Nov. 17, 1953 T. E. LEONTIS ET AL 2,659,129

COMPOSITE ALLOY

Filed Aug. 16, 1950

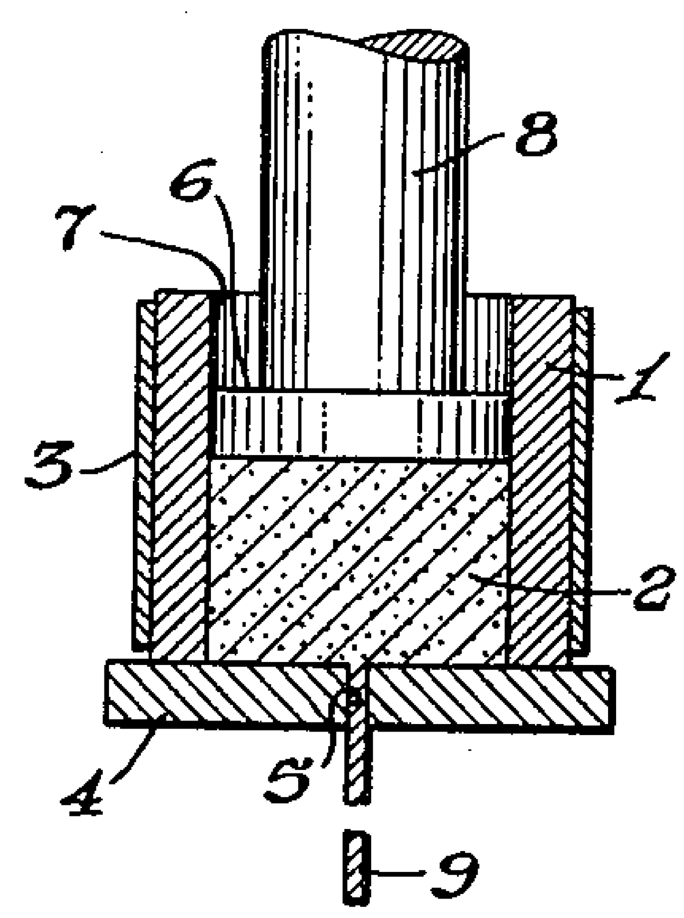

Fig. 1

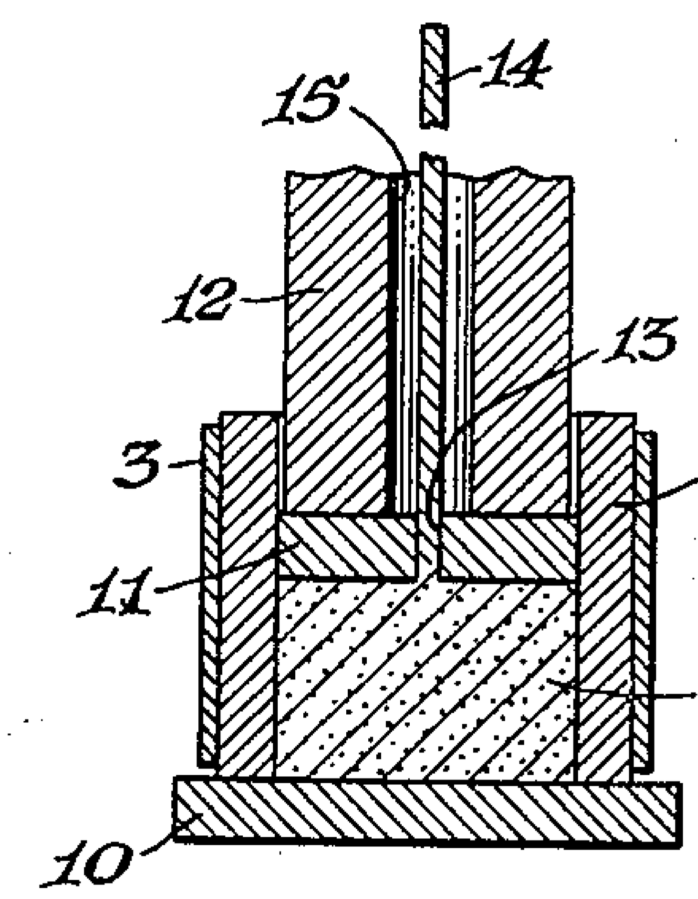

Fig. 2

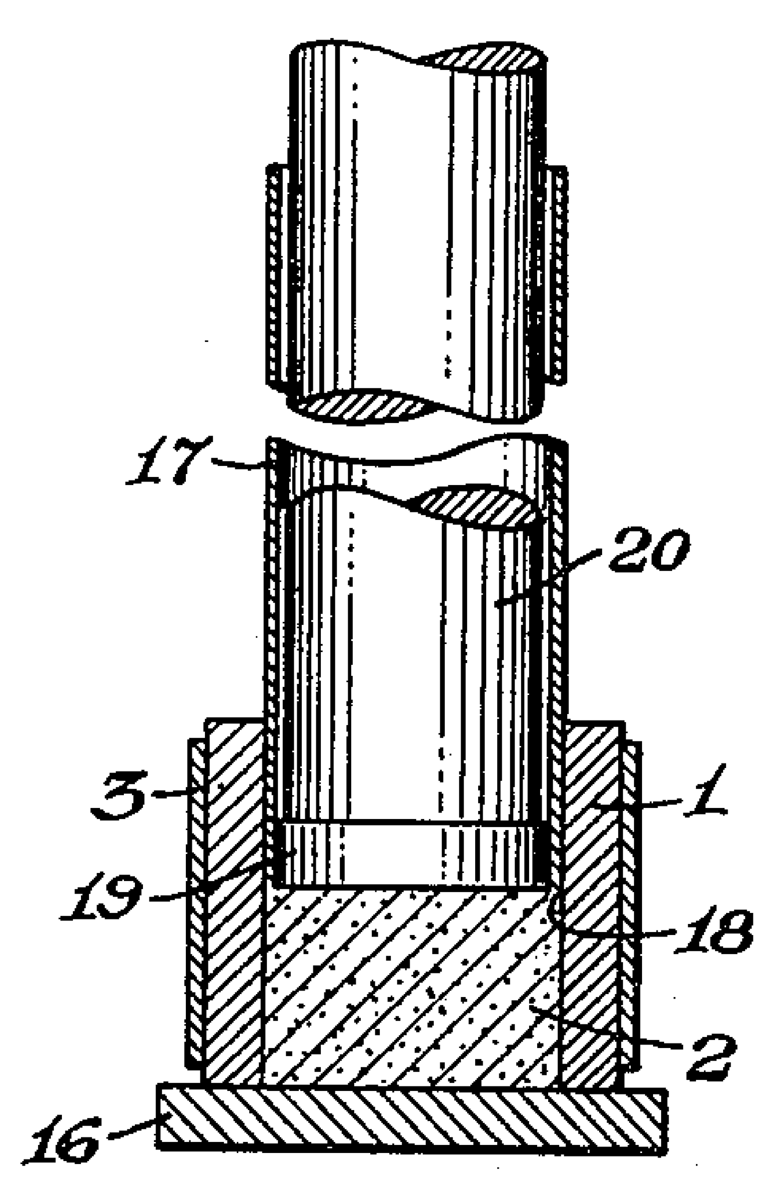

Fig. 3

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Patented Nov. 17, 1953 2,659,129

UNITED STATES PATENT OFFICE

2,659,129

COMPOSITE ALLOY

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Application August 16, 1950, Serial No. 179,772

8 Claims. (Cl. 29—182.2)

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The invention relates to a composite metal body of which magnesium is the predominant constituent. It more particularly concerns a die-expressed composite metallic body comprising magnesium having alloyed therewith at least one solid solution-forming constituent.

Because magnesium is one of the lightest, as well as most easily obtainable, of the abundant metallic elements, and but moderately strong, numerous attempts have been made to improve its strength and other properties, thereby to increase its usefulness by alloying with it other metallic elements. As a result, many magnesium-base alloys have been made exhibiting greater strength than magnesium itself while possessing its characteristic lightness. Nevertheless, it is an ever present desideratum in the art to provide still stronger and more corrosion resistant magnesium-base alloys having a wider range of uses.

