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COMPOSITE ALLOY

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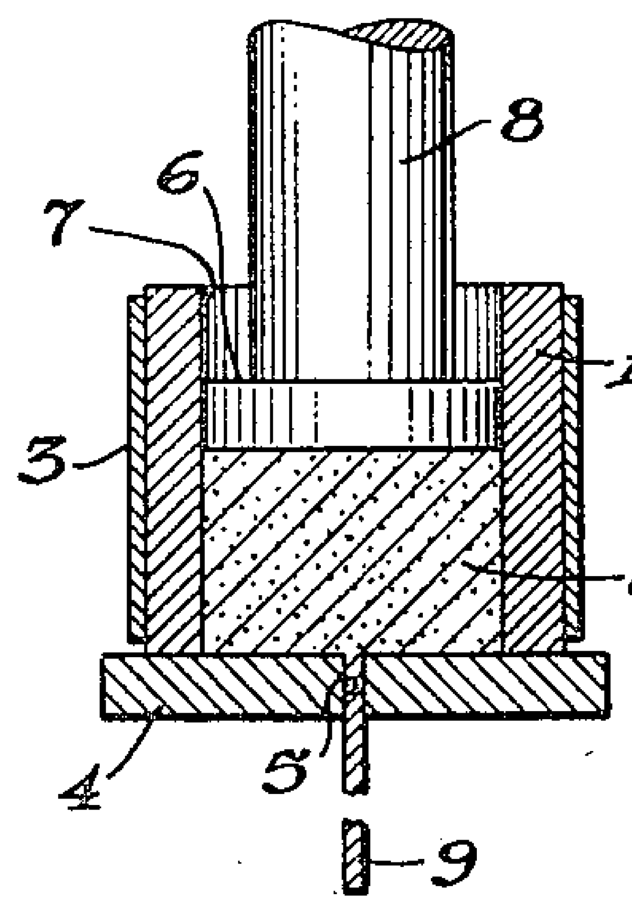

