

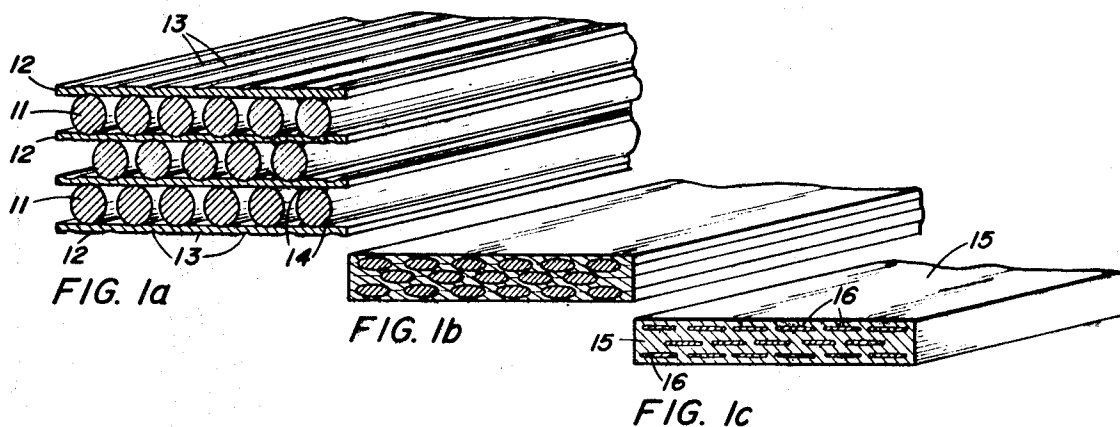
Oct. 5, 1971

R. SCHMIDT

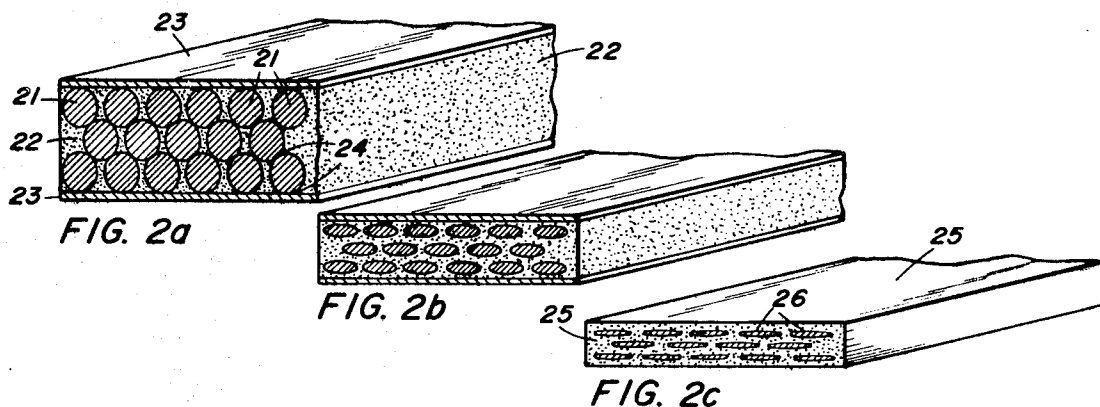
3,609,855

PRODUCTION OF BERYLLIUM RIBBON REINFORCED COMPOSITES

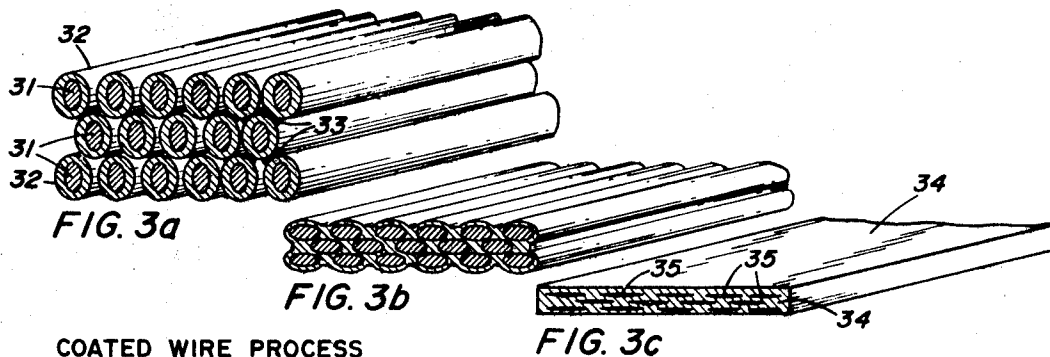
Filed April 25, 1969



STRAIGHT ROLL BONDING



METAL SPRAY OR POWDER SINTERING
PRIOR TO ROLL BONDING



COATED WIRE PROCESS

A COVER PLATE AND SIDE PLATES USING A
PICTURE FRAME APPROACH MAY BE DESIRED.
ALSO, THE COATED WIRES COULD BE
PLACED INTO A TUBE PRIOR
TO DEFORMATION.

