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COMPOSITE ALLOY

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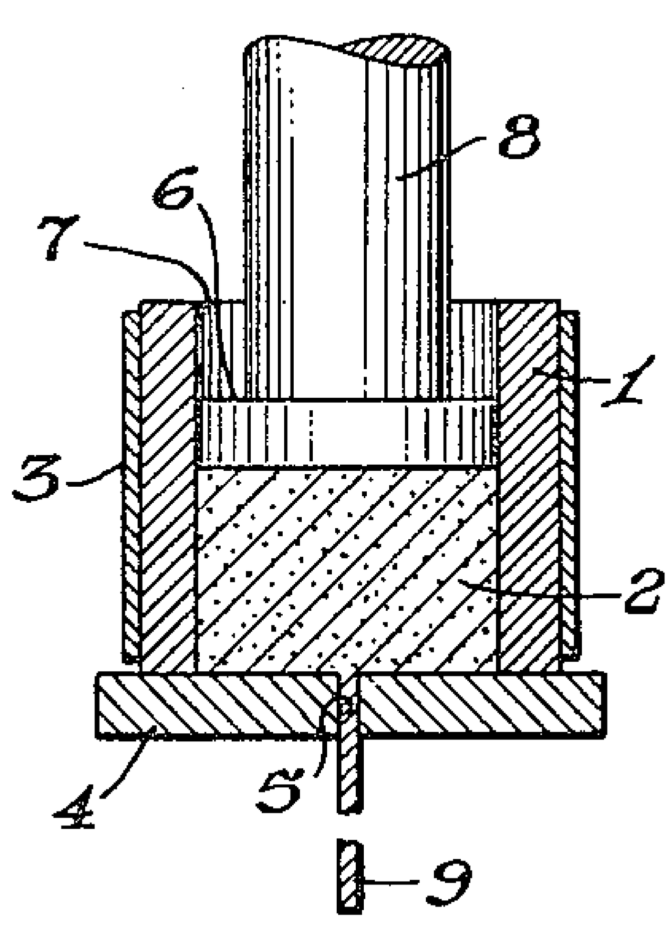

