

[54]	COMPOSITE METAL BODIES	1,750,751	3/1930	Geyer	75/138
[75]	Inventors: Frank Arthur Badia, Ringwood, N.J.; Pradeep Kumar Rohatgi, Bethlehem, Pa.	2,170,259	8/1939	Borofski et al.	75/135
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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 715,937, March 25, 1968, abandoned, which is a continuation-in-part of Ser. No. 644,429, May 25, 1967, abandoned, which is a continuation-in-part of Ser. No. 585,097, Oct. 7, 1966, abandoned.

[52] U.S. Cl. 75/138; 29/191.2; 75/135;
75/146; 75/147

[51] Int. Cl. C22c 21/00

[58] Field of Search 75/135, 138, 146, 147;
29/191.2

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[57]

ABSTRACT

Composite metal bodies are provided in which particles of at least one constituent are embodied in metal in which the constituent is normally insoluble or incompatible when the metal is in the molten state, e.g., graphite in aluminum, the composites being produced by melt processing.

21 Claims, 2 Drawing Figures

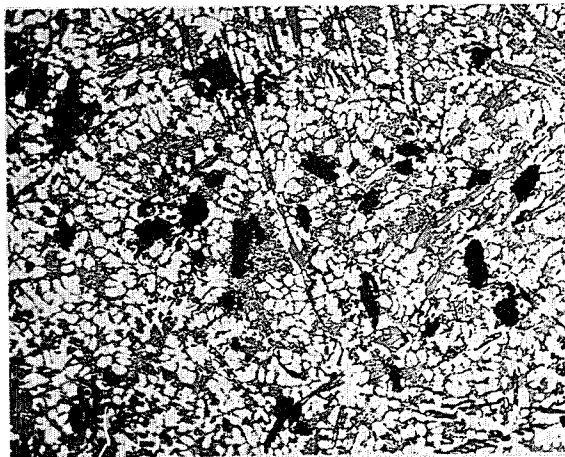


FIG. 1

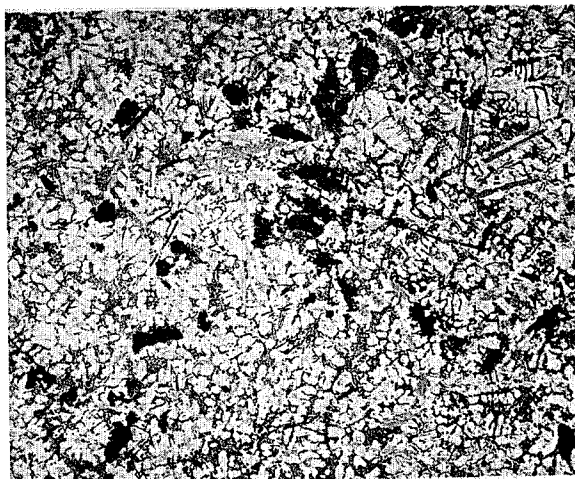


FIG. 2

COMPOSITE METAL BODIES

This application is a continuation-in-part of U.S. application Ser. No. 715,937, now abandoned filed Mar. 25, 1968, which is a continuation-in-part of application Ser. No. 644,429, filed May 25, 1967, now abandoned, which in turn is a continuation-in-part of application Ser. No. 585,097, filed Oct. 7, 1966, now abandoned.

As is well recognized in the metallurgical art, various metals manifest any number of useful properties, properties enhanced by alloying with other constituents. Aluminum, for example, has many desirable characteristics, notably, light weight, resistance to various corrosive media and relatively high strength in relation to weight. However, aluminum surfaces are quite susceptible to surface damage such as galling and scoring when subjected to sliding contact with other aluminum surfaces.

The frictional characteristics of aluminum and known aluminum alloys are such that articles thereof cannot be used in self-mated sliding contact without maintaining therebetween a fluid film lubrication condition, a condition often impossible to maintain, particularly where contact pressures are high or sliding speeds are low. Therefore, where two such articles were to be used in self-sliding contact it has been necessary for most practical purposes to make one of the articles of a metal other than aluminum or to provide an interposing metal therebetween. For example, the skirts of aluminum pistons used in aluminum cylinder blocks have been plated with iron, chromium or tin or an iron liner has been provided in the cylinder.

