickness of unicellular cushioning material. A complete armored garment, as shown in Figure 1, weighs about 7 $\frac{3}{4}$ lbs.

While I do not wish to commit myself to any particular theory as to the ballistic efficacy of an armored garment in accordance with the present invention, I believe that the forward momentum of the projectile is progressively dissipated by the energy expended in the distortion and delamination of the successive textile layers. Surprisingly, I have found that the penetration resistance of the resin-bonded areas of the armor plate is not significantly different from that of the unbonded interstices between such areas.

In ballistic limit tests on armored garments made in accordance with the present invention, it was found that a 12-ply spot-laminated nylon armor weighing about 18.6 oz./sq. ft., backed with $\frac{1}{4}$ " unicellular rubber material and enclosed in a tightly woven nylon shell possessed an average protection (V_{50}) ballistic limit of 1375 ft./sec.; i. e. stopped at least 50% of 17-grain fragmentation-simulating projectiles propelled against it at a velocity of 1375 ft./sec. at the point of impact; this is ample protection against most hand grenade, mortar and antiaircraft shell fragments and against pistol or submachine bullets, though not against .30 cal. rifle bullets unless ricocheting or nearly spent. The average protection (V_{50}) ballistic limit of the same armor enclosed in a rubber-coated fabric shell was found to be 1342 ft./sec., which is substantially the same as the preceding test, the difference being within the limit of experimental error. In a third test, using 15-ply nylon armor enclosed in a nylon shell, and having an average weight of 22 oz./sq. ft., the average protection (V_{50}) ballistic limit was 1485 ft./sec., which is a substantial improvement over the other two tests, but at a rise of 18% in weight. In evaluating the foregoing tests it will be understood that, while a stoppage of only 50% of the projectiles by an armored garment would be of little value in com-

bat, the same garment will stop nearly all projectiles having a slightly lower velocity at the point of impact than that established by the V_{50} ballistic limit test; in this sense, this test may be compared to load limit tests of structural materials, wherein the point of failure furnishes an indication of the safety limits of the same material if a proper margin of safety is subtracted.

While I have chiefly described my armored garment in terms of an armored vest, it will of course be understood that the principles underlying the invention may also be employed in armored garments such as trousers or coveralls, which are of value, not so much to the infantryman for whom they are probably too heavy, but to fliers, gun crews and other personnel whose combat duties do not normally require them to move quickly from place to place while fighting.

While changes in the arrangement, proportions, dimensions and shape of the armored garment and component parts thereof, disclosed in this specification will readily occur to the expert without departing from the spirit of my invention, it is my desire to encompass such variations within the scope of such invention. I thus desire to be limited only by the appended claims.

I claim:

1. Armored garment comprising outer, intermediate and inner layers of woven high tenacity elongatable plastic textile material, said layers being resin spot-laminated over limited areas substantially less than the entire area of said garment, the spot-laminations of said outer, intermediate and inner layers being transversely aligned, and the spot-laminations in the front and back portions of said armored garment being of large dimensions and arranged in spaced rows extending over substantial portions of the area of said garment, the interstices between said spot-laminations in said rows being less than the maximum linear dimensions of said last-mentioned spot-laminations; whereby said garment is rendered flexible.

2. Armored garment comprising outer, intermediate and inner layers of woven nylon textile material, said layers being resin spot-laminated over limited areas substantially less than the entire area of said garment, the spot laminations of said outer, intermediate and inner layers being transversely aligned, and the spot-laminations in the front and back portions of said armored garment being of large dimensions and arranged in spaced rows extending over substantial portions of the area of said garment, the interstices between said spot-laminations in said rows being less than the maximum linear dimensions of said last-mentioned spot-laminations; whereby said garment is rendered flexible.

3. Armored garment comprising outer, intermediate, and inner layers of woven high tenacity elongatable plastic textile material, said layers being resin spot-laminated, the spot laminations of said outer, intermediate and inner layers in the front and back portions of said armored garment being in the pattern of a large plurality of large triangles which are transversely aligned and arranged in spaced rows extending over substantial portions of the area of said garment, the interstices between said spot-laminations in said rows being less than the maximum linear dimensions of said last-mentioned spot-laminations; whereby said garment is rendered flexible along the interstices between said rows.

4. Armored garment for protecting the human

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torso, comprising outer, intermediate and inner layers of woven high tenacity elongatable plastic textile material extending over the front and back of the torso, said layers being resin spot-laminated, the spot laminations of said outer, intermediate and inner layers in the front and back portions of said armored garment being in the pattern of a large plurality of large triangles which are transversely aligned and arranged in spaced rows extending over substantial portions of the area of said garment, the interstices between said spot-laminations in said rows being less than the maximum linear dimensions of said last-mentioned spot-laminations; whereby said garment is rendered flexible along the interstices between said rows.

