United States Patent [19]

Russell et al.

[11] **3,904,405**

[45] **Sept. 9, 1975**

[54] **SLIDING SEAL PARTS AND PROCESS OF MAKING**

[75] Inventors: **Robert A. Russell**, Rosemont; **Irving J. Hess**, Philadelphia, both of Pa.

[73] Assignee: **Ametek, Inc.**, New York, N.Y.

[22] Filed: **Feb. 2, 1973**

[21] Appl. No.: **328,926**

[52] **U.S. Cl.** ..... **75/201;** 75/212; 75/226; 204/14 N; 418/178

[51] **Int. Cl.**[2] **C22C 1/04**

[58] **Field of Search**. 117/160, 114 C, 228, DIG. 11, 117/46 CC; 418/178, 179, 113, 152; 204/14 N; 75/201, 212, 226

[56] **References Cited**

UNITED STATES PATENTS

3,550,247 12/1970 Evans et al. 117/228

Primary Examiner—Cameron K. Weiffenbach
Assistant Examiner—Edith R. Buffalow
Attorney, Agent, or Firm—Smythe & Moore

[57] **ABSTRACT**

A sliding seal part and method of making by use of coated carbon filaments or particles with aluminum, the coated particles being subjected to heat and pressure to form the seal part.

6 Claims, 5 Drawing Figures

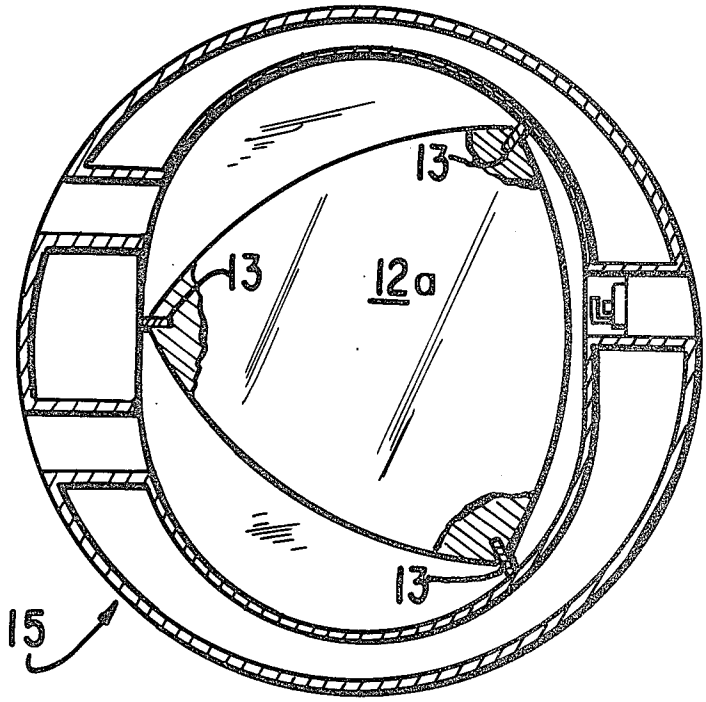


FIG. 1

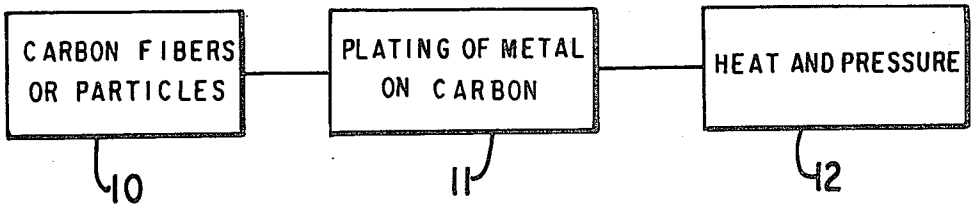


FIG. 2

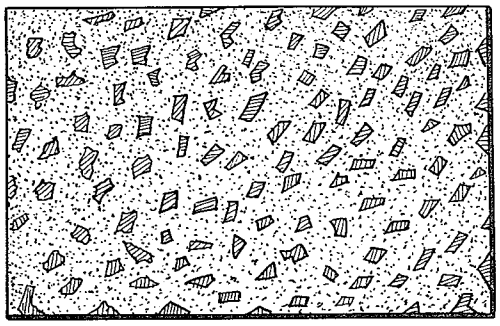


FIG. 3

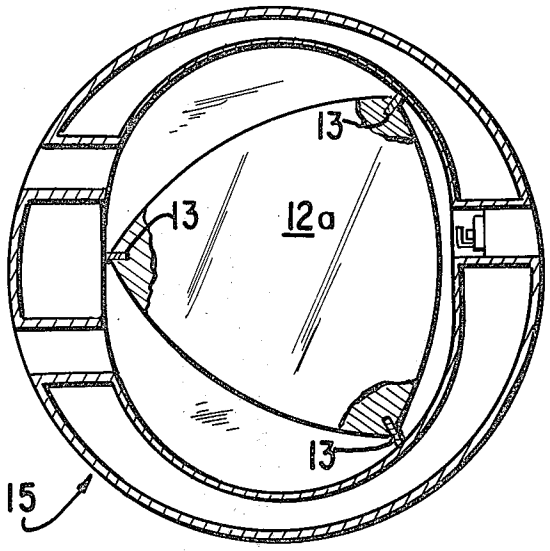
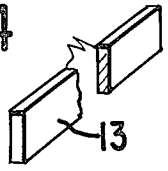


FIG. 4



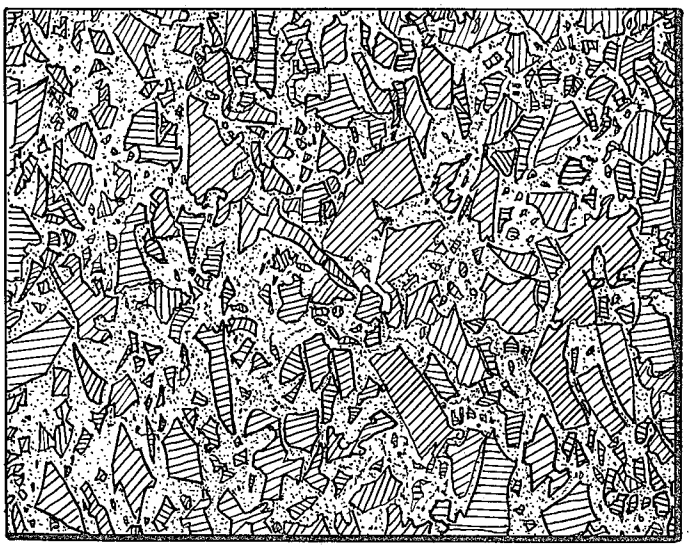


FIG. 5

SLIDING SEAL PARTS AND PROCESS OF MAKING

This invention relates to sliding seal parts or the like and a method of making the parts.