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

One of the well-known magnesium-base alloys possessing higher corrosion resistance than magnesium itself is that containing manganese as the principal alloying element in solid solution. Although the alloy is much more corrosion resistant than magnesium itself, its strength is only moderately greater than unalloyed magnesium. It has been proposed to increase the strength of this manganese-containing magnesium-base alloy by alloying the magnesium-soluble metal, aluminum, with it in the molten state but the results have not been wholly satisfactory. One of the difficulties in attempting to alloy aluminum with magnesium in conventional manner in the presence of manganese, as when the manganese is already alloyed with magnesium or is being alloyed with the magnesium at the same time as the aluminum is being alloyed, is that some of the manganese either fails to alloy or is precipitated and settles out of the melt and is lost. Also during the alloying operation, some of the aluminum is always lost along with the manganese by precipitation as a magnesium-aluminum compound. As a consequence, there results an alloy in which the beneficial effects of the manganese, normally realized to the fullest extent in the binary magnesium-base magnesium-manganese alloys, as well as the beneficial effect of alloying aluminum with magnesium, cannot be fully attained in the more complex magnesium-base alloys containing both manganese and aluminum.

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It is the principal object of this invention to provide a method of making a magnesium-base alloy body containing both manganese and aluminum which permits the inclusion in the magnesium-base alloy body of any amount of manganese within its range of alloyability in magnesium. Other objects and advantages will appear as the description of the invention proceeds.

The invention is predicated upon the discovery that by die-expressing the solid binary magnesium-base magnesium-manganese alloy in atomized form in admixture with the magnesium-soluble metal aluminum, in suitably comminuted form, a solid magnesium-base composite metal body is obtained having enhanced tensile strength and other desirable properties. In addition, the method makes possible the inclusion in the die-expressed magnesium-base composite metal body of a higher useful proportion of manganese than is possible in the alloying practices heretofore employed with the magnesium-base alloys containing manganese together with aluminum. Also other unalloyed (elementary) magnesium-soluble metals, in solid comminuted form, may be included in the mixture to be die-expressed, thereby still further modifying the properties of the composite metal product.

The invention then consists of the improved magnesium-base alloy composite metal body and method of making the same hereinafter 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, magnesium with which manganese has been alloyed in conventional manner is used in atomized form. The proportions of manganese which may be alloyed with the magnesium are about 0.1 to 2.5 per cent. It is preferable to use about 1 to 2 per cent of manganese. If desired, small amounts of calcium, oftentimes included in the commercial binary magnesium-base magnesium-manganese alloy, may be present in usual amounts, e. g. between about 0.05 and 0.5 per cent by weight of the alloy. The alloy is reduced to particulate form preferably by atomizing.

The atomized form may be obtained in suitable manner as 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 fine spherical rapidly solidified particles of the alloy with a very fine grain structure. It is desirable to screen out and reject particles coarser than those passing through about a 10 or 20 mesh standard sieve and finer than those retained on about a 200 mesh standard sieve.

The magnesium-soluble metals including the aluminum, which may be either unalloyed (elemental) or alloyed with magnesium, with which the atomized manganese-containing magnesium-base magnesium-manganese alloy is to be mixed prior to die-expression, may be comminuted in any suitable way such as by atomizing in a manner similar to that described for the manganese-containing magnesium-base alloy, if the metal admits of such atomization, or by mechanically subdividing the solid metal as with an impact, hammer, beetling, or stamping mill. The size of the particles of these metals may be similar to or finer than those of the atomized magnesium-base magnesium-manganese alloy to be used.

The procedures used for reducing each of the metals to particulate form for use in the invention do not constitute a part of the invention, although it appears to be necessary to use the magnesium-base magnesium-manganese alloy in atomized rather than other subdivided form. The atomized form has an extremely fine grain because the individual atomized particles are quickly solidified from small drops of molten metal.

The metals in the particulate form described are mixed together to form a uniform mixture of the metal particles. The proportions may be varied to suit the end in view, the proportion of magnesium-soluble metal, including the aluminum added, being from about 0.1 to 12 per cent by weight of the mixture. The mixture 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 heated metal mixture to be compacted and expressed through the die opening.

The temperature of the metal mixture in the container may be the same as that conventionally employed for extruding the known magnesium-base magnesium-manganese alloys, e. g. from about 500° to 1000° F., the usual temperature being about 600° to 750° 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 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 rate of die-expression depends to some extent upon the size and shape of the die as well as the temperature of operation and is to be held down to that at which the extrusion produced is free from hot shortness. In general, the properties of the product are better at low extrusion speeds, e. g. 3–7 feet per minute. 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 extruded composite product obtained has the same degree of compactness and integrity as the usual magnesium-base alloy extrusion made from a solid mass, such as an ingot of a magnesium-base alloy and may be worked as by rolling, forging, pressing, drawing, etc., although the metallographic structure of the composite product is uniquely different from the conventional magnesium-base alloy extrusion. Metallographic examination of the composite product reveals a new type of structure in a magnesium-base alloy article. The structure is essentially