In accordance herewith, however, the frictional shortcomings of aluminum can be appreciably minimized by incorporating therein certain percentages of graphite. These constituents are generally considered metallurgically incompatible in the sense that when graphitic carbon is mixed with molten aluminum it is rejected from the melt. In any case, using metal processing (pyrometallurgy), no such alloy, insofar as we are aware, has been produced on a commercial scale which contained an appreciable amount of graphite, say, 0.5, 0.6 percent, or more, and which significantly affected the frictional characteristics of the aluminum. Actually, the more recent attempts have been generally directed to powder metallurgical techniques but such are unsatisfactory in many instances for various reasons.

While the foregoing is directed to the aluminum-graphite metallurgical system, other incompatible systems in which one constituent is insoluble as a practical matter in a molten bath of a second are clearly contemplated. For example, zinc and magnesium are characterized by metallurgical incompatibility with graphitic carbon and it would be desirable to obtain lubricity and machinability benefits of graphite as a dispersoid in these metals. Illustrative of other incompatible environments are silicon carbide in nonferrous metals, e.g., aluminum, zinc or copper; diamond in metals such as aluminum and zinc; mica in such incompatible low melting point metals as zinc, lead, aluminum and magnesium; heavy oxides in lead; silica, magnesia, alumina and other oxides in metals such as copper and nickel; silica, magnesia and others in aluminum; etc.

Accordingly, it is an object of the invention to provide alloys having improved characteristics, the alloys having dispersed substantially throughout a constituent

(dispersoid) normally incompatible with the base metal when the latter is in the molten condition.

A particular object is to provide aluminum alloy products characterized by improved resistance to scoring, galling and/or seizure when used in sliding contact against aluminum alloys under conditions of poor lubrication.

Other objects and advantages will become apparent from the following description taken in conjunction with the accompanying drawing in which:

FIGS. 1 and 2 are reproductions of photomicrographs (magnification 100 diameters), of etched sections of an aluminum alloy casting in accordance with the invention.

Generally speaking, the present invention contemplates composite compositions of matter comprised of particles of at least one constituent (dispersoid), e.g., graphite, distributed substantially uniformly throughout a solidified (cast) matrix of metal in which the constituent is, as a practical matter, normally insoluble when the matrix metal is in the molten condition, e.g., metal from the group consisting of aluminum, magnesium and zinc in the case of graphite, the constituent particles upon being introduced into and dispersed within a molten bath of such metal being characterized by coatings effective to impart compositional stability to the molten bath. The percentage of dispersoid so embodied should be at least 0.5 percent and up to not more than about 15 or 20 percent by volume, a range of 1.5 or 2 to 5 or 10 percent being deemed quite satisfactory for numerous applications. More than one such dispersoid can be present and other elements can be incorporated as necessary.

Incompatible systems include those in which a constituent is insoluble in alloys as well as the base metals which might form the alloys. In respect of graphitic aluminum, for example, this includes not only pure aluminum but alloys containing, in weight per cent, in addition to a major proportion of aluminum, up to about 25% silicon, up to about 25% tin, up to about 15% copper, up to about 15% magnesium, up to about 20% zinc, up to about 10% nickel, up to about 8% cobalt, up to about 5% manganese, up to about 1% chromium and up to about 1.5% iron. Such alloys preferably contain at least 5%, e.g., at least 8%, silicon to promote uniform distribution of graphite in the melt and to avoid detrimental graphite segregation during solidification. For good toughness and wear resistance, from 5 to 16 percent, say, 8 to 13 percent, silicon is beneficial. However, the silicon should be controlled in relation to any nickel so that the total percentage thereof does not exceed about 20 percent in order to avoid embrittlement. Small amounts of optional elements, e.g., titanium, boron, zirconium, vanadium, antimony and cadmium, may be included for purposes such as grain refinement, strengthening, raising the recrystallization temperature, improving weldability, etc.