Bearing or sliding seal parts, including carbon or graphite, which have self-lubricating properties are known in the art, but such have been brittle with low fatigue strength and have had a tendency to score. The impregnation of formed structures of carbon filaments or particles with plastic resins or metals, such as silver, copper, bronze, cadmium or babbit, have been tried, but these have not had the required properties or strength and wear resistance. It also has been suggested that carbon powder be pressed and the pressed particles put into an autoclave and immersed in a molten aluminum metal bath in said autoclave under pressure. Aluminum carbide will form between the particles in the pressed shape. A seal so made has not been completely satisfactory and has been uneconomical to make.

One of the objects of the invention is to make an improved sliding seal part or piece having the desired physical characteristics.

Another of the objects of the invention is to provide a method for making sliding seal parts which produces seals of improved strength and physical characteristics.

Another object of the invention is to produce sliding seal parts in a more economical manner than previously accomplished.

In one aspect of the invention, carbon filaments or particles, herein referred to as elements, are coated or plated with aluminum. This is carried out preferably by electrodeposition. Other plating methods such as electroless or chemical plating can be used. The plating process can be carried out at room temperature. The metal coated or plated elements are then formed under pressure and heat to the desired seal and sliding part form. The forming can be carried out in various manners as described hereafter. It has been found that the products of the present invention have been particularly efficacious for uses such as the apex seals for the rotor of Wankel-type engines.