multimetallic, being composed of innumerable elongated particles of each of the particulate forms of the metals in the extrusion mixture. The elongated particles are oriented with the long axis of the particles parallel to that of the extrusion. The elongated metal particles are all welded one to the other without voids. There is diffusion of some of the aluminum constituent of the aluminum-containing particles into the magnesium-base magnesium-manganese alloy particles and precipitation thereby of manganese therein; other magnesium-soluble metal, if present, also more or less diffuses into the particles of magnesium-base magnesium-manganese alloy; and there is some diffusion of magnesium from the magnesium-base magnesium-manganese alloy particles into the aluminum and other magnesium-soluble metal particles, if present, forming composite alloy. The mechanical properties of the composite extrusion obtained generally surpass those otherwise obtainable in a magnesium-base magnesium-manganese alloy. Moreover, the ratio of the amount of aluminum to manganese need not be limited by the incompatibility exhibited by these metals in conventional fusion alloying. A generally higher than conventional amount of manganese can be present in the composite product of the invention than can be tolerated in the conventional magnesium-base magnesium-manganese alloy, with beneficial results as regards mechanical and other properties.

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** 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** while it 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 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 kinds of particles which are interspersed and become extended and lengthened during extrusion. At these surfaces during extrusion, some diffusion takes place between the aluminum-containing particles and the magnesium-containing particles and some manganese is precipitated largely as an intermetallic compound of aluminum and manganese, as already mentioned.

The following examples are illustrative of the invention:

EXAMPLE 1

97 parts by weight of atomized particles of a binary magnesium-base alloy containing 1.08 per cent of manganese, passing through a 20 mesh sieve and being retained on a 200 mesh sieve, are mixed with 3 parts by weight of mechanically comminuted aluminum having a particle size below passing through a 200 mesh sieve. The mixture is charged into an extrusion press container of an apparatus of the type illustrated. The container is heated to 750° F. The ratio of the area of the die opening to that of the container is 50 to 1. Extrusion pressure is applied, thereby compacting the charge which extrudes as the compacting pressure is increased to about 40,000 p. s. i. The rate of extrusion is held to about 5 feet per minute with a die temperature of 630° F. The extrusion obtained contains about 6 times as much manganese as normally present in the commercial ternary magnesium-base magnesium-aluminum-manganese alloy containing 3 per cent of aluminum. Metallographic examination shows that the extrusion obtained is essentially a solid bimetallic body of elongated particles of the binary magnesium-manganese alloy and elongated aluminum particles, the two kinds of particles being interspersed and welded together, all the particles being oriented with their long axes parallel to the axis of the extrusion. Some diffusion occurs of aluminum into the surface of the elongated magnesium-manganese alloy particles and of magnesium into the surface of the elongated aluminum particles as well as precipitation of some manganese-aluminum compound in the binary magnesium-manganese alloy particles near the boundaries demarking the two kinds of metal particles of the extrusion charge. The tensile yield strength of the extrusion is 40,000 pounds per square inch (the tensile yield strength is the stress in pounds per square inch at which the stress-strain curve deviates 0.2 per cent from the modulus line). For comparison, the same atomized binary magnesium-base magnesium-manganese alloy extruded alone under the same conditions of temperature, ratio of reduction in area, and extrusion speed has a tensile yield strength of 32,000 pounds per square inch.

The extent of the diffusion and precipitation which occurs in the composite product may be affected by heat treatment following the extrusion operation, generally with beneficial results as regards strength. As illustrative of this, the extrusion product of the foregoing example was aged by heating for 16 hours at 350° F. as a result its tensile yield strength was increased to 42,000 p. s. i.

EXAMPLE 2

97 parts by weight of atomized particles of a binary magnesium-base alloy containing 1.6 per cent of manganese, the balance being magnesium, passing through a 20 mesh sieve and being retained on a 200 mesh sieve are uniformly mixed with 3 parts by weight of aluminum powder passing through a 200 mesh sieve. The mixture is directly extruded using apparatus like that of Fig. 1, at 600° F. through a die opening 0.375 inch in diameter producing a round extrusion at the rate of five feet of extrusion per minute. The tensile yield strength of the extruded product is 38,000 p. s. i. On heat treating by heating for 1 hour at 750° F. followed by heating for 16 hours at 350° F., the tensile yield strength increases to 41,000 p. s. i. For comparison, the same atomized binary magnesium-base magnesium-manganese alloy as used in the foregoing mixture extruded alone using the same apparatus and other conditions of extrusion produces an extrusion having a tensile yield strength of 30,000 p. s. i. On subjecting this extrusion to the same heat treatment as given the composite extrusion, the tensile yield strength declines to 27,000 p. s. i.

