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METHOD FOR ARRESTING PROPAGATING FRACTURES IN STRESSED-SKIN MONOCOQUE TYPE OF CONSTRUCTION

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Fig. 1.

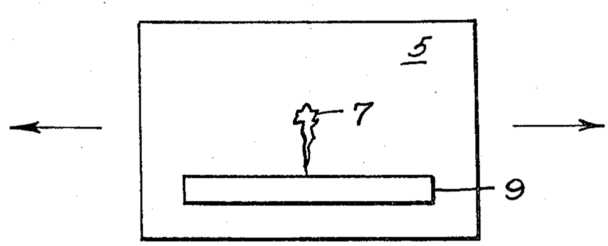
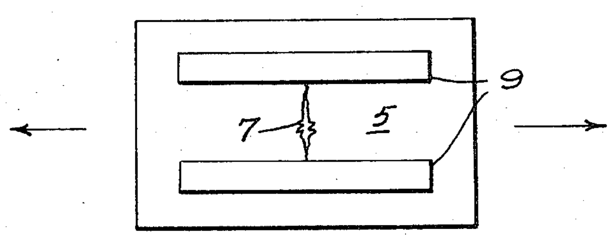


Fig. 2.



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METHOD FOR ARRESTING PROPAGATING FRACTURES IN STRESSED-SKIN MONOCOQUE TYPE OF CONSTRUCTION

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ABSTRACT OF THE DISCLOSURE

A method for arresting fractures in stressed-skin monocoque type of construction used in aircraft comprising the bonding of fiber straps generally parallel to the maximum load trajectory thereby arresting the fracture when it progresses to the fiber straps.

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

This invention relates in general to a method for arresting fractures and more particularly to a method for arresting fractures in stressed-skin monocoque type of construction utilized in aircraft.

A problem exists in stressed-skin monocoque type of construction when the skin is damaged. Since the skin is under tension a sharp crack progresses across the plate or skin at a very high velocity unless means are utilized to arrest the progress of the crack or unless the structure is designed to work at such a low stress level that the stress intensity at the point of the crack is less than that required for propagation. The latter would require a structure which is thicker and therefore heavier. This results in higher cost of construction and lower payload for the aircraft.

The most common method of arresting fractures in a stressed-skin monocoque type of construction is the incorporation of riveted seams in the structure so that the fracture will stop at the plate edge or in a rivet hole. Another method is to rivet shape sections to the plate at various intervals thereby providing a structurally rendundant stress path. The added weight of this arrangement is normally 12 to 15% of the panel weight and therefore uneconomical. Another proposal involves the placing of a compressive stress at a position ahead of the crack. However, this is difficult to achieve especially if a projectile causes the crack. Other methods of arresting fractures may be applied after the fracture has been initiated, such as drilling a hole at the end of the crack.

It is known from analysis and photoelectric observation that the actual area of the plate at the end of the fracture that is affected during the cracking process is, e.g., in the case of aircraft plate having a thickness of .025″ to .055″, of the order of 10 to 15 microns in diameter. The stress intensity in this area is exceedingly high, i.e., of the order of the ultimate strength of the material or momentarily, even higher. Although the stress intensity is high, the actual load carried by the area is slight since the area is so small. It was contemplated that if another path (mechanism) could be devised to divide and share this load, the stress intensity would be reduced below the level required to continue the fracture. As an example, the stress intensity might well be 200,000 pounds per square inch at the tip of the crack. If the ultimate strength of the material is slightly less than 200,000 pounds per square inch, the plate will continue to crack. If, however, the load across this minute affected area at the tip of the crack is only of the order of, for example, six pounds, than a fiber strand that crosses the affected area and that could take three pounds would divide the load and thus half the stress intensity to 100,000 per square inch, much less than required for the cracking to continue. A small glass fiber cemented to the plate at this area would carry the load. This is the essence of the invention. Since it is impossible to cement single fibers at the time of the crack, I propose to cement the fiber to the plate as a lamination or as tapes each of which would act as fracture arrestors when the fracture progresses to the fiber.

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It is an object of this invention to provide and disclose a single method for the arrest of propagating fractures which develop in a stressed-skin monocoque type of construction.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims taken in conjunction with the accompanying drawing in which:

FIG. 1 shows a top view of an illustration of the invention.