These and other objects, advantages and features of the invention will become apparent from the following description and drawings which are merely exemplary.

In the drawings:

FIG. 1 is a schematic diagram of the steps involved in the invention;

FIG. 2 is a representation of a photomicrograph (500X) of a part made in accordance with Example I described hereafter;

FIG. 3 is an example of one use of the invention which is in a "Wankel" engine;

FIG. 4 is a broken perspective view of a seal as used in FIG. 3; and

FIG. 5 is a representation of a photomicrograph of a part made in accordance with Example II described hereafter.

Referring to the flow diagram of FIG. 1, the carbon or graphite fibers or particles are represented in box **10** which are plated at **11** and then consolidated under heat and pressure at **12** to the form of a sliding seal part or bearing.

The carbon or graphite filaments or fibers can be the desired dimensions as set forth hereafter. If particles of carbon or graphite are used, then these can be sized as described hereafter.

The carbon elements, discrete fibers or particles, are adheringly plated with aluminum by electrodeposition or by electroless deposition.

In the case of electrodeposition, such can be carried out, for example, as described in U.S. Pat. No. 2,651,608 to Brenner in a bath as set forth therein. The bath can consist of an ether, such as ethyl ether, ethyl n-butyl ether, a mixture of ethyl and butyl ethers, anisole, phenetole or diphenyl ether; a metal hydride such as lithium hydride or lithium aluminum hydride; and anhydrous aluminum chloride.

Following are examples of manners in which the invention can be practiced.

EXAMPLE I

The graphite yarn used was "Thornel 400," the trademark of Union Carbide Corp. for its brand of high strength, high modulus graphite yarn, such a yarn being comprised of 1,000 filaments, approximately 7.6 microns in diameter, twisted to form a yarn.

Aluminum was electrodeposited on 12-inch lengths of graphite yarn using the methods described in the aforementioned Brenner patent. Sufficient aluminum was deposited to form an aluminum plated yarn having approximately 60 weight percent aluminum and 40 weight percent graphite fiber. Sections of aluminum plated yarn approximately two inches long were plied together in a rectangular die and subjected to heat and pressure. The temperature was maintained at 900°F. and the pressure at 4,000 p.s.i. for 30 minutes. The plated aluminum coating on the individual filaments of the graphite yarn consolidates to form a homogeneous distribution of graphite fibers in an aluminum matrix. FIG. 2 of the drawing represents a 500X magnification of the cross section of the resultant composite as viewed in a direction perpendicular (90°) to the orientation of the graphite fiber axis. The tensile strength of the part so made was 38,000 p.s.i. as measured in a direction parallel to the axis of the graphite fibers. The tensile strength of a comparable aluminum part of the same dimensions but not containing any graphite fiber is 10,000 p.s.i.

EXAMPLE II

The carbon powder used was "M351" vitreous carbon, as sold by Beckwith Carbon Co.

Aluminum was electrodeposited on a specific size of M351 vitreous carbon (−200 mesh + 325 mesh) using the methods described in the aforementioned Brenner patent. Sufficient aluminum was deposited to yield a plated powder containing 30 weight percent of aluminum and 70 weight percent of vitreous carbon powder.

Sliding seal parts were formed from the aluminum plated vitreous carbon powder as follows:

1. The plated powder was blended with sufficient aluminum alloy powder, designated as Al32, made by Aluminum Company of America, to yield a mixture containing 50 percent vitreous carbon by weight.
2. The blend was cold compacted at a pressure of 40,000 p.s.i. to yield a form having sufficient green strength to be subjected to subsequent processing.
3. The form made in step 2 was heated without pressure to a temperature of 1,100°F. in a furnace containing N_2 or an inert atmosphere for a period of 15 minutes.

4. Upon completion of step 3, the form while still hot was placed in a die whose dimensions conformed to the finished dimensions of the sliding seal part and was subjected to a pressure of approximately 150,000 p.s.i. and was maintained at this pressure for 5 minutes.

