

[54] **COMPOSITE SHOCK RESISTING BODIES**

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89/36 R, 36 A, 36 Z; 109/82, 83, 84

[56] References Cited

UNITED STATES PATENTS

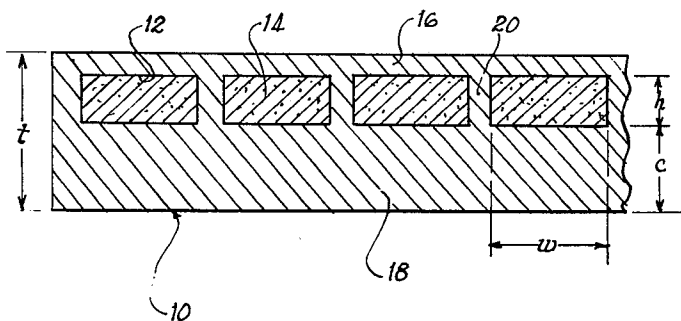
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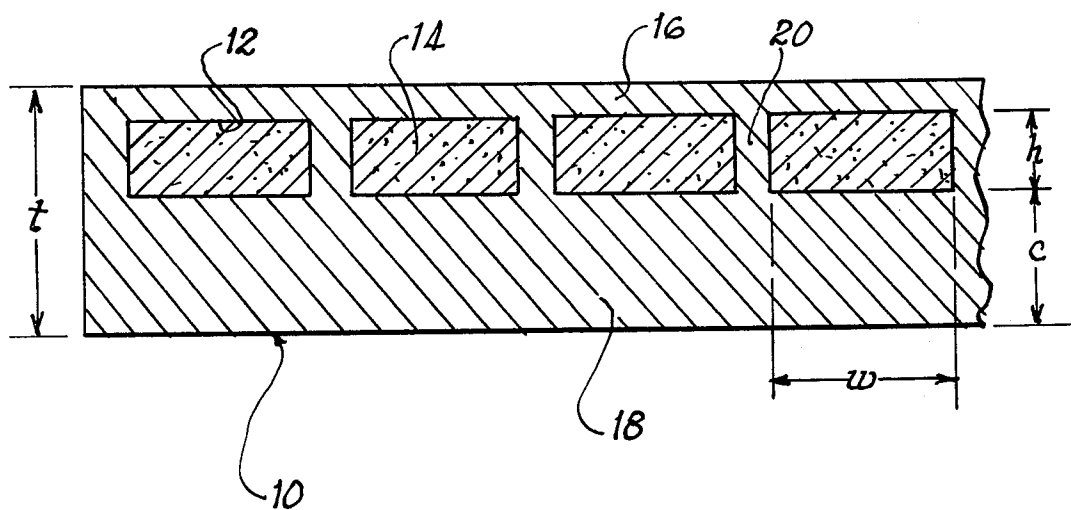
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ABSTRACT

A shock resisting composite product characterized by maximum resistance with minimum density formed from a wrought alloy of aluminum having cells formed therein which are packed with a hard material in a compact or fritted condition.

2 Claims, 1 Drawing Figure





COMPOSITE SHOCK RESISTING BODIES

This application is a continuation-in-part of applicant's application Ser. No. 843,546 filed on July 22, 1969 now abandoned, and entitled Composite Shock Resisting Bodies and Method.

This invention relates to composite shock resisting products. The invention is particularly concerned with products useful as armor plate or other plate or wall constructions which are subject to high velocity impact by pieces of material, for example, fragments which might be thrown against a wall such as turbine blade pieces.

Shock resisting composite products have been previously produced using hard materials such as fritted materials. The hard materials are held together by means of metal cast about the materials to form the composite body. It has been considered necessary to use high strength cast materials in order to provide suitable mechanical characteristics. The use of lighter materials such as aluminum or alloys of aluminum has not been considered suitable in view of the relatively weak mechanical characteristics of cast aluminum alloys. Accordingly, the prior art has not taken advantage of the light weight of the aluminum whereby low density composite products could be obtained.

It is an object of this invention to produce shock resisting composite products which have a desired maximum resistance to impact by projectiles and the like while also being characterized by a minimum density.