INVENTOR

RICHARD SCHMIDT

BY

Richard G. Schmitt

ATTORNEY

1

3,609,855

PRODUCTION OF BERYLLIUM RIBBON REINFORCED COMPOSITES

Richard Schmidt, McLean, Va., assignor to the United States of America as represented by the Secretary of the Navy

Filed Apr. 25, 1969, Ser. No. 819,287

Int. Cl. B23k 31/02

U.S. Cl. 29—471.1

10 Claims

ABSTRACT OF THE DISCLOSURE

A process of producing a composite consisting in aligning a plurality of beryllium wires, rods or ribbons and covering the beryllium with a metal. Rolling with sufficient heat to convert the metal to a plastic state and the wires to flat ribbon strips and produce a metal composite having beryllium ribbon reinforcement.

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to a composite and the process of making this composite which consists in arranging a plurality of beryllium wires in spaced parallel relation and by hot rolling immersing these wires in a matrix of metal, the rolling operation reducing the wires to ribbons of reinforcing beryllium.

Description of the prior art

A truly useful composite for most structural applications must have the following characteristics:

- (1) Low density
- (2) High strength
- (3) High modulus of elasticity
- (4) Good impact resistance
- (5) Adequate ductility for deformation after fabrication.

The above requirements are obvious with the possible exception of No. 5. The reason for this requirement is that most manufacturing operations require a final bending of a structure for fit up, or, for example, the twisting of an aircraft compressor blade for tuning. In addition, this ductility is required for redistribution of stresses in complex parts. The lack of ductility has proven to be a serious limitation in boron aluminum and boron epoxy type composites.

In order to have the above-listed characteristics a ductile reinforcement is necessary. To date, the only known ductile high modulus of elasticity, high strength, low density reinforcement material is the metal beryllium. High strength ductile beryllium wire has been developed and is presently in commercial production. It is presently being used as a reinforcement in a beryllium wire aluminum matrix high strength ductile composite.

SUMMARY OF THE INVENTION

A composite formed of a matrix of aluminum or titanium with reinforcing ribbons of beryllium and the processes for making this composite form the subject of this invention. The first process consists of aligning the beryllium wires in spaced parallel relation and covering them with a metal. Hot rolling changes the wires into ribbons and the metal covering into a matrix surrounding the reinforcing ribbons of beryllium. The second process

2

is similar except the metal is in the form of metal powder, which is sifted over the aligned wires and sintered. In this process additional covering sheets of metal may also be used to add to the matrix. The third process involves coating the wires, prior to aligning them in spaced parallel relationship, with the coating metal forming the matrix after hot rolling the bundles of wire. Here also additional metal may be added in the form of sheets or as powder.

The object of the invention is to provide a composite formed of a metal matrix of aluminum or titanium having multiple layers of flat beryllium ribbon as reinforcement.

Other objects, advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIGS. 1a, 1b and 1c show, respectively, the first step in the process with the wires in spaced parallel relation and the plates forming the subsequent matrix in position; after the rolling operation the matrix is formed and the wires reduced in thickness and extended in width and the final stage where the wires have been reduced to flat ribbons and the matrix shaped to form square edges and to completely embed the reinforcing ribbons;

FIGS. 2a, 2b and 2c illustrate a slightly different process showing, respectively, the aligned spaced parallel wires surrounded by a powdered metal and covered with a plate of the same metal; a second stage showing the changing of the shape of the wires and the forming of the integral matrix and a third stage showing the completed composite with the shaped matrix and the flat reinforcing ribbons; and

FIGS. 3a, 3b and 3c illustrate a still further process showing, respectively, a plurality of coated wires in spaced parallel relation; the wires being spaced from one another by the thickness of the coating; a second stage showing the beginning of the formation of the matrix and the flattening of the wires and a third stage showing the completed composite.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the process illustrated in FIGS. 1a, 1b and 1c, a plurality of wires 11 formed of beryllium metal are arranged in spaced parallel relation, separated by plates 12 of aluminum or titanium. These plates may be grooved at 13 to provide means of spacing and aligning the wires or the wires may be held in place by adhesive means or any other way desired. The plates here shown as four with reinforcing layers of wires between each plate, may be of any number depending on the desired thickness of the finished product. The plates and reinforcing wires are bound together by tack welding 14 at the ends or by an adhesive or any suitable means to form a bundle or pre-preg. The bundle shown in FIG. 1a is passed through a hot rolling mill, the temperature of which is sufficient to cause the covering metal plates to flow and form a matrix 15 and to soften the beryllium wires so that it may be flattened into ribbons 16. In the rolling operation, end pieces, not shown, may be applied to shape the composites into slabs or sheets having flat parallel top and bottom faces and square and parallel edges. The finished product is a composite formed of an aluminum or titanium matrix with reinforced ribbons of beryllium, all held in a metallurgical bond, produced by the rolling operation, which is carried out at temperatures that metallurgically cold work the wire from a round cross-section to a flat strip or ribbon, while diffusion bonding the reinforcing ribbons into the matrix.