5. Armored garment for protecting the human torso, comprising outer, intermediate and inner layers of woven high tenacity, elongatable plastic textile material extending over the front and back of the torso, said layers being resin spot-laminated, the spot laminations of the front and back portions of the outer, intermediate and inner layers being in the pattern of a large plurality of large triangles which are transversely aligned and extending over substantial portions of the front and back portions of said garment, the interstices between said triangular spot-laminations being less than the maximum linear dimensions of said triangular spot-laminations, and the spot laminations of the shoulder portions of said garment being in the pattern of transversely aligned dots, whereby said garment is rendered flexible along the interstices between said triangular spot-laminations and along the interstices between said dots.

6. Armored garment according to claim 1, wherein the number of layers is about 9 to 20.

7. Armored garment according to claim 2, wherein the number of layers is about 12.

8. Armored garment according to claim 2, wherein said laminating resin is a mixture of phenol-formaldehyde and polyvinyl-butylal resins.

9. Armored garment according to claim 8, wherein said phenol-formaldehyde resin and said polyvinyl butylal resin are mixed in approximately equal parts.

10. Armored garment according to claim 2, wherein the weight of said laminating resin is about 10% of the weight of said nylon textile layers.

11. Armored garment according to claim 1, wherein said spot-laminated layers are backed by a thick layer of highly resilient material laminated to the inner layer of said textile material.

12. Armored garment according to claim 11, enclosed in a shell of thin flexible water-resistant material.

13. Armored garment according to claim 11, wherein said spot-laminated layers are backed by a thick layer of highly resilient unicellular material laminated to the inner layer of said textile material.

14. Armored garment according to claim 1, enclosed in a shell of thin flexible water-resistant material.

15. Armored garment according to claim 1, wherein said spot-laminated layers are backed by a thick layer of highly resilient foraminous material laminated to the inner layer of said textile material.

16. Armored garment for protecting the human torso, comprising outer, intermediate and inner layers of woven high tenacity elongatable plas-

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tic textile material of a configuration substantially resembling a Y, the oblique portions of said Y extending over the front of the torso and meeting in a fly front and the straight portion of said Y extending over the back of the torso and joined to said front portions along the sides of the torso, said layers being resin spot-laminated, the spot laminations of said outer, intermediate and inner layers being transversely aligned, and the spot-laminations in the front and back portions of said armored garment being of large dimensions and arranged in spaced rows extending over substantial portions of the area of said garment, the interstices between said spot-laminations in said rows being less than the maximum linear dimensions of said last-mentioned spot-laminations; whereby said garment is rendered flexible.

17. Armored garment for protecting the human torso, comprising about 9 to 20 outer, intermediate and inner layers of woven nylon textile material of a configuration substantially resembling a Y, a thick layer of high resilient material laminated to the inner nylon layer, the oblique portions of said Y-shaped layers extending over the front of the torso and meeting in a fly front and the straight portion of said Y-shaped layers extending over the back of the torso and joined to said front portions along the sides of the torso, said layers being resin spot-laminated, the spot laminations of said outer, intermediate and inner nylon layers being in the pattern of a large plurality of transversely aligned large triangles arranged in spaced rows extending over substantial portions of the area of said garment with the exception of the shoulder portions, the interstices between said triangular spot-laminations being less than the maximum linear dimensions of said triangular spot-laminations, and the spot laminations of the shoulder portions being in the pattern of transversely aligned dots, whereby said garment is rendered flexible along the interstices between said rows of triangles and along the interstices between said dots.

18. Flexible armor plate for an armored garment, said plate comprising outer, intermediate and inner layers of woven high tenacity elongatable plastic textile material, said layers being resin spot-laminated over limited areas substantially less than the entire area of said armor plate, the spot-laminations of said outer, intermediate and inner layers being transversely aligned, and the spot-laminations in the principal protective areas of said armor plate being of large dimensions and arranged in spaced rows extending over substantial portions of the area of said armor plate, the interstices between said spot-laminations in said rows being less than the maximum linear dimensions of said last-mentioned spot-laminations.

19. Flexible armor plate for an armored garment, said plate comprising outer, intermediate and inner layers of woven high tenacity elongatable plastic textile material, said plate comprising a rectangular front portion, a rectangular back portion and a shoulder portion, the longitudinal axes of said front portion and of said back portion being disposed at an obtuse angle relative to each other, said front portion and said back portion being resin spot-laminated in the pattern of a large plurality of large triangles which are transversely aligned and extend over the area of said front and back portions in spaced rows, the interstices between said spot-laminations in said rows being less than the

maximum linear dimensions of said spot-laminations.