FIG. 2 shows an alternative of the illustration of FIG. 1.

Referring now to FIG. 1 of the drawing, reference number **5** represents an illustrative stressed-skin monocoque plate having fracture **7** thereon. Fiber strap **9** is bonded to plate **5** parallel to the maximum load trajectory which is indicated in the drawing by directional arrows. As seen in the drawing, the fracture propagates along the surface of the plate until it reaches fiber strap **9**, where it is arrested.

FIG. 2 represents an alternative of FIG. 1. A crack extends in both directions from fracture **7**. The cracks are arrested by fiber strips **9**. In the alternative, fiber strips may be bonded on both the top and bottom sides of the plate.

The present stressed-skin monocoque construction embraces all types of construction where the stress is carried in the skin rather than internal framework. The type of materials contemplated include, for example, aluminum, titanium, stainless steel, etc. The fiber strip utilized was S glass which is a alumino-silicate glass. The dimensions of the fiber strip were 0.75″ wide and 0.010″ in thickness. EPON–828 which is a resin possessing terminal epoxy groups (Shell Chemical Co.) was utilized to bond the fiber strips to the substrate. However, any high strength adhesive which is compatible with both the substrate material and fiber straps may be utilized.

Experimentation was conducted utilizing 7075–T6 bare aluminum alloy. The specimen utilized was 0.032″ thick, 12″ wide and 20½″ in length. The specimen was first cleaned with acetone and then lightly ground in the strap bond area. The specimen was then cleaned and 8 to 10 millimeter thickness of EPON–828 resin with Z curing agent was applied to the bond area. A single layer of 1002–S unidirectional prepreg tape was placed parallel to the direction of loading on the impact side of the specimen as shown in FIG. 2. The tape was rolled with a roller to remove entrapped air and placed in a press at 30 p.s.i. and at a temperature of 330° F. for a period of 1 hour. The specimen was subsequently postcured in an air circulating oven at a temperature of 280° F. for a period of 1 hour. The method was repeated utilizing 7075–T6 clad aluminum alloy.

In addition the above method was repeated utilizing 7075–T6 bare and clad aluminum alloys using:

(a) no straps,

(b) 1 strap on both front and back side of the specimen,

(c) 2 straps on both front and back sides of specimen, and

(d) 1 wide strap on impact side of specimen.

Stressed panels, prepared as described above, were subjected to impact loading by driving a pointed 0.375-inch-diameter rod through the midpoint of the specimens and the crack arrest and residual static behavior of the specimens was observed. The tests indicated that running cracks can be arrested by Fiberglas straps. Significant increase in the crack arrest behavior of up to 48 percent was obtained with two 0.75" by 0.010" straps spaced 2.75 inches apart on the front and back sides of the specimens. Table 1 below summarizes the improvements in regards to arrest of propagated cracks and residual static strength as compared to specimens which have not been modified in accordance with the present invention.

TABLE 1

No.	Configuration	Improvement in crack arrest, percent	Improvement in residual static strength, percent
1	Two 0.75" by 0.010" straps front and back sides of specimen, spacing 2.75".	48	70
2	Two 0.75" by 0.010" straps front and back sides of specimen, spacing 3.75".	15	63
3	Two 0.75" by 0.010" straps impact side of specimen, spacing 2.75".	15	46
4	One 3" by 0.010" strap impact side of specimen.	19	----------------
5	One 4" by 0.010" strap impact side of specimen.	39	----------------
6	One 7" by 0.010" strap impact side of specimen.	39	33

Although I have described my invention with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example and that numerous changes in the selection of components, and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

Having described my invention, I claim:

1. A method for arresting propagated fractures in a metal stressed-skin of construction when the skin is damaged, comprising the bonding of a fiber strap to the metal outside the edge of the fracture and traverse thereto, thereby arresting the fracture when it progresses to the fiber straps.

2. A method in accordance with claim **1** comprising the bonding of two fiber straps to the front side of the metal.

3. A method in accordance with claim **1** comprising the bonding of four fiber straps to the front and back side of the metal on both sides of the fracture.

4. A method in accordance with claim **3** wherein the metal is selected from the group consisting of aluminum, titanium and stainless steel.

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