Further with respect to graphitic aluminum, in obtaining particularly good results it has been found that at least about 1 percent of graphite by volume (0.6 percent by weight) should be present, advantageously at least about 1.9 or 2 percent by volume (about 1.2 percent by weight), for satisfactory frictional characteristics under conditions of poor lubrication, such as the mixed film condition where the fluid film partially breaks, and to be sildably operable to a substantial extent in the boundary lubrication region. For toughness

and good fluidity, the graphite content should be not greater than about 7.8 or 8 percent by volume (about 5 percent or slightly above by weight). A preferred alloy contains about 1.9 to about 7.8 percent (by volume) graphitic carbon and, by weight, about 4 to about 7 percent nickel, about 8 to about 13 percent silicon, up to 4 percent, e.g., 0.5 to 4 percent, copper, up to 1.2 percent, e.g., 0.3 to 1.2 percent, magnesium, up to 0.6% iron, the balance essentially aluminum, the alloy possessing in the chill cast condition, gall and heat resistant characteristics particularly well suited for sliding contact elements in internal combustion engines, e.g., pistons.

With reference to graphitic alloys generally, beneficial improvements in frictional and/or machinability characteristics of metals such as zinc and magnesium as well as aluminum are obtainable with graphite in amounts of at least 0.2 percent by weight, and upwards to 5, 10 or even to 15 percent by weight in these metals. While improvement is obtainable with as little as 0.05 percent graphite, the characteristics of such alloys are greatly less desirable. Accordingly, it is of considerable benefit to have substantially greater amounts of graphite, advantageously at least 0.6 or 1.8 percent, dispersed throughout the matrix metal.

In carrying the invention into practice, the constituent particles are most advantageously metal coated when dispersed in a melt. And in this connection, the surface coatings are essentially metal, i.e., are in the metallic condition characterized by being essentially uncombined metal and essentially devoid of oxides or other compounds. The coatings become at least partially dissolved in the molten bath and can ultimately impart useful characteristics. Beneficially, the alloys are chill cast, e.g., permanent mold cast or die cast, or are similarly rapidly solidified such as in continuous casting.

In striving for the maximum percentage of retained dispersoid particles in the melt and final product based upon the amount of particles added, the coatings should be completely continuous over the entire surface of each particle. While, for practical purposes, the coatings need not be entirely perfect, it is to be emphasized that the particles must be substantially surrounded by the coatings, e.g., coatings over at least 80 or 90 percent, advantageously 95 percent, of the surface of the particle.

In formulating alloy compositions, the amount and nature of coating metal is taken into account. For example, should the coating be nickel, up to 10 percent, e.g., 0.05 to 10 percent thereof, can be added in producing graphitic aluminum alloys since at least a goodly portion melts, dissolves or is otherwise incorporated into the alloy, e.g., as a nickel aluminide, and provides, especially in amounts of at least 4 percent, e.g., 4 to 7 percent, hardness, strength and wear resistance at room and elevated temperatures, and high retention and uniform distribution of the graphite.

For the purpose of giving those skilled in the art a better understanding of the invention the following illustrative examples are given:

To illustrate the importance of having at least about 1 percent by volume (0.6 percent by weight) and most desirably at least 2.8 percent by volume (1.8 percent by weight) of graphitic carbon in an aluminum-base in accordance herewith, a series of alloys (Alloys 1-12

Table I) were chill cast and wear tested using a Hohman tester.

Alloy Preparation

The alloys were prepared using nickel-coated graphite particles introduced into baths in a stream of nitrogen gas while the baths were maintained at a temperature of about 1,400°F. Average particle sizes (U.S. series and including coating) are also given in Table I.