Fig. 1

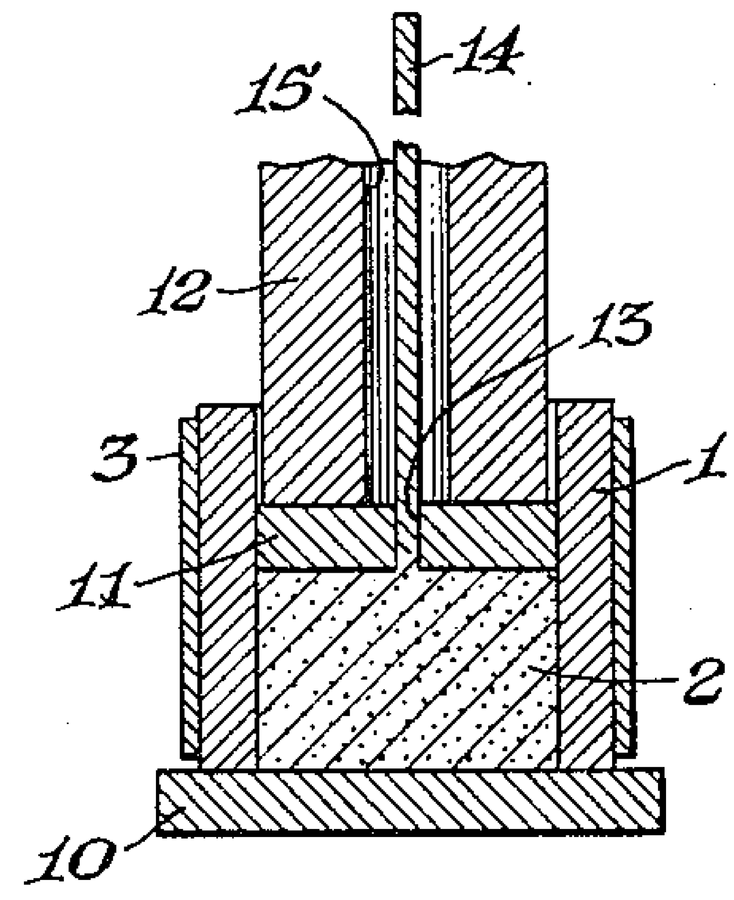

Fig. 2

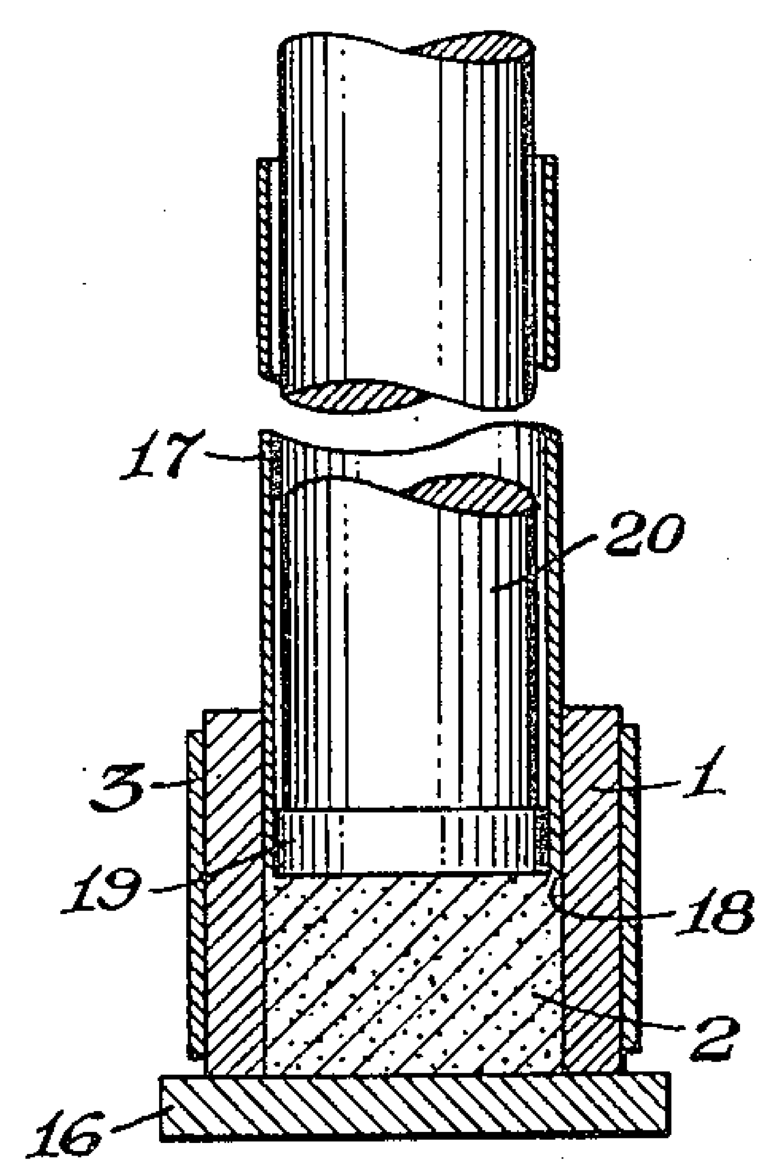

Fig. 3

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COMPOSITE ALLOY

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The invention relates to a magnesium-base alloy article. It more particularly concerns a composite magnesium-base alloy containing manganese.

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

One of the well-known magnesium-base alloys containing manganese is the binary magnesium-manganese alloy which usually contains about 1.5 per cent of manganese, the balance being magnesium. Its outstanding characteristics are lightness of weight, superior resistance to corrosion, and lack of stress corrosion sensitivity. In spite of these desirable characteristics, the alloy is not as generally used as some of the other commercially available magnesium-base alloys because it possesses somewhat lower strength.

The principal object of the present invention is to provide an improved metal product comprising the conventional binary magnesium-base magnesium-manganese alloy exhibiting high strength and method of making the same.

