United States Patent [19]

Coes

[11] 3,859,892

[45] Jan. 14, 1975

[54] **COMPOSITE CERAMIC ARMOR**

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[22] Filed: **Mar. 14, 1969**

[21] Appl. No.: **809,060**

Related U.S. Application Data

[63] Continuation of Ser. No. 594,649, Nov. 14, 1966, abandoned.

[52] **U.S. Cl.** ..... **89/36 A,** 109/80, 161/404

[51] **Int. Cl.** **F41h 5/04**

[58] **Field of Search** ..... 89/36 R, 36 A; 161/404, 161/102, 99; 109/80

[56] **References Cited**

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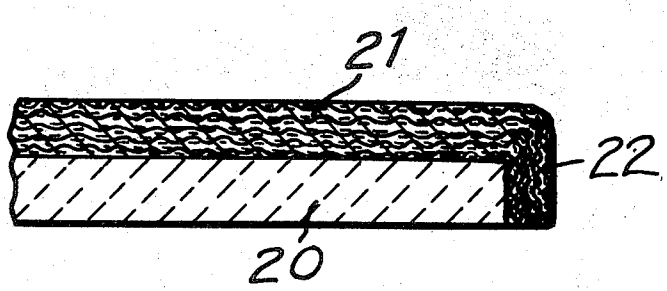
Primary Examiner—Stephen C. Bentley

Attorney, Agent, or Firm—Cushman, Darby & Cushman

[57] **ABSTRACT**

A present variety of composite ceramic armor for protection against small arms fire consists of a dense ceramic plate bonded to a laminated fiberglass backing. the resistance of such armor to hits close to a free edge can be significantly improved by extending the backing over the edge of the plate and bonding it thereto, or by folding over the backing at the free edges and bonding it to itself.

1 Claim, 5 Drawing Figures



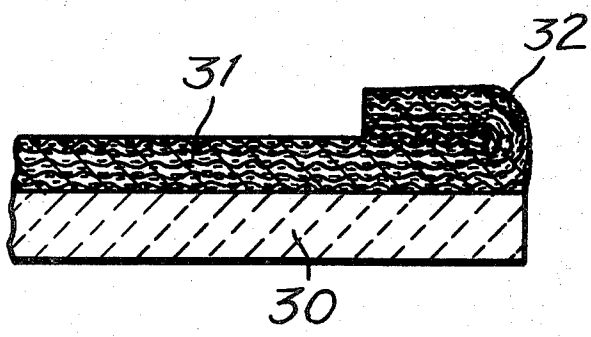
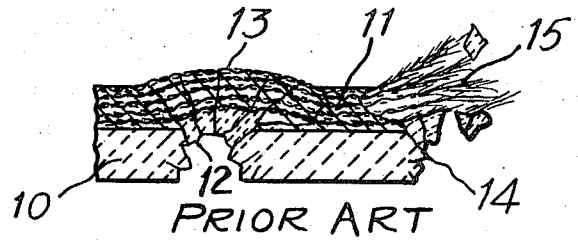


FIG. 1



PRIOR ART

FIG. 2

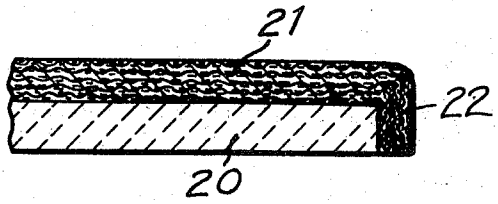


FIG. 3

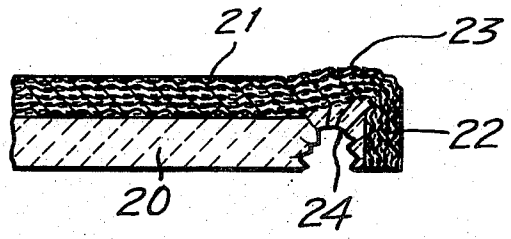


FIG. 4

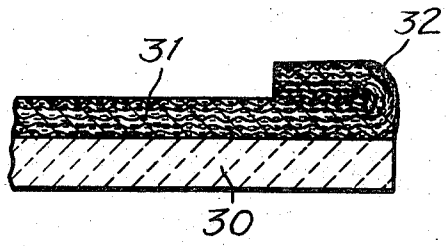
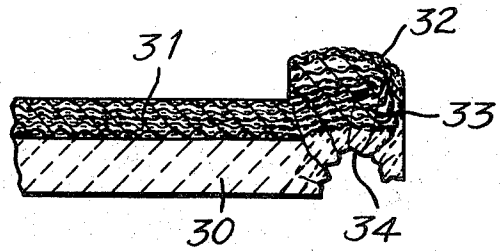


FIG. 5



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COMPOSITE CERAMIC ARMOR

This application is a continuation of application Ser. No. 594,649 filed Nov. 14, 1966, now abandoned.