The particles were introduced at a positive pressure of 2 psi from a feeder assembly comprised of a gas pressurized hopper with a valve at the bottom for regulating flow, a steel tube connected to the valve exit and leading downward from the hopper, and a graphite nozzle attached at the lower end of the tube. Nitrogen was provided from a pressurized cylinder connected to the assembly by two conduits, one leading from the cylinder into the hopper, thereby pressurizing the hopper, and the second leading into the steel tube below the hopper. The weight of particles introduced was about 10 percent of the initial weight of the baths and dispersion and retention of the particles in the bath metals were satisfactory. The melts were cast at a pouring temperature of about 1,400°F. into iron chill molds and subsequent metallographic examination confirmed that the castings contained a great number of graphite particles dispersed uniformly throughout the matrix.

In preparing alloys 2 through 6, 9, 11 and 12, the nickel coatings were about 2 microns average thickness, whereas for 7, 8 and 10 the coatings were about 15, 50 and 30 microns, respectively. The extent, if any, to which the coatings remained on the particles of Alloys 1 to 12 could not be determined. Optical and electron micrographic examination did not disclose any nickel coating around the graphite particles in the solidified alloys.

TABLE I

Alloy No.	C (%)	Ni (%)	Cu (%)	Si (%)	Mg (%)	Fe (%)	Al (%)	Graphite Size
1	1.80	6.3	2.4	8.1	1	0.23	Bal.	80
2	1.88	5.4	2.7	12.4	1	0.28	Bal.	80
3	1.42	4.9	2.4	9.8	1	0.88	Bal.	80
4	0.66	4.24	0.47	9.9	0.3	0.61	Bal.	60
5	0.72	5.14	0.43	10.0	0.3	0.66	Bal.	120
6	0.26	4.6	2.6	7.8	1	0.26	Bal.	80
7	0.55	4.19	0.47	10.6	0.3	0.65	Bal.	200
8	0.26	5.14	0.43	9.2	0.3	0.63	Bal.	200
9	0.11	4.25	0.48	9.9	0.3	0.60	Bal.	40
10	0.08	4.72	0.46	9.9	0.3	0.66	Bal.	400
11*	0.9	6.0	0.5	11.5	0.4	0.6	Bal.	40
12*	1.12	2.0	0.5	11.5	0.4	0.6	Bal.	40

C(%) = % Graphitic Carbon; Bal. = Balance Essentially

*Nominal composition except for graphitic carbon content.

Graphite Size = The numeral 60 refers to particles which passed through a 200 mesh screen (opening about 74 microns) but retained by a 325 mesh screen (opening about 44 microns) and is thus a representative approximate average of the largest and smallest of such particles. The other sizes were determined in a similar manner.

Test Procedure and Results

For purposes of test, circular discs were rotated in contact with shoes having concave surfaces which mated with the peripheral surfaces of the discs. During test, the specimens were submerged in lubricating mineral oil (Aturbrio). The testing cycle, except when specimens galled so greatly that binding caused rotation to cease and necessitated discontinuance of the test, was to rotate the specimens at 830 revolutions per minute (rpm.) and to increase the bearing pressure in steps until the pressure forcing the mating surfaces to-

gether reached a maximum level of 2,480 psi. When the maximum bearing pressure was reached, the rotational speed was decreased (without decreasing the load) in steps until rotation ceased due to binding or else, if galling did not occur, until the heat and friction increased to about the limiting capacity of the test apparatus.

A bearing parameter, $B = ZN/P$, where Z is the oil viscosity in centipoises, N is the rotation speed in rpm. and P is the pressure in psi at the mating surface, was used as an index of lubrication conditions at the mating surfaces. Inasmuch as the pressure increases and viscosity and speed decrease during test, the specimens were subjected to progressively deteriorating lubricating conditions.

One characteristic evaluated was resistance to seizure (due to galling) under conditions of poor lubrication, e.g., mixed lubrication or boundary lubrication, conditions where some breakdown of the lubricating oil film occurs. Alloys which did not seize at relatively low bearing parameters are characterized by good galling resistance superior to that of alloys which seized at relatively high bearing parameters.