These and other objects of this invention will appear hereinafter and for purposes of illustration, but not of limitation, specific embodiments of the invention are

In the preferred form of the invention, the thinner wall portion preferably has a thickness of from 10 to 30 percent of the thickness of the over-all aluminum body. The cells preferably comprise from 30 to 50 percent of the cross sectional area of the body while the remainder of the body including the thicker wall portion for the cells has a thickness of about 40 to 60 percent of the over-all thickness of the body.

In the preferred practice of the invention, the wrought aluminum alloy is preferably characterized by the following properties:

load at break:	30 to 55 kg/mm ²
limit of elasticity:	25 to 45 kg/mm ²
elongation:	8 to 20 %

The following alloys are representative of aluminum alloys which provide the desired properties:

- an alloy of aluminum containing 4.8% zinc, 1.2% magnesium and 0.2% chromium, the remainder aluminum plus minor impurities;
- an alloy of aluminum containing 8% zinc, 2.7% magnesium, 1.6% copper, 0.2% chromium, the remainder aluminum plus minor impurities;
- an alloy of aluminum containing 3.8% to 4.9% copper, 1.2% to 1.8% magnesium, 0.3% to 0.9% manganese, the remainder aluminum plus impurities.

Aluminum-zinc-magnesium alloys and aluminum-copper-silicon-magnesium alloys 7005 and 2014 are particularly suitable when the aluminum body is formed by forcing the heated aluminum through dies dimensioned in accordance with the desired size of the final product. Typical alloys of this type are set forth in the following tables:

	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Zr
7005)	0.30	0.40	0.15	0.50	0.90	0.35	4.1	0.15	0.05
)	max.	max.	max.	max.	1.50	max.	4.9	max.	0.25
)	0.50	0.70	3.9	0.40	0.20	0.10	0.25	0.15	
2014)	1.20	max.	5.0	1.2	0.8	max.	max.	max.	

shown in the accompanying drawing in which the FIGURE is a cross-sectional view of a composite product embodying the features of this invention.

The composite product of this invention generally consists of a main body portion comprising an aluminum alloy in wrought condition. The aluminum body is produced with a plurality of cells formed in the body and in the production of the product, these cells are filled with a hard material such as compacted or fritted products having high hardness characteristics.

The product of the invention is characterized by dimensions which provide a combination of reactions upon the receipt of an impact from a projectile or the like. Specifically, products characterized by the features of the invention have a solid aluminum portion on one side of the cells which is of substantial thickness. The opposite side of the aluminum body is thinner, and if a projectile impact is sustained, this thin part is relatively easily pierced by the projectile. Energy absorption does, however, occur due to the presence of the thin wall, and the balance of the energy of the impact is then absorbed between hard material present in the cells as well as the thick remaining portion of the composite body.

In the case of 7005 alloys, the following mechanical characteristics are obtained:

elastic limit:	32 - 38 hb*
break load:	36 - 42 hb
elongation:	12 - 18 %

In the case of 2014 alloys, the following mechanical characteristics are obtained:

elastic limit:	41 to 45 hb
break load:	46 to 50 hb
elongation:	8 to 14 %

The elements of hard materials inserted to fill the cells or openings can be selected from metals or metal salts having high impact resistance in compact or fritted condition, as represented by the following, namely: Stellite, which is a series of alloys of cobalt, chromium and tungsten, the carbides and nitrides of boron, tungsten and vanadium, steel with high mechanical properties, and hard metallic oxides such as silica, magnesia and corundum. The fritted products may be obtained

by agglomeration of the metals or metal compounds into a paste which is then fritted by compression and heating, after which they are introduced into the cells, preferably under pressure. The elements are fixed by gluing (e.g., an epoxy glue or elastomer) or by introduction in a liquid condition of a low melting alloy.

In the case of ceramic, fritted alumina having a Mohr hardness of 9, boron carbide and tungsten oxides are particularly suitable.

The structures of this invention are particularly useful as armor plate for protection against shells including direct impact therefrom or due to impact from fragments or other objects which engage the plate upon the explosion of a shell. Similar uses such as protective plating and the like surrounding mobile parts, for example turbine blades, are also contemplated whereby any of the adverse effects of any explosions or other occurrences which lead to the impact of the plating by objects can be avoided.