Fig. 1

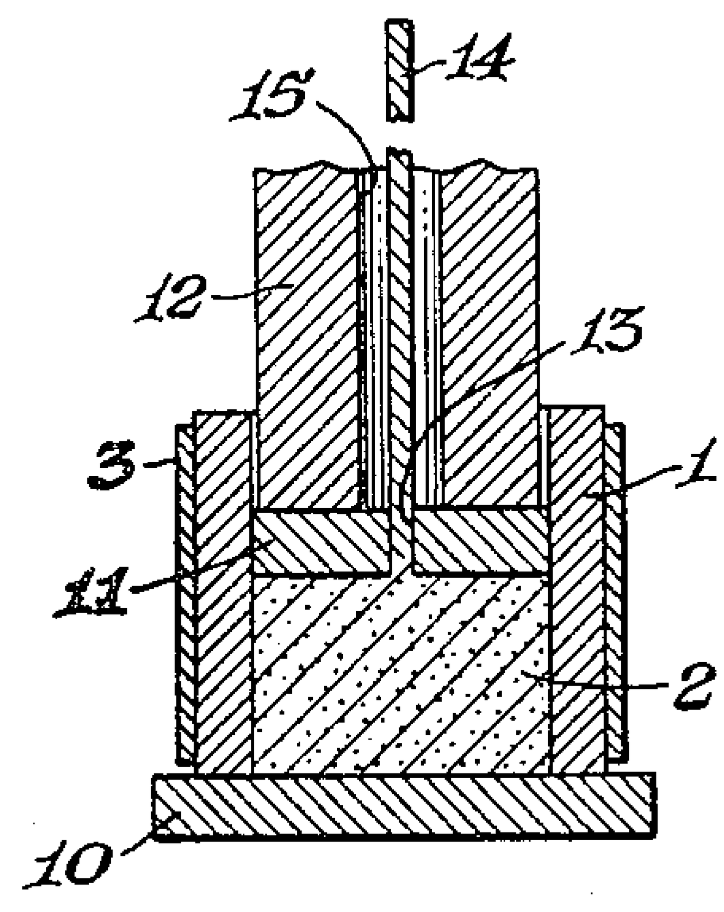

Fig. 2

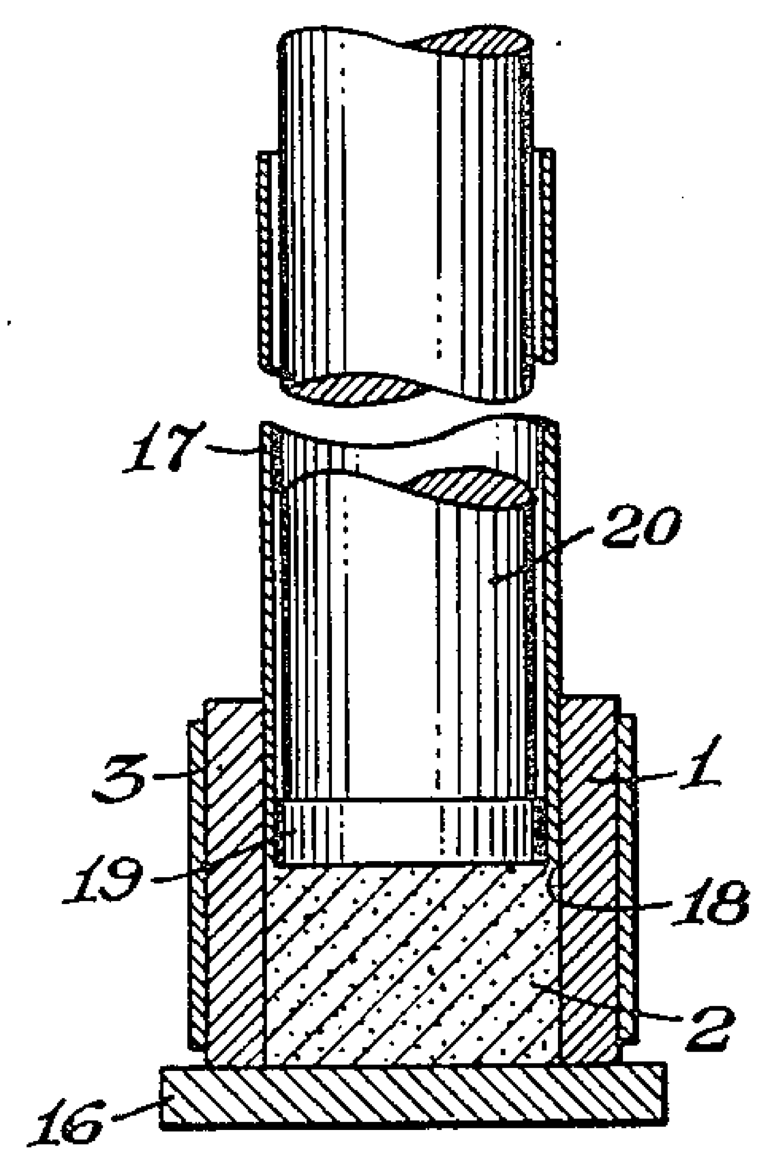

Fig. 3

INVENTORS.
Thomas E. Leontis
Robert S. Busk
BY Griswold & Burdick
ATTORNEYS

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COMPOSITE ALLOY

Thomas E. Leontis and Robert S. Busk, Midland, Mich., assignors to The Dow Chemical Company, Midland, Mich., a corporation of Delaware

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2 Claims. (Cl. 29—182.2)

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The invention relates to a magnesium-base alloy article. It more particularly concerns a zinc-containing magnesium-base composite alloy having a high tensile strength and the lightness characteristic of magnesium.

The term "magnesium-base alloy" used herein means a magnesium alloy containing at least 80 per cent of magnesium by weight.

The invention is predicated upon the discovery that by die-expressing at elevated temperature a zinc-containing magnesium-base alloy in particulated form in admixture with particulated aluminum a high strength composite alloy extrusion is obtained. The composite alloy extrusion of the invention has the same compactness and integrity as the usual magnesium-base alloy extrusions made by extruding a solid mass, such as an ingot of a magnesium-base alloy, but the metallographic structure of the composite product is uniquely different. Metallographic examination reveals a new type of structure in a magnesium-base alloy article. The structure is essentially multimetallic. Each of the particulated metals of the mixture which is extruded is changed to the form of elongated particles with the long axis parallel to that of the extrusion. The elongated particles are all welded one to the other into a solid mass without voids forming a product which may be subjected to all the metal working operations in use with conventional magnesium-base alloys, such as rolling, forging, drawing, welding, electroplating, heat treating, etc. The invention then consists of the composite magnesium-base alloy product and method of making the same herein fully described and particularly pointed out in the claims, the following description setting forth several modes of practicing the invention.

In carrying out the invention, various aluminum-and zirconium-free magnesium-base alloys containing zinc may be used, such as those containing from about 0.5 to 8 per cent of zinc. It is advantageous to include in the zinc-containing magnesium-base alloy a conventional amount of manganese, e. g. from about 0.1 to 2.5 per cent, a generally desirable amount being about 1 per cent. If desired, the alloy also may contain calcium in amount up to 1.0 per cent, or copper in amount up to 0.5 per cent. The zinc-containing magnesium-base alloy, used as one of the ingredients of the composite alloy of the invention, is reduced to particulate form in any suitable way, such as by grinding or atomizing. The atomized form yields superior results and may be produced by forming a melt of the alloy and atomizing it by impinging a jet of a cool gas, e. g. natural gas, against a thin falling stream of the molten alloy. The atomized alloy consists of a mixture of various sized fine spherical rapidly solidified particles, the particles having a very fine grain structure. It is desirable to screen out particles coarser than those passing about a 10 to 20 mesh standard sieve.