EXAMPLE 3

97 parts by weight of atomized particles of a magnesium-base alloy containing 1.81 per cent of manganese, 0.6 per cent of calcium, the balance being magnesium, passing a 20 mesh sieve and being retained upon a 200 mesh sieve are mixed with 3 per cent by weight of aluminum powder passing 200 mesh. The mixture is extruded at 650° F. into strip ⅛ inch thick and ⅞ inch wide. The extrusion is then heated to 700° F. and rolled in two passes at this temperature producing a reduction in thickness of 30 per cent each. The as-rolled strip product has a tensile yield strength of 39,400 p. s. i. with an elongation of 6.5 per cent. For comparison, the same atomized magnesium-base alloy extruded alone and rolled under the same conditions of extrusion and rolling has a tensile yield strength of 24,000 p. s. i. with an elongation of 6 per cent.

Although the aluminum constituent may be in commercially pure form, as in the foregoing examples, it has been found that a smoother surface is obtained on the extruded product by alloying the aluminum with magnesium before comminuting to produce the aluminum-containing particles for use in the invention. Examples 4, 5, 6 and 7 are illustrative of the use of alloyed aluminum in the invention.

EXAMPLE 4

An atomized magnesium-base magnesium-manganese alloy, containing 1.71 per cent manganese, in particles passing through a 20 mesh sieve and being retained on a 200 mesh sieve, is mixed with an equal weight of a comminuted magnesium-base binary magnesium-aluminum alloy containing 6 per cent of aluminum. The aluminum-containing alloy particles pass through a 200 mesh sieve. The mixture is heated to 650° F. and extruded at this temperature. It forms a solid extrusion having an average content of aluminum of about 3 per cent by weight and of manganese of about 0.85 per cent by weight. Its tensile strength is 43,000 p. s. i. as extruded. For comparison, an atomized magnesium-base magnesium-manganese alloy, containing 1.7 per cent of manganese having particles passing a 20 mesh sieve and remaining on a 200 mesh sieve, on being extruded alone under the same conditions, yields an extrusion having a tensile strength of 41,000 p. s. i.

EXAMPLE 5

An atomized magnesium-base alloy containing 1.77 per cent of manganese, the balance being magnesium, is mixed with a comminuted binary alloy consisting of 80 parts of magnesium and 20 parts of aluminum, in various proportions and the mixtures are extruded into a composite alloy wire 0.092 inch in diameter with a reduction in area of 29 to 1. Each mixture is at about 800° F. and the die at about 680° F. The as-extruded tensile strength (TS) and tensile yield strength (TYS) in 1000's of pounds per square inch of the resulting composite extrusions are tabulated in Table I for each proportion of the two alloys in the extrusion charge. A blank of the atomized binary magnesium-manganese alloy similarly extruded is included for comparison in the same table.

Table I

No. 5	Extrusion Charge Composition, Parts by Wt.		Extrusion Properties As-Extruded	
	Mg-Mn Alloy	Mg-Al Alloy	TYS	TS
a	95	5	29	40
b	90	10	37	49
c	85	15	35	45
d	80	20	39	48
e	60	40	42	51
f	40	60	46	54
blank	100	----------	25	40

A desirable form in which to employ the magnesium alloyed aluminum according to the invention is as comminuted magnesium-aluminum eutectic. Examples 6 and 7 are illustrative of this.

EXAMPLE 6

88 parts by weight of an atomized magnesium-manganese alloy containing 1.81 per cent of manganese, and 0.6 per cent of calcium, the balance being magnesium, is mixed with 12 parts by weight of the magnesium-aluminum eutectic (67 per cent magnesium, balance aluminum). The mixture is extruded at 600° F. into a strip ⅛ inch by ¾ inch. The strip is rolled in two passes each producing a reduction in thickness of about 30 per cent, the metal being at about 700° F. during the rolling. The tensile strength of the rolled composite alloy product is about 52,000 p. s. i.