The invention is predicated upon the discovery that by die-expressing a comminuted form of the magnesium-base magnesium-manganese alloy in admixture with at least two of the magnesium-soluble metallic elements of the group: cadmium, lead, manganese, tin, silver, and zinc, a composite alloy comprising the magnesium-base magnesium-manganese alloy is obtained having improved strength. The composite alloy thus obtained may be subjected to any of the fabrication operations conventionally used with ordinary magnesium-base alloys, such as rolling, forging, drawing, welding, heat treatment, 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, the magnesium-base magnesium-manganese alloy used may contain manganese in various proportions, e. g. from about 0.5 to 2.5 per cent, although preferable proportions are about 1 to 1.8 per cent, the balance being commercial magnesium. The alloy is reduced to particulate form in any convenient manner, such as by grinding or atomizing. The atomized form is preferred 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 sieve.

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The magnesium-soluble metals with which the particulated magnesium-manganese alloy are to be mixed may be reduced to particulate form in any convenient manner. Their particle size preferably is made finer than that of the magnesium-base alloy.

Before extrusion, the particulated metals are mixed together in any convenient manner to form a uniform mixture of the metal particles composing the extrusion charge. The amounts of the particulated magnesium-soluble metal in the extrusion charge may be from about 1 to 9 per cent, a preferred proportion being about 2 per cent, the balance of the extrusion charge being the aforesaid particulated magnesium-base magnesium-manganese alloy. The relative amounts of the two particulated magnesium-soluble metals in the extrusion charge may be varied from a minimum of about 10 per cent to a maximum of about 90 per cent of one soluble metal, the balance being the other. A preferred ratio of the amount of one of the two magnesium-soluble metals with respect to the other in the extrusion charge is about 1:1.

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 manganese-containing magnesium-base alloys, e. g. 600° to 850° 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 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 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

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 which is 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 receives 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 which is forced into the container by the ram 20.

The forms of the apparatus shown are conventional.

By putting a charge of the mixture of the particulated metals involved under pressure while at heat, as with the apparatus shown the metal particles are not subjected to further mixing before

extrusion, the metals originally in the charge as individual metal particles become welded together without voids and do not lose their original distinctive composition except at the united surfaces of the particles which become extended and lengthened during extrusion. At these surfaces, during extrusion or heat treatment, some diffusion of metal takes place between the manganese-containing particles and the magnesium-soluble metal particles.

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 Magnesium-Base Alloy Mixed with Particulated Magnesium-Soluble Metals A and B			Reduction in Area	Extrusion Size [2] Inch	Mechanical Properties [3] in 1000's p. s. i. of Extrusions Made at 700° F.							
	Wt. Percent Alloy	Mg Soluble Metal				ASX		Aged		H. T.		H. T. A.	
		A Percent	B Percent			TYS	TS	TYS	TS	TYS	TS	TYS	TS
Blank 1	[1] 100	none	none	31:1	0.090	32	40	32	44	31	39	30	40
Example 1	98.9	Zn 1	Sn 0.1	31:1	0.090	40	47	42	46	34	42	33	42
Example 2	98.0	Zn 1	Sn 1.0	31:1	0.090	44	47	44	46	36	41	33	42
Example 3	96.0	Zn 1	Sn 3.0	31:1	0.090	41	47	43	48	32	41	32	41
Example 4	93.0	Zn 1	Sn 6.0	31:1	0.090	42	48	43	48	33	42	34	41
Example 5	96.0	Zn 3	Sn 1.0	31:1	0.090	39	47	41	48	28	39	29	40
Example 6	98.5	Zn 1	Mn 0.5	31:1	0.090	40	49	41	48	31	42	30	40
Example 7	96.0	Zn 1	Mn 3.0	31:1	0.090	39	47	41	46	32	41	31	41
Example 8	98.5	Zn 1	Cd 0.5	31:1	0.090	40	48	41	49	32	42	34	42
Example 9	98.0	Zn 1	Cd 1.0	31:1	0.090	44	47	43	46	34	41	34	41
Example 10	93.0	Zn 1	Cd 6.0	31:1	0.090	40	48	41	48	32	42	31	40
Example 11	98.0	Zn 1	Ag 1.0	34:1	0.086	39	46	42	47	35	43	34	42
Example 12	98.0	Zn 1	Pb 1.0	34:1	0.086	44	46	45	47	37	41	38	41
Example 13	98.0	Cd 1	Mn 1.0	34:1	0.086	40	43	42	44	36	39	35	40
Example 14	98.0	Cd 1	Pb 1.0	34:1	0.086	41	43	44	45	38	41	38	39
Example 15	98.0	Cd 1	Sn 1.0	34:1	0.086	35	43	40	45	37	40	38	41
Example 16	98.0	Cd 1	Ag 1	34:1	0.086	34	44	39	46	34	41	35	42
Example 17	98.0	Ag 1	Mn 1	34:1	0.086	33	42	37	45	34	42	34	41
Example 18	98.0	Ag 1	Pb 1	34:1	0.086	35	44	39	46	34	41	33	41
Example 19	98.0	Ag 1	Sn 1	34:1	0.086	35	45	38	46	36	43	37	44
Example 20	98.0	Mn 1	Pb 1	34:1	0.086	42	43	42	45	37	40	28	39
Example 21	98.0	Mn 1	Sn 1	34:1	0.086	39	42	42	44	33	39	37	39
Example 22	91.0	Sn 3	Pb 6	31:1	0.090	37	44	37	45	37	43	36	43
Example 23	91.0	Sn 6	Pb 3	31:1	0.090	37	43	40	44	36	40	35	41