Referring to the accompanying drawings, there is illustrated a cross section of a wrought aluminum alloy 10 having a thickness *t*. The body defines a plurality of cells 12 which are filled with a hard material 14. These cells may comprise elongated passages which are formed either by machining or in the processing of the body, for example during an extrusion operation.

The cells 14 comprise from 30 to 50 percent of the cross sectional area of the body. The cells are defined by means of a thin outer wall 16 and a thicker inner wall 18 with side walls 20 dividing the respective cells.

The wall 16 preferably has a thickness of from 10 to 30 percent of the thickness *t*. The wall 18 preferably has a thickness *c* of from 40 to 60 percent of the thickness *t*.

As indicated, the wall 16 is preferably positioned so that this surface of the body 10 will be exposed to impact. This will, in view of the characteristics of the aluminum, will be rather readily penetrated by a projectile or other object while absorbing a portion of the energy of the impact. Upon engagement with the material in the cells 12, and because of the presence of the thick wall portion 18, the balance of the energy of the impact will be absorbed.

Aluminum bodies of the type illustrated in the drawing have been prepared from 7005 alloys with the mechanical characteristics being measured as follows:

elastic limit:	34 hbars
Break load:	39 hbars
elongation at break:	16 %

2014 alloys having the following mechanical characteristics have been successfully tested:

elastic limit:	43 hbars
break load:	49 hbars
elongation at break:	12 %

In both instances, the cells of the bodies have been filled with alumina and with boron carbide with the material being held together by means of an epoxy resin by means of an alloy of 60% Sn and 40% Pb or similar low melting point alloy.

Typical dimensions of a cross section produced in accordance with the concepts of the invention are as fol-

lows (referring to the drawing):

$$\begin{aligned} h &= 0.2 - 0.4 \text{ } t \\ w &= 1-5 \text{ } h \\ c &= 0.4 - 0.6 \text{ } t \end{aligned}$$

In a typical body of the type described, the thickness *t* will be from 20 to 70 mm, and the interconnecting portions 20 will be from 4 to 6 mm. It will be appreciated, however, that actual dimensions may vary depending upon the application involved. It will also be understood that the over-all size of a plate or other structure can be within any practical range since multiplicity of plates can be secured together by welding.

As noted, the structures of the invention may be extruded, and this is the preferred form of the invention since the passages of the body can then be formed automatically through the use of appropriate mandrels. It is understood that by the use of the term "wrought," these extruded bodies, as well as other bodies having a substantially similar structure, are included. The passages may of course be formed or finished by machining where desired.

The products of the invention may comprise an assembly of aluminum bodies of the type described and such assemblies may comprise bodies which are welded together by means of known welding techniques.

The superiority of the wrought aluminum bodies of this invention is dramatic when compared with the properties of cast aluminum bodies. Aluminum-magnesium, aluminum-copper, and aluminum-silicon castings are 30 to 50 percent less efficient than wrought bodies prepared in accordance with the concepts of this invention. The particular structural design of the bodies illustrated herein is also of maximum importance in achieving the desired results.

It will be understood that various changes and modifications may be made in the above described invention which provide the characteristics of the invention without departing from the spirit thereof particularly as defined in the following claims.

That which is claimed is:

1. An armor plate comprising a composite product consisting of a wrought aluminum alloy body, a plurality of cells defined by said body, and a material of high hardness filling said cells, said body providing a wall portion subject to impact and adapted to be pierced while absorbing a portion of the energy of the impact, the thickness of said wall portion comprising about 10 to 30 percent of the thickness of said body, said hard material and the remainder of said body absorbing the balance of the energy of the impact, said cells comprising from 30 to 50 percent of the cross sectional area of said body, and said body defining a thick wall portion on the side of said cells opposite said thin wall portion, the thickness of said thick wall portion being from 40 to 60 percent of the thickness of said body.

2. A construction in accordance with claim 1 wherein said hard material comprises at least one of the members selected from the group consisting of an alloy of cobalt, chromium and tungsten, the nitrides and carbides of boron, tungsten and vanadium, steel, silica, magnesia and corundum.

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