EXAMPLE 7

In this example, the atomized magnesium-manganese alloy used contained 1.77 per cent of manganese, the balance being magnesium. It was mixed with comminuted magnesium-aluminum eutectic (same composition as that used in Example 6) in various proportions and the mixtures were extruded into a composite alloy wire 0.092 inch in diameter at the rate of about two feet of wire per minute. The extrusion charge was at about 800° F. and the die about 680° F. The proportions of the two alloys in the extrusion charge and the properties of the composite extrusions obtained are set forth in Table II together with the properties of the extrusion of the atomized magnesium-base magnesium-manganese alloy extruded alone for comparison.

Table II

Example 7	Composition of Extrusion Charge, Parts by Weight		Extrusion Properties [1]							
			ASX		Aged		H. T.		H. T. A	
	Mg-Mn Alloy	Mg-Al Eutectic	TYS	TS	TYS	TS	TYS	TS	TYS	TS
a	97	3	30	41	36	44	27	38	31	40
b	94	6	32	43	37	45	29	41	31	41
c	91	9	34	43	40	47	36	44	38	46
d	88	12	35	42	--------	--------	39	47	45	48
e	76	24	45	45	46	46	46	53	45	49
f	64	36	--------	42	--------	44	48	49	47	49
Blank	100	----------	25	40	29	41	26	37	25	38

[1] In nearest 1,000 p. s. i.—
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.

The beneficial effects of mixing aluminum with the atomized magnesium-base magnesium-manganese alloy, the aluminum being used as such or alloyed with magnesium, as in Examples 4, 5, 6 and 7, may be further increased by including in the extrusion charge one or two other unalloyed magnesium-soluble metals in comminuted form. Example of such metals are cadmium, lead, manganese, silver, tin, and zinc. The following examples are illustrative of this:

EXAMPLE 8

98 parts by weight of an atomized magnesium-base magnesium-manganese, the balance being 1.6 per cent of manganese, the balance being magnesium, passing a 20 mesh sieve and remaining on a 200 mesh sieve, is mixed with 1 part by weight of comminuted aluminum and 1 part by weight of comminuted cadmium, the aluminum and cadmium particles passing a 200 mesh sieve. The mixture is heated to 750° F. and extruded through a die having an opening 0.086 inch in diameter, the ratio of the reduction in area being 34 to 1. A solid composite alloy extrusion is obtained having a tensile strength of 46,000 p. s. i.

EXAMPLE 9

On substituting an equal amount of comminuted lead for the cadmium of Example 8, the solid composite extrusion obtained has a tensile strength of 43,000 p. s. i.

EXAMPLE 10

On substituting an equal amount of comminuted manganeses for the cadmium of Example 8, the solid composite extrusion obtained has a tensile strength of 44,000 p. s. i.

EXAMPLE 11

On substituting an equal amount of comminuted silver for the cadmium of Example 8, the solid composite extrusion obtained has a tensile strength of 44,000 p. s. i.

EXAMPLE 12

On substituting an equal amount of comminuted tin for the cadmium of Example 8, the solid extrusion obtained has a tensile strength of 45,000 p. s. i. 3 parts of tin similarly used per 100 parts of the mixture provides an extrusion having a tensile strength of 45,000 p. s. i.

EXAMPLE 13

On substituting an equal amount of comminuted zinc for the cadmium of Example 8, the solid extrusion obtained has a tensile strength of 48,000 p. s. i.

EXAMPLE 14

On using 3 parts by weight of aluminum and 3 parts by weight of tin instead of 1 part of each of these metals per 100 parts of the mixture, as in Example 12, the solid extrusion obtained has a tensile strength of 45,000 p. s. i.

EXAMPLE 15

The use of two or three comminuted magnesium-soluble metals in the extrusion charge in addition to aluminum in the manner described in Example 8, using a die opening of 0.090 inch and producing a reduction in area of 31:1, is illustrated in the data tabulated in Table III.

The extruded composite product of the invention may be subjected to any of the metal treating or working operations common to the conventional non-composite magnesium-base alloy extrusions including heat treatment and rolling already mentioned as well as forging, pressing, and drawing. If desired, a conventional chemical or other finish may be applied. The product may be electroplated by methods suitable for magnesium.

Among the advantages of the invention are that a higher effective manganese content can be had than in a conventional magnesium-base alloy containing aluminum, especially in the range of manganese content beyond its solid solubility in conventional magnesium-base alloys containing aluminum, thereby improving the tensile and other properties of the alloy. In addition, other elementary magnesium-alloyable metals may be included in the composition.