20. Flexible armor plate for an armored garment, said plate comprising about 9 to 20 outer, intermediate, and inner layers of high tenacity elongatable plastic textile material, said outer, intermediate, and inner layers being resin spot-laminated in the pattern of a large plurality of large triangles which are transversely aligned and extend over the area of said armored plate in spaced straight rows, the interstices between said spot-laminations in said rows being less than the maximum linear dimensions of said spot-laminations, whereby said armor is rendered flexible along the interstices between said rows of triangles.

21. Flexible armor plate according to claim 20, wherein said textile material is nylon.

22. Flexible armor plate according to claim 20, wherein the number of said laminated layers is about 12.

23. Flexible armor plate according to claim 20, wherein the weight of said laminating resin is about 10% of the weight of said armor plate.

24. Flexible armor plate according to claim 20, wherein a thick layer of highly resilient material is laminated to said inner layer.

25. Flexible armor plate for an armored garment, said plate comprising outer, intermediate and inner layers of woven high tenacity elongatable plastic textile material, said plate comprising a rectangular front portion, a rectangular back portion and a shoulder portion, the longitudinal axes of said front portion and of said back portion being disposed at an obtuse angle relative to each other, said front portion and said back portion being resin spot-laminated in the pattern of a large plurality of large triangles which are transversely aligned and extend over the areas of said front and back portions in spaced rows, the interstices between said spot-laminations in said rows being less than the maximum linear dimensions of said spot-laminations, and the shoulder portion of said plate being spot-laminated in a pattern of a plurality of transversely aligned dots.

26. Flexible armor plate for an armored garment, said plate comprising outer, intermediate and inner layers of woven high tenacity elongatable plastic textile material, said plate comprising a rectangular front portion, a rectangular back portion and a shoulder portion, the longitudinal axes of said front portion and of said back portion being disposed at an obtuse angle relative to each other, said front portion, back portion and shoulder portion being resin spot-laminated, the spot laminations of said front and back portion being of large dimensions and arranged in spaced rows extending over substantial portions of the areas of said front and back portions, the interstices between said spot-laminations in said rows being less than the maximum linear dimensions of said last-mentioned spot-laminations; and the spot laminations over said shoulder portion extending over a relatively lesser portion of the area thereof as compared with the spot-laminated areas of said front and back portions, whereby said armored plate is rendered more flexible in its shoulder portion than in its front and back portions.

27. Armored garment comprising a pair of armored plates of outer, intermediate, and inner layers of woven high tenacity elongatable plastic

textile material, each of said plates comprising a rectangular front portion, a rectangular back portion and a shoulder portion, the longitudinal axes of said front portion and of said back portion being disposed at an obtuse angle relative to each other, said front portion and said back portion being resin spot-laminated in the pattern of a large plurality of large triangles which are transversely aligned and extend over the area of said front and back portions in spaced rows, the interstices between said spot-laminations in said rows being less than the maximum linear dimensions of said last-mentioned spot-laminations; said pair of plates being hinged together along the inner edges of their back portions in a substantially Y-shaped formation, the oblique portions of said Y-shaped formation meeting in a fly front and the outer edges of the hinged back portion being joined to said oblique front portions along the sides of the torso.

28. Armored garment comprising a pair of armor plates of outer, intermediate, and inner layers of woven high tenacity elongatable plastic textile material, said textile material comprising a rectangular front portion, a rectangular back portion and a shoulder portion, the longitudinal axes of said front portion and of said back portion being disposed at an obtuse angle relative to each other, said front portion, back portion and shoulder portion being resin spot-laminated, the spot laminations of said front and back portion being large and arranged in spaced rows extending over substantial portions of the areas of said front and back portions, the interstices between said spot-laminations in said rows being less than the maximum linear dimensions of said last-mentioned spot-laminations; and the spot laminations over said shoulder portion extending over a relatively lesser portion of the area thereof as compared with the spot-laminated areas of said front and back portions, whereby said armored plate is rendered more flexible in its shoulder portion than in its front and back portions, said pair of plates being hinged together along the inner edges of their back portions in a substantially Y-shaped formation, the oblique portions of said Y-shaped formation meeting in a fly front and the outer edges of the hinged back portion being joined to said oblique front portions along the sides of the torso.

29. Armored garment according to claim 28, wherein a thick layer of highly resilient material is laminated to the inner layers of said pair of armored plates.

RUSSELL W. EHLERS.

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