As a further part of the overall wear test, the maximum coefficient of friction at which sliding contact operation was successfully maintained, i.e., the maximum coefficient of friction prior to seizure (if seizure occurred) was determined. High maximum friction coefficients (Max. Mu) show good frictional characteristics and vice versa. In general, where coefficients of 0.07 or greater were obtained, the alloys were satisfactory under boundary lubrication. If less than 0.07, the alloys failed to reach a boundary lubrication condition characterized by a bearing parameter not greater than 3.0 and could be operated only in mixed or full film lubrication.

Results of the Hohman tests are set forth in Table II. Except for Alloys 2 and 3, the bearing shoes were made from chill castings of an alloy which is commercially used in cast cylinder blocks for internal combustion engines and nominally contains about 12% silicon, less than 0.005% carbon with the balance being aluminum. As to Alloys 2 and 3, the shoes were made of the same alloy as the rotating disc. The lubricating oil for the aluminum-silicon alloy shoes was a No. 50 oil having a viscosity of 29 centipoises at 100°F. and the oil for the self-mated tests was a No. 60 oil having a viscosity of 60 centipoises at 100°F. The numbers in the columns "average Max. Mu" and "Average Min. B" in Table II show the average values of the highest friction coefficients and the lowest values of the bearing parameter, respectively, that were reached at the finish of each test.

TABLE II

Disc Alloy	Number of Tests	Average Max. Mu	Average Min. B.
1	3	0.096	0.27 No Galling
2	4	0.121	1.10 No Galling
3	5	0.107	1.82
4	3	0.098	2.03
5	3	0.096	1.3
6	2	0.016	4.00
7	3	0.042	10.6
8	3	0.060	11.9
9	3	0.044	26.0
10	3	0.034	14.0

Table II, reflects that Alloys 1 through 5, which contained at least 0.6% graphite by weight (at least about 1% by volume), were operable up to and into boundary lubrication conditions characterized by a combination of a high coefficient of friction of at least 0.07 and a low bearing parameter not greater than 3.0. Alloys 1 and 2, containing at least 1.8 percent (about 2.8 percent by volume) graphite were slidably operable and resisted galling and seizure under severe boundary lubrication conditions characterized by very high friction coefficients of at least about 0.09 in combination with very low bearing parameters not exceeding about 1.5. In contrast, alloys which did not contain as much as 0.6 percent graphite all failed to resist galling and seizure when subjected to lubrication conditions which were not as severe as the boundary lubrication conditions endured by Alloys 1 through 5.

Hohman tests of greater severity, wherein the bearing load was increased to a maximum of about 3,000 psi, were performed with specimens of Alloys 11 and 12 mated against aluminum-silicon alloy shoes and using Aturbrio 50 oil. Both alloys operated successfully into the boundary lubrication region and resisted galling until very low bearing parameters of 0.75 with Alloy 11 and 0.47 with Alloy 12 were reached, the maximum coefficients of friction obtained at galling being 0.110 and 0.099, respectively.

Uniform dispersion of graphite particles in accordance with the invention are illustrated in FIGS. 1 and 2 by microstructures from a 7-inch long, 2 inch-diameter chill cast bar of Alloy 3 cast in the vertical position. FIG. 1 was taken from a section of the bar which was near the top during casting and solidification, FIG. 2 being taken from near the bottom. Accordingly, microstructures from the same casting at cross sections separated by a vertical distance of about 6 inches show that the graphite particles remained uniformly dispersed and did not detrimentally segregate. FIGS. 1 and 2 also reflect the effectiveness of the nickel coatings in imparting compositional stability to the molten alloy.

Nickel-coated graphite particles were also successfully injected into a molten bath containing about 6.5% tin, the balance essentially aluminum. Metallographic examination showed a high recovery of uniformly distributed graphite. And, copper-coated graphite particles (75% copper and about 25% graphite) were successfully used in connection with an aluminum-base melt containing about 11.5% silicon, less than 0.005% carbon, about 0.6% iron, about 0.5% copper and about 0.3% magnesium. Particle size ranged from about 75 to 150 microns and the weight of the injected powder was about 10 percent of the initial melt weight. The particles were dispersed satisfactorily, the alloy containing 4.7% copper and 0.69% graphitic carbon.