We claim:

1. The method of making a solid composite high strength metal article comprising magnesium alloyed with manganese which comprises forming a mixture of an atomized magnesium-base magnesium-manganese alloy containing from 0.1 to 2.5 per cent of manganese and at least one comminuted magnesium-soluble metal including aluminum, the magnesium-soluble metal comprising between 0.1 and 12 per cent by weight of the mixture, and the magnesium-soluble metal being associated with up to but not more than 4 times its weight of magnesium, and die-expressing the mixture in solid condition at a temperature above about 500° F.

Table III

Example 15	Composition of Extrusion Charge Parts by Weight					Composite Extrusion Properties[1]							
	Mg-Mn Alloy[2]	Magnesium-Soluble Metal				ASX		Aged		H. T.		H. T. A.	
						TYS	TS	TYS	TS	TYS	TS	TYS	TS
a	97	1 Al	1 Zn	1 Ag	--------	44	47	46	49	40	46	42	47
b	97	1 Al	1 Zn	1 Cd	--------	42	48	42	47	40	46	40	47
c	97	1 Al	1 Zn	1 Mn	--------	41	46	43	48	41	47	40	47
d	97	1 Al	1 Zn	1 Pb	--------	41	47	43	48	40	47	40	47
e	97	1 Al	1 Zn	1 Sn	--------	41	47	44	49	40	46	41	47
f	96	1 Al	1 Zn	1 Ag	1 Cd	42	48	43	48	41	47	41	47
g	96	1 Al	1 Zn	1 Ag	1 Mn	39	46	43	48	39	47	40	47
h	96	1 Al	1 Zn	1 Ag	1 Pb	42	48	44	48	41	46	39	47
i	96	1 Al	1 Zn	1 Ag	1 Sn	42	48	43	48	39	47	40	47

[1] See footnotes Table II.
[2] Same alloy as "Blank" in Table II.

The foregoing examples are to be regarded as illustrative rather than limitative as considerable variations may be made in the proportions of the metals in the charge to be extruded and details of operation, such as the temperature, and speed of extrusion, and reduction in area within the scope of the invention. In general, the proportion of magnesium-soluble metal (exclusive of magnesium but including the aluminum) which is mixed with the atomized magnesium-base magnesium-manganese alloy in forming the mixture to be die-expressed, may be as much as about 12 per cent of the weight of the mixture and the proportion of included aluminum being at least 0.1 per cent. A preferred proportion of aluminum in the mixture is about 3 per cent. The other unalloyed magnesium-soluble metals, e. g. cadmium, lead, manganese, silver, tin and zinc, if included, may be used in a proportion between about 0.2 and 3 per cent, a preferred amount being about 1 per cent.

2. The method according to claim 1 in which the proportion of magnesium-soluble metal in the mixture is not over about 12 per cent and includes at least about 0.1 per cent of aluminum, said aluminum being alloyed only with magnesium.

3. The method according to claim 1 in which the proportion of magnesium-soluble metal in the mixture is not over about 8 per cent and includes at least about 3 per cent of aluminum said aluminum being alloyed only with magnesium.

4. The method according to claim 1 in which the proportion of magnesium-soluble metal in the mixture is not over about 6 per cent including at least about 3 per cent of aluminum, and about 1 to 3 per cent of at least one of the unalloyed metals selected from the group consisting of cadmium, lead, manganese, silver, tin and zinc.

5. The method according to claim 1 in which the atomized magnesium-base magnesium-man-

ganese alloy contains 0.05 to 0.5 per cent of calcium.

6. A composite metal body comprising two particulate metals one of the metals being a magnesium-base magnesium-manganese alloy, the other comprising at least one magnesium-soluble metal including aluminum, the magnesium-soluble metal comprising between 0.1 and 12 per cent by weight of the composite body and the aluminum being associated with up to but not more than 4 times its weight of magnesium, the particles of each metal being elongated, oriented in the same direction, and welded together into an integral solid.

7. A composite metal body according to claim 6 including in addition to the elongated particles of aluminum, elongated particles of one of the magnesium-soluble unalloyed metals selected

from the group consisting of cadmium, lead, manganese, silver, tin and zinc.

8. A composite metal body according to claim 6 in which the aluminum is alloyed with magnesium.

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