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The aluminum ingredient of the mixture of particulate metals to be extruded according to the invention, is elementary aluminum which has been finely divided in any convenient manner. Its particle size is preferably made finer than that of the zinc-containing aluminum- and zirconium-free magnesium-base alloy with which it is to be mixed.

Before extrusion, the particulated metals are mixed together in any convenient manner to form a uniform mixture of the metal particles comprising the extrusion charge. The relative amounts of the particulated zinc-containing magnesium-base alloy and particulated aluminum are adjusted so that there is at least 0.1 part by weight of the particulated aluminum per 100 parts of the mixture. Beneficial results are had with up to as much as about 6 parts of particulated aluminum per 100 parts of the mixture. A preferred proportion is about 3 parts of the particulated aluminum per 100 parts of the mixture.

The mixture of particulated metals is charged into the heated container of a ram extruder, having a suitable size container and die opening and subjected to extrusion pressure to cause the mixture of particulated metals to be heated and extruded through the die opening.

As to the extrusion conditions, the temperature of the particulated metal mixture in the container may be about the same as that conventionally employed for extruding solid ingots of the known zinc-containing aluminum-free magnesium-base alloys, e. g. 600° to 800° F. The ratio of the cross-sectional area of the extrusion container to that of the die opening has a material effect on the mechanical properties of the composite extrusion product obtained. A desirable ratio is at least about 30 to 1, although ratios as high as 150 to 1 or more may be used. The speed of extrusion may be varied over a wide range and depends to some extent upon the size and shape of the die opening. In any case, the extrusion speed is to be held down to that at which the extrusion produced is free from hot shortness. A safe extrusion speed may be ascertained by visual examination of the product as it extrudes, the hot shortness being evident as cracks in the extruded product and sharply reduced strength. The composite extrusion product may be subjected to any of the fabrication operations conventionally in use with the conventional or non-composite magnesium-base alloys, such as rolling, forging, drawing and welding, and its tensile properties may be enhanced by heat treatment.

The invention may be further illustrated and explained in connection with the accompanying drawing in which:

Fig. 1 shows a schematic sectional elevation of an extrusion apparatus suitable for use in practicing the invention;

Fig. 2 is a similar view to Fig. 1 showing a modification of the apparatus; and

By putting a charge of the mixture of the metals involved under pressure while at heat, as with the apparatus shown, the mixture of metal particles is compacted but not subjected to further mixing before extrusion. The metals originally in the charge as individual metal particles do not lose their original distinctive composition except at the surfaces of the union of the different metal particles which become extended and lengthened during extrusion. At these surfaces, during extrusion or heat treatment, some diffusion of metal takes place between the zinc-containing particles and the aluminum particles, forming composite alloy.

The following examples, set forth in the table below, are illustrative of the invention:

Table

Example No.—Blank No.	Composition of extrusion charge of particulated Mg alloy mixed with particulated aluminum			Extrusion conditions			Mechanical properties in 1,000 p. s. i. of extrusions [1]							
	Weight percent alloy	Analysis of Mg alloy	Weight percent Al	Temp., °F.	Reduction in area	Extrusion diameter, inch	ASX		Aged		H. T.		H. T. A.	
							TYS	TS	TYS	TS	TYS	TS	TYS	TS
1	99.9	1.13% Zn, balance Mg	0.1		34:1	0.086	35	44	36	43	24	32	26	37
2	99.5	do	0.5		34:1	0.086	33	41	34	42	25	37	26	38
3	94.0	do	6.0		34:1	0.086	34	40	36	40	32	41	35	42
Blank 1	100	do	None		34:1	0.086	32	40	33	39	24	36	22	41
4	99.0	0.95% Zn, balance Mg	1.0		34:1	0.086	32	37	31	38	27	36	29	37
Blank 2	100	do	None		34:1	0.086	27	37	26	36	18	32	23	33
5	99.9	1.2% Mn, 3.9% Zn, balance Mg	0.1		34:1	0.086	32	45	42	49	24	35	34	41
6	99.5	do	0.5		34:1	0.086	34	46	45	50	27	40	34	43
7	99.0	do	1.0		34:1	0.086	35	45	42	49	32	45	40	49
8	97.0	do	3.0		34:1	0.086	35	39	45	50	35	44	41	49
9	94.0	do	6.0		34:1	0.086	39	47	42	44	41	52	43	52
Blank 3	100	do	None		34:1	0.086	30	41	42	48	29	39	38	44
10	99.0	1.03% Zn, 0.62% Ca, balance Mg	1.0	600	64:1	0.375	34	40	34	41	22	36	25	37
Blank 4	100	do	None	600	64:1	0.375	34	40	31	40	20	33	21	36
11	99.0	0.77% Zn, 0.14% Cu, balance Mg	1.0	650	150:1	Strip ¾ x 1/16	29	37	30	38	27	36	28	36
Blank 5	100	do	None	650	150:1		27	37	27	37	23	34	28	36
12	99.5	5.61% Zn, balance Mg	0.5	650	150:1	Strip ¾ x 1/16	26	41	44	50	26	41		
Blank 6	100	do	None	650	150:1		24	41	42	49	22	32		