Nickel-coated graphite particles comprising about 75% nickel were also injected into a melt containing about 4% aluminum and balance essentially zinc. Microexamination showed a high recovery and uniform distribution of graphite. Using optical and electron micrographic equipment the nickel coating was not observed around the graphite particles. By chemical analysis the alloy contained 1.15% graphitic carbon, 3.25% nickel and 4.16% aluminum. Similarly, metal-coated graphite particles can be used in conjunction with other known zinc alloys including those containing up to about 30% aluminum, up to about 4% copper, up to

about 0.4% lead, up to about 0.3% cadmium, up to about 0.5% magnesium, balance essentially zinc.

Graphitic magnesium alloys containing 0.05 percent or more graphite can also be produced in accordance with the invention. Such alloys can contain up to 10% aluminum, up to 6% zinc, up to 4% rare earth metals, up to 3.3% thorium and up to 0.75% zirconium.

As exemplary of composites utilizing dispersoids other than graphite, highly satisfactory results have been obtained with both alumina and silicon-carbide in each of aluminum, an aluminum-base alloy containing about 12% silicon and a zinc-base alloy containing about 4% aluminum, and also with silica in the same aluminum-base and zinc-base alloys. About 3percent by weight of dispersoid powder (nickel coated) was added to the aluminum and aluminum 12% silicon alloy, about 2% being added to the zinc 4% aluminum alloy. The data is reported in Table III in respect of chill cast specimens.

TABLE III

Dispersoid	Bath Melt	% Dispersoid found In Casting	Recovery, % of Dispersoid Added
Silicon carbide	Al-12 Si	2.9	96
"	Al	2.46	82
"	Zn-4 Al	1.98	99
Silica	Al-12 Si	1.54	51
"	Zn-4 Al	1.59	79
Alumina	Al-12 Si	2.78	92
"	Al	2.63	87
"	Zn-4 Al	1.95	97

The abrasion resistance of the above alloys was deemed to be extremely good owing to the fact that these materials resisted cutting with steel blades and machining with carbide tool bits. For example, in order to machine aluminum tensile bars containing the silicon carbide and alumina particles it was necessary to resort to diamond cutting tools. This is considered rather remarkable. It might also be added that copper-coated and zinc-coated silica particles resulted in good composites.

In terms of specific articles of manufacture, good compositional stability was achieved with chill casting fourteen automotive pistons from a melt of molten graphitic aluminum (nickel coating used). Molten metal for each piston was tapped and hand ladled to the mold as a separate operation, with stirring or skimming before each tap, so that the period while the metal was held in the furnace, tapped, ladled and cast covered about 40 minutes. The alloy was a commercial type nominally containing 9.5% silicon, 3.5% copper, 1% magnesium, the balance being aluminum. Chemical analysis of the pistons reflected that each contained at least 1.25% graphite by weight. Using a conventional permanent mold, an aluminum piston containing 3.89% graphite has been successfully cast and thereafter readily machined without difficulty.

Graphitic aluminum castings made by the process of the invention have also been induction melted, stirred and recast without excessive loss of graphite, thereby demonstrating that for commercial purposes, master alloys or scrap castings, gates, risers, etc., can be used as melting stock for making graphitic aluminum cast articles and other products. This was unexpected and

it is considered that this data indicates that a portion of the coating metal may remain or can remain intimately associated with a goodly percentage of the dispersed particles, say, 5 or 10 percent or more thereof, in the original solidified cast composite state whereby the wetted condition is retained upon re-melting. Good compositional and microstructural stability at room temperature and elevated temperatures is another favorable attribute of the alloy.

In producing the subject composites, it is of benefit to propel or otherwise force the coated particles into the molten baths in a non-reactive gas stream. Nitrogen, argon, helium and other non-reactive gases can be used.