The part made in the above example was subjected to a wear test. Results of the wear test are described in Table I.

EXAMPLE III

Example III is the same as Example II except that calcined anthracite or carbon powder sold under the trademark "A-Carb," a trademark of U.S. Graphite Co., was used.

Tests were performed on articles made in accordance with prior art as described hereafter.

SAMPLE	DESCRIPTION
1	Commercially available carbon-aluminum apex seal used in the Wankel-type engine and manufactured by the molten aluminum metal infiltration process.
2	Seal made according to the method described in Example II.
Sample Size	A retangular bar 0.5 inch in length by 0.24 inch in width and 0.34 inch in height. The bar had a radius of 5/32 inch on the face subjected to wear testing.

TEST METHOD

The test seal was held against the rotating surface of a hard chrome plated aluminum alloy disc. The disc was rotated at a peripheral speed of 5,400 feet per minute. The test seal was mounted on a lever arm which extends 6 inches beyond the point at which the seal touched the rotating disc. A load of 5 pounds was placed on the end of the lever arm. The disc surface was lubricated with SAE20 oil, and the disc was rotated for each of the test samples for the same period of time. The wear rate of the samples was determined by measuring the difference between original height of the test sample and the height after the wear test and dividing this difference in height by the length of time the test was run so as to obtain wear rates in inches of wear per hour. The results are reported in Table I.

TABLE I

Test Sample	Wear Rate
1	.00145 inches/hour
2	.00019 inches/hour

The plating also can be performed by electroless or chemical plating such as chemical vapor deposition or vacuum deposition.

The heat and pressure or consolidation step can be carried out in various manners. The plated filaments or particles can be heated in a mold which has pressure applied. Also, powder metallurgy techniques can be employed compacting under high pressure the coated elements without heat. The pressure of the aluminum on the carbon provides sufficient green strength to handle the part for subsequent processing. Such is not the case when uncoated carbon powder and aluminum powder are mixed. The second step is the sintering of the formed green shape. The third step, optional, is coining, pressing or otherwise treating the sintered part.

One example of use of the invention is seen in FIG. **3** wherein the seal **13** is shown in conjunction with rotor **12***a* of the Wankel engine **15.** The combination is the subject of copending application Ser. No. 328927, filed Feb. 2, 1973.

It should be apparent that variations can be made in details hereof without departing from the spirit of the invention except as defined in the appended claims.

What is claimed is:

1. The process of producing sliding seal part means comprising the steps of adheringly plating discrete carbon elements with aluminum, then consolidating said plated elements into sliding seal part means by pressure and heat, wherein the plating is carried out by electrodeposition from an ethereal bath containing anhydrous aluminum chloride and a metal hydride selected from the group consisting of lithium hydride and lithium aluminum hydride.

2. The process of producing sliding seal part means comprising the steps of adheringly plating discrete carbon elements with aluminum, then consolidating said plated elements into sliding seal part means by pressure and heat, wherein the plating is carried out by electrodeposition from an ethereal bath containing anhydrous aluminum chloride and a metal hydride and wherein the ethereal bath is selected from the group consisting of ethyl ether, ethyl n-butyl ether, anisole, phenetole, diphenyl ether and mixtures of ethyl and butyl ethers.

3. The process of producing sliding metal seal part means as claimed in claim **1** wherein the discrete carbon elements are vitreous carbon particles.

4. The process of producing sliding metal seal part means as claimed in claim **1** wherein the discrete carbon elements are calcined anthracite particles.

5. The process of producing sliding seal part means as claimed in claim **2,** wherein the discrete carbon elements are vitreous carbon particles.

6. The process of producing sliding seal part means as claimed in claim **2,** wherein the discrete carbon elements are calcined anthracite particles.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,904,405

DATED : September 9, 1975

INVENTOR(S) : Robert A. Russell and Irving J. Hess

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

Patent Front Page, [54], "Sliding Seal Parts and Process of Making" should be --A Process of Making Sliding Seal Parts--.

Signed and Sealed this

ninth Day of *December 1975*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks

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