[1] ASX=as extruded.
Aged=heat treated 16 hours at 350° F.
H. T.=heat treated 1 hour at 750° F.
H. T. A.=heat treated 1 hour at 750° F. followed by heat treating for 16 hours at 350° F.
TYS=tensile yield strength defined as the load at which the stress curve deviates 0.2% from the modulus line.
TS=tensile strength.

Fig. 3 is a similar view to Fig. 1 showing another modification of the apparatus.

As shown, the apparatus comprises, in its three forms, an extrusion container **1** adapted to confine a charge **2** of the mixture of metal particles to be compacted and extruded. The container is provided with a heating element **3**. In Fig. 1, one end of the container **1** is closed by the die plate **4** in which is provided the die opening **5**. In this form of the apparatus, the charge **2** is caused to be compacted in the container and extruded through the die opening **5** by application of pressure by means of the dummy block **6** forced into the bore **7** of the container by the ram **8** to form the extrusion **9**.

In the form of the apparatus shown in Fig. 2, the container **1** is closed at one end by the plate **10**. The other end of the container received the die block **11** carried by the hollow ram **12** which forces the die block into the container causing the charge **2** to be compacted and to extrude through die opening **13** to form the extrusion **14** which extends into bore **15** of the hollow ram **12**.

In the modification of Fig. 3, the container is closed at one end with a plate **16**. The charge **2** is extruded as a tubular extrusion **17** through the annulus **18** around the die block **19** while it is forced into the container by the ram **20**.

The forms of the apparatus shown are conventional.

In making the composite alloys shown in the foregoing table, the zinc-containing magnesium-base alloys used were in atomized form the particles of which were of various sizes substantially all passing through a 20 mesh sieve while being retained on a 200 mesh sieve. The particles of the particulated aluminum were of generally finer size than those of the magnesium alloy. The two particulated metals were mixed together in the proportions indicated and the mixture charged into the heated container of a ram extruder of the type illustrated in Fig. 1. For the blanks, the zinc-containing magnesium alloy in the same particulated form as used in the mixtures was extruded alone under comparable extrusion conditions. The rate of extrusion of the examples numbered 1 to 10, inclusive, and Blanks 1, 2, 3 and 4 was about 2 lineal feet of extrusion per minute. In Example 11 and Blank 5, the rate of extrusion was 5 lineal feet per minute. In Example 12 and Blank 6, the rate of extrusion was 15 lineal feet per minute.

Among the advantages of the invention are that a workable metal product is obtained having the light weight characteristic of magnesium-base alloys but with enhanced strength, which is generally retained or increased by a more or less prolonged (e. g. 1 to 20 hours) heating in the temperature range of about 300° to 800° F. This property enables the composite alloy to be hot worked in the foregoing temperature range without loss of strength.

We claim:

1. The method of making a solid composite high strength metal product which consists in forming a mixture of two particulated metals, one consisting of aluminum in amount from 0.1 to 6 per cent of the weight of the mixture, the other forming the balance of the mixture and consisting of a magnesium-base alloy containing 0.5 to 8 per cent of zinc, up to 2.5 per cent of manganese, up to 1 per cent of calcium, and up to 0.5 per cent of copper, the balance of the alloy being magnesium, and die expressing the mixture at a temperature between 600° and 800° F.

2. A composite metal body consisting of two particulated metals one consisting of aluminum in amount from 0.1 to 6 per cent of the weight of the body, the other forming the balance of the body and consisting of a magnesium-base alloy containing 0.5 to 8 per cent of zinc, up to 2.5 per cent of manganese, up to 1 per cent of calcium, up to 0.5 per cent of copper, the balance of the alloy being magnesium, the particles being elongated, orientated in the same direction, and welded together into an integral solid.

THOMAS E. LEONTIS.
ROBERT S. BUSK.

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