3

The second process is different in the use of powdered metal in a sintering process or by using plasma metal by spraying. After the bundle or pre-preg is formed the hot rolling operation is carried out as in the first-described process. Either with the powdered metal or the plasma sprayed metal, covering sheets may be used, top and bottom if desired. FIGS. 2a, 2b and 2c illustrate this process, where the beryllium wires, indicated at 21, are covered by a powdered metal 22 to which may be added the upper and lower plates 23. The wires are secured together by spot welding 24 or other means so that they may be fed through a hot rolling mill to produce the composite shown in FIG. 2c with an aluminium or titanium matrix 25 reinforced by beryllium ribbons 26.

The third process again differs from that of both one and two. In this process the beryllium wires 31 are coated with metal 32 by vapor or electroplating, by sintered powder techniques or by drawing the wire through a molten bath. The outer metal 32 may be in the form of a tube through which the wire is threaded. In this process, the percentages of the metals, the matrix and the reinforcing metal may be carefully controlled by the thickness of the coating and the diameter of the wire. FIGS. 3a, 3b and 3c illustrate this process where the beryllium wire is indicated at 31, the tubing or coating 32 and the bond or weld for holding the wires together previous to hot rolling at 33. A fixture, not shown, in the form of a picture frame may be used together with either top or bottom plates to assist in producing a desired composite. The bond could be welding or the coated wires could be placed in a form which could be withdrawn. The finished composite would be similar to that of the other processes having a metal matrix 34 with beryllium reinforcing ribbons 35.

The fact that we are dealing with a ductile reinforcement (beryllium wire as opposed to boron, carbon, etc.) enables the accomplishment of forming the composite into a complex shape either during the initial fabrication of the composite or after the composite sheets are made. It is only necessary to heat the composite to a temperature where the shear strength of the matrix or ribbon matrix bond is very low permitting the ribbons to bend and the matrix to flow around the reinforcement.

The new feature that the beryllium ribbon reinforcement composite has over other composites is that the ribbon shape permits reinforcement in both the longitudinal and transverse direction with a uniaxially aligned reinforcement. This results in a composite that is much more efficient than other fiber composites which require cross-ply for comparable strength and modulus of elasticity. There are some applications that may require a cross-ply of the ribbon reinforcement, however, the composite will still be more efficient since fewer layers of ribbons in the cross direction will be required. In addition, the ribbon reinforced composite will have greatly improved impact resistance and fatigue life over that of a fiber reinforced composite.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings.

What is claimed is:

1. The process for producing a ribbon reinforced composite which comprises the steps of:
forming a bundle of metal and reinforcing material by

4

aligning a plurality of round beryllium wire strands within a framework of metal selected from a group consisting of aluminum and titanium; and
hot rolling the bundle to form a metal matrix with flat reinforcing ribbons, the hot rolling being carried out at a temperature and pressure which cause the metal framework to flow and form a matrix while flattening the round beryllium wire strands into flat ribbons and diffusion bonding the ribbons into the matrix.

2. The process of claim 1 wherein the step of forming a bundle of metal and reinforcing material further comprises the steps of:

providing a plurality of metal plates;
aligning the plurality of beryllium wire strands in spaced parallel relationship on each of the plates;
placing the plates, having the aligned wire strands on them, one on the other, the bottom of one plate resting on the aligned wire strands of its lower adjacent plate;
and placing a covering plate on the stacked plates and the wires.

3. The process of claim 1 wherein the step of forming a bundle of metal and reinforcing material further comprises the steps of:

sifting a metal powder over the aligned beryllium wires; and
sintering the bundle thus formed.

4. The process of claim 1 wherein the step of forming a bundle of metal and reinforcing material further comprises the steps of:

coating the beryllium wires with a metal prior to aligning them; and
gathering the coated beryllium wires into a bundle.

5. The process of claim 2 wherein the metal is aluminum and the wire is annealed beryllium and the step of hot rolling is conducted at a temperature which cold works the beryllium wire.

6. The process of claim 3 wherein the metal is aluminum and the wire is annealed beryllium and the step of hot rolling is conducted at a temperature which cold works the beryllium wire.

7. The process of claim 4 wherein the metal is aluminum and the wire is annealed beryllium and the step of hot rolling is conducted at a temperature which cold works the beryllium wire.

8. The process of claim 2 wherein the metal is titanium and the wire is cold worked beryllium.

9. The process of claim 3 wherein the metal is titanium and the wire is cold worked beryllium.

10. The process of claim 4 wherein the metal is titanium and the wire is cold worked beryllium.

References Cited

UNITED STATES PATENTS

3,419,952	1/1969	Carlson	29—472.3
3,523,354	8/1970	Lowenstein	29—472.3

JOHN F. CAMPBELL, Primary Examiner

D. P. ROONEY, Assistant Examiner

U.S. Cl. X.R.

29—191, 420.5