Coatings, particularly metal, about 0.2 to about 50 microns thick applied by known methods, including vapor or chemical deposition, are satisfactory. Coating thickness should be at least about 2 microns to ensure the particles are essentially covered, but to avoid an excess of coating the thickness is preferably not greater than about 5 microns. Metal coatings may comprise, nickel, copper, cobalt, iron aluminum or zinc and alloys thereof. Others that might be mentioned, and this depends, of course, upon what might be desired in the final product, are silicon, tin, cadmium, antimony, chromium and tungsten.

Dispersoid particles are preferably at least about 40 microns in average cross-section size, particularly in the case of graphite, although sizes down to 10 or 5 microns or even finer can be used. Particle size should not exceed about 200 microns since larger particles may tend to segregate too rapidly. With respect to graphite particularly, especially good recovery and uniform dispersion obtains with an average size of about 40 or 60 to 120 microns. In some exceptional instances, if solidification can be brought about very quickly after injection, e.g., 3 to about 30 seconds, satisfactory results can be obtained with particles as large as 2,000 microns. Casting fluidity is benefited by having, at least in the case of graphite, particles of generally equiaxed configurations, e.g., relatively spheroidal or lump-like, and not acicular or flake-like.

As will be appreciated by those skilled in the art, in the selection of the two or more incompatible materials, the dispersoid constituent should not be one which decomposes at the bath temperature. In addition to the incompatible systems enumerated hereinbefore, it is contemplated that the dispersoid can be selected from the group consisting of oxides, carbides, nitrides and borides. Molybdenum disulfide would be another such constituent, particularly for lubricity qualities. Various intermetallic compounds are also contemplated.

As to graphite specifically, molten bath metals other than aluminum, zinc, magnesium, etc., in which graphite is virtually insoluble include copper and copper-base alloys, notably brass and bronze, lead alloys and tin alloys.

As a practical matter, in dealing with various incompatible systems the densities of the respective incompatible constituents should, generally speaking, preferably be such that one does not exceed the other by a factor of about three; otherwise, there is the possibility of encountering immediate or rapid segregation as by sinking or floating. This, of course, is by no means an absolute requirement. Advantageously, the difference in respective densities should not exceed a factor of two. Incompatible systems include those in which the

mutual insolubility obtains and there is non-reactivity at temperatures up to several hundred degrees above the melting point of the dispersion medium.

The subject invention is particularly applicable in the production of graphitic and other alloys for sliding contact elements including pistons, bearings, cylinder liners and blocks, sliding valves, internal combustion engine rotors, electrical pick-up shoes, etc. The invention is also applicable to the production of wrought articles including rods, bars, tubes, plates, etc., made by working cast, including continuously cast, alloys contemplated herein. For example, a graphitic aluminum alloy containing 0.51% carbon and 4.1% nickel was hot forged, hot rolled, cold rolled into rod and thereafter cold drawn to produce wire. Furthermore, the graphitic alloys, particularly of aluminum, are useful for providing wear and/or gall resistant surface claddings or overlays, e.g., welded overlays, on composite articles. Also, abrasion resistant articles, including dies and the like, can be produced to advantage in accordance herewith.

Although the present invention has been described in conjunction with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention as those skilled in the art will readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and appended claims.

We claim:

1. A new and improved cast aluminum base alloy, said alloy containing at least about 0.6 percent by weight of uncombined graphitic carbon in the form of graphite particles of at least about 5 but not greater than about 2,000 microns average cross-section size, about 5 to 25% silicon, up to about 25% tin, up to about 15% copper, up to about 15% magnesium, up to about 20% zinc, up to about 10% nickel with the proviso that when the nickel content is at least 4% the total percentage of nickel plus silicon does not exceed 20%, up to about 8% cobalt, up to about 5% manganese, up to about 1.5% iron, up to about 1% chromium, and the balance essentially aluminum, said graphite particles having been introduced into a molten bath of the aluminum-base alloy in the form of metal coated particles, the metal coating being effective to have imparted compositional stability to the base alloy in the molten condition.

2. An alloy in accordance with claim 1 in which the graphite particles are from about 40 microns to about 400 microns in average cross-section size and the carbon content is present in an amount from about 1.8 to about 5 percent.