[1] 1.6% Mn, balance Mg.
[2] Wire.
[3] ASX=as extruded.
Aged=heat treated for 16 hours at 350° F.
H. T.=Heat treated for 1 hour at 750° F.
H. T. A.=Heat treated for 1 hour at 750° F. followed by heat treatment for 16 hours at 350° F.
TYS=Tensile yield strength, defined as the stress at which the stress strain curve deviates 0.2% from the modulus line.
TS=Tensile strength.

In making the composite alloys shown in the foregoing table, the manganese-containing magnesium-manganese binary alloy used was in atomized form, the particles of which were of various sizes substantially all passing through 20 mesh sieve while being retained on a 200 mesh sieve. The particles of the particulated magnesium-soluble metal were of generally finer size than those of the magnesium alloy used. The particulated metals were mixed together in the proportions shown and the mixture charged into the container of a ram extruder of the type illustrated in Fig. 1. For the blank, the manganese-containing magnesium-base alloy, in the same particulated form as used in the mixture was extruded alone under comparable extrusion conditions. The rate of extrusion was about 1 to 2 feet per minute, and the temperature about 700° F.

We claim:

1. The method of making a solid composite high strength metal comprising magnesium alloyed with manganese which comprises forming a mixture of a particulated binary magnesium-manganese alloy containing from 0.5 to 2.5 per cent of manganese, the balance being magnesium, and at least two particulate magnesium-soluble metals selected from the group consisting of cadmium, lead, manganese, tin, silver, and

[redacted]

zinc, said magnesium-soluble metal forming from 1 to 9 per cent of the weight of the mixture the balance of the mixture being said binary alloy, and die-expressing the mixture at a temperature from 600° to 850° F.

2. The method according to claim 1 in which two magnesium-soluble metals are used and the amount of one of the magnesium-soluble metal is from 10 to 90 per cent of the total amount of magnesium-soluble metal in the mixture.

3. The method according to claim 2 in which the two magnesium-soluble metals are zinc and tin.

4. The method according to claim 2 in which the two magnesium-soluble metals are zinc and manganese.

5. The method according to claim 2 in which the two magnesium-soluble metals are zinc and cadmium.

6. The method according to claim 2 in which the two magnesium-soluble metals are silver and manganese.

7. The method according to claim 2 in which the two magnesium-soluble metals are silver and tin.

8. A composite metal body comprising a particulate binary magnesium-base magnesium-manganese alloy containing from 0.5 to 2.5 per cent of manganese the balance of the alloy being magnesium and at least two particulate metals selected from the group consisting of cadmium, lead, manganese, tin, silver, and zinc, in amount between 1 and 9 per cent of the weight

of the said body the balance of the said body being the said binary alloy, the particles of each metal being elongated, oriented in the same direction and welded together into an integral solid.

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