BACKGROUND OF INVENTION

There has recently been developed a new armor system for protection against high energy projectiles such as small arms fire. This armor consists of a hard high density ceramic plate backed by a bonded laminate of glass cloth bonded thereto. When such armor is struck on its ceramic face by a projectile of sufficiently high energy, the ceramic face will fail and the energy delivered to the laminated glass cloth backing will be dissipated in delamination of the bonded layers of cloth. When this occurs, persons or objects protected behind the armor will suffer no injury from the projectile. However, when the projectile hits the armor within a few diameters of the projectile from a free edge of the armor, delamination of the backing occurs at the edge permitting particles of ceramic and the projectile to escape behind the armor and thus personnel or equipment behind the armor, but in the path of such projectiles will not be protected.

SUMMARY OF THE INVENTION

The present invention improves the performance of the above described prior art armor with respect to edge hits by preventing free or open delamination at any edge of the backing material. This may be accomplished in the fabrication of the armor by extending the backing over the free edges of the ceramic front plate and bonding the backing thereto. Alternatively, the same result may be accomplished by folding the laminated backing material back upon its self at the edges of the armor and bonding the backing to itself outward from the fold.

THE DRAWINGS

FIG. 1 shows a cross-section of a conventional type of ceramic composite armor which has been hit by a projectile centrally of the plate and by a projectile near the edge of the plate;

FIG. 2 shows a cross-section of a piece of ceramic armor according to one modification of the present invention;

FIG. 3 shows a cross-section of the armor of FIG. 2 which has suffered an edge hit;

FIG. 4 shows a modification of the armor of the present invention in cross section;

FIG. 5 shows the affect of an edge hit on the armor of FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1 it may be readily seen that although the armor of conventional design consisting of ceramic plate **10** and glass cloth laminate **11** is adequate to protect against an impact such as at **12**, an impact at **14** results in delamination and separation of the glass cloth backing and essentially in failure of the armor to perform its function. At **13**, although the glass cloth laminates have separated in an area at and around the point of impact, the surrounding glass cloth remains bonded and effectively retains the integrity of the composite plate. However, at **14** where the impact was close to an edge, delamination of the glass backing occurs at the edge and frees the particles shattered from the ceramic plate and the projectile itself to travel in paths behind the armor.

FIGS. 2 and 3 show preferred embodiments of the present invention in which the type of failure shown at **15** in FIG. 1 is avoided.

The particular materials of which the ceramic plates **10** and **20** are formed is of no moment insofar as the present invention is concerned. Typically, such materials may be high temperature fabricated polycrystalline alumina, silicon carbide or boron carbide. The backing element **21** is formed of a plurality of plies of glass cloth bonded together with a suitable resin such as a standard commercial catalyzed polyester resin system. The backing **21** is bonded to the ceramic **20** by means of any suitable commercial resin adhesive such as an epoxy resin adhesive.

The particular dimensions of the ceramic plate and the backing depend upon the specific requirements for the armor and the particular materials which are employed in its manufacture. Merely for purposes of illustration, the plates in FIGS. **1, 2** and **3** are three-fourths inch in overall thickness with the ceramic plate being one-half inch thick and the laminated glass fabric being one-fourth inch thick.

As can be seen by examination of FIG. **1**, an area **13** in the glass cloth **11** undergoes delamination around the site of the projectile impact on the plate **10** shown in the drawing at **12.** Where the impact occurs near the edge of the plate closer than that diameter of the area **13** to the edge, failure such as indicated at **15** will occur. Such failure is avoided in the embodiment of FIG. **2** by folding the backing element **21** over the edge of the ceramic armor plate and bonding it thereto. This simple expedient entirely eliminates the spreading of the delaminating forces occasioned by a hit such as at **14** to the extreme edge of the glass cloth laminate. FIG. **3** shows the effect of an edge hit at **24** on the plate **20.** As shown, while the glass cloth laminate delaminates at **23,** the separation of the laminations does not extend all the way to the outer edge of the glass cloth.

FIG. **4** shows another embodiment of the invention wherein protection against edge hits on the armor is improved. Instead of folding the glass cloth laminate backing down over the edge of the ceramic plate **30** as in the embodiment of FIG. **2,** the glass cloth is folded back over itself at the free edges of the plate and securely bonded at and along the fold. As shown in FIG. **5,** delamination of the backing occasioned by projectile impact at **34** is limited in its spread due to the fold at **32** and no failure of the backing occurs at its extreme edge.

The composite armor referred to herein may be of various shapes and sizes. It may generally be described as plate-like or planar. The plates are, in many instances, slightly curved, and so by "planar" or "plane" as used in the appended claims, we do not mean absolutely flat in the mathematical sense.

I claim:

1. A composite armor plate having a free edge, including a ceramic front plate and a resin bonded glass fiber cloth laminated backing plate bonded to said front plate, for protection against high energy projectiles, the edge portion of said backing plate being bent at an angle of substantially 180°, folded back onto and bonded to itself, to reinforce said free edge against impact of high energy small arms projectiles near said free edge.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,859,892 Dated Jan. 14, 1975

Inventor(s) Samuel H. COES

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

At paragraph [76] on the front page format, after "Samuel H. Coes," delete "385 Daris Rd." and insert --385 Davis Rd.--

After paragraph [76], insert: --[73] Assignee: Norton Company, Worcester, Massachusetts 01606--

At paragraph [57] entitled "Abstract", line 4, delete "the" and insert --The--

Signed and sealed this 1st day of July 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
and Trademarks

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