3. As a new article of manufacture, a cast sliding contact element in accordance with claim 1 in which the alloy contains 8 to 13% silicon, about 4 to 7% nickel and about 0.6 to 5% graphitic carbon and wherein the particles are from about 60 to 400 microns in average cross-section size and characterized by sliding contact operability when mated against an aluminum surface under a boundary lubrication characterized by a coefficient of friction of at least 0.7 and a bearing parameter up to about 3.0.

4. A new article of manufacture in accordance with claim 1 in which the cast sliding contact element is a piston.

5. A metal body in the solidified condition having dispersed therein at least about 0.6 percent and up to

about 5 percent by weight of uncombined graphitic carbon particles of an average size of from about 40 microns to about 400 microns, the particles being dispersed throughout a matrix metal in which graphite is substantially insoluble in the molten condition and formed of an alloy predominantly of one metal from the group consisting of aluminum, magnesium and zinc, said metal body being characterized by enhanced frictional characteristics over the frictional characteristics of the matrix metal when substantially devoid of graphite, said graphite particles having been introduced into a molten bath of the aluminum-base alloy in the form of metal coated particles, the metal coating being effective to have imparted compositional stability to the base alloy in the molten condition.

6. An alloy as set forth in claim 5 wherein the predominant metal is zinc.

7. A metal body in accordance with claim 5 and formed of an aluminum-base alloy containing 0.6 to about 5 percent by weight of graphitic carbon in the form of graphite particles of about 40 microns to about 2,000 microns average cross-section size, 0.05% to about 10% nickel, up to about 25% silicon provided that when the nickel content is at least 4% the total percentage of nickel plus silicon does not exceed 20 percent, up to about 25% tin, up to about 15% copper, up to about 15% magnesium, up to about 20% zinc, up to about 5% manganese, up to about 1.5% iron, up to about 1% chromium with the balance essentially aluminum and characterized by improved frictional characteristics including resistance to galling and seizing under mixed lubrication conditions.

8. A composite metal body in the solidified condition and consisting essentially of particles of at least one dispersoid constituent distributed substantially uniformly throughout a metal matrix in which the dispersoid is normally insoluble, the dispersoid particles being present in an amount of at least 0.5 and up to about 20 percent by volume, the dispersoid particles being of an average cross-section size of less than 400 microns and being in intimate association with a coating metal which substantially enveloped the particles to confer compositional stability between the particles and matrix metal when in the molten state.

9. A composite metal body in accordance with claim 8 in which at least one of the dispersoid constituents is graphite.

10. A composite metal body in accordance with claim 9 in which the matrix metal is from the group consisting of aluminum, aluminum alloys, zinc, zinc alloys, magnesium and magnesium alloys, the dispersoid particles being of an average cross section size of not greater than about 120 microns.

11. A composite metal body in accordance with claim 10 containing nickel in which the matrix metal is aluminum or an aluminum alloy.

12. A composite metal body in accordance with claim 8 in which the coating metal is from the group consisting of nickel, copper, cobalt, iron, aluminum and zinc and alloys thereof.

13. A composite metal body in accordance with claim 8 in which the dispersoid constituent is selected from the group consisting of oxides, carbides, nitrides and borides.

14. A composite metal body in accordance with claim 13 in which the dispersoid constituent is selected

11

from the group consisting of silica, alumina and silicon carbide.

15. A composite metal body in accordance with claim 14 in which the matrix metal is selected from the group consisting of aluminum, aluminum alloys, zinc and zinc alloys.

16. A composite metal body in accordance with claim 15 in which the constituent material is silicon carbide.

17. The composite metal body in accordance with claim 15 in which the constituent material is silica.

18. A composite metal body in accordance with

12

claim 15 in which the constituent material is alumina.

19. A composite metal body in accordance with claim 14 in which the constituent particle constitutes from about 0.5 to about 15 percent by volume of the composite.

20. A composite metal body in accordance with claim 19 in which the particles are from about 5 to about 400 microns average cross-section size.

21. As a new article of manufacture, on abrasion resistant product formed from a composite body in accordance with claim 15.

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