

UNITED STATES PATENT OFFICE

1,979,452

MAGNESIUM ALLOY

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No Drawing. Application March 25, 1933,
Serial No. 662,835

5 Claims. (Cl. 75—1)

The invention relates to magnesium alloys which are useful as clean-up agents or "getters" for improving the vacuum in thermionic devices and the like.

Alloys of barium and magnesium are widely used as getters. These alloys are ordinarily used in the form of tablets made by compressing the powdered alloy. Long experience with the use of these getter tablets has indicated that one direction in which improvement is desirable is to make them more stable in air. While barium-magnesium alloys are sufficiently stable for most practical purposes, conditions of undue exposure to hot moist atmospheres sometimes arise, and such conditions have caused getter tablets made from these alloys to deteriorate during their manufacture, storage, shipment, and use. A common result of such deterioration is that the tablets when heated give off a considerable quantity of gas, including water vapor, prior to and during vaporizing in the vacuum device. Such evolution of moisture and gas may affect adversely the emission or other characteristics of the thermionic device.

The surprising discovery has been made that when strontium is added to binary barium-magnesium alloys the resulting ternary alloys are more stable in air, yet even more active as getters, than the binary alloys. The properties of the ternary alloys are such as to render the material extremely useful as a getter.

The superior air-stability of the ternary alloys is particularly surprising in view of the experimentally determined fact that strontium metal is chemically more active in many respects than either barium or magnesium, and deteriorates in the air more readily than the latter metals. For example, in a typical test freshly extruded pieces of pure barium and strontium were exposed to the atmosphere under identical conditions of temperature and humidity for 16 hours. During this period the barium increased in weight by 2.78%, while the strontium increased in weight by 12.5%. These tests show that strontium is more active in air than barium, and would reasonably indicate that the replacement in a barium-magnesium alloy of any part of the barium by strontium would decrease the air-stability of the material.

However, extensive experiments show that the ternary alloys of barium, strontium, and magnesium, are more stable in air than either the binary barium-magnesium alloys or the binary strontium-magnesium alloys. For instance, a series of binary and ternary alloys of magnesium with barium and strontium were powdered, made into getter tablets, and exposed to the atmosphere

for 26 days, each alloy receiving the same treatment under identical conditions. The increase in weight was then determined and the results obtained are shown in Table A.

Table A

Alloy No.	Composition			Percentage gain in weight
	Ba	Sr	Mg	
	Percent	Percent	Percent	
1.....	25		75	0.28
2.....	27		73	0.32
3.....	26	1	73	0.14
4.....	23	4	73	0.18
5.....	20	7	73	0.16
6.....	15	10	75	0.14
7.....		25	75	0.20

The experimental data given in Table A show that when strontium is added to a binary barium-magnesium alloy, to the extent of only a few percent, the air stability is greatly increased. In view of the greater activity of strontium itself, this result is most unusual. Further, when all the barium is replaced by strontium, as in alloy number 7, the air stability is less than that of the ternary alloys. The figures given in Table A represent the average of a great many individual experiments conducted under similar experimental conditions.

Tests have been made comparing the effectiveness of the new ternary alloys of the invention with the binary barium-magnesium and strontium-magnesium alloys as getters in vacuum thermionic tubes. One series of these tests involved flashing getter tablets of the various alloys in vacuum tubes and subsequently measuring the degree of vacuum in each tube.

The amount of gas that remains in a well gettered radio tube is so small that there is no ready means of measuring it in terms of absolute pressure. It is readily possible, however, to measure the degree of gas ionization that takes place in any tube having three or more electrodes. This degree of ionization bears a relation to the amount of gas in the tube, and in practice it is used as a measure of tube vacuum. A common method of measurement is to make the control grid slightly negative with respect to the cathode, and to make all the other electrodes highly positive with respect to the cathode. This scheme of connections causes an electron current to flow in the anode circuit, which ionizes the gas in the tube. A proportional ionization current then flows in the grid circuit. The ratio of this ioniza-

tion or grid current, to the electron or plate current that causes it, is sometimes called the ionization factor of the tube, and is the most logical representation of the gas in the tube. Its physical significance is that it represents the number of gas ions formed per electron that flows through the tube. In the more common types of tubes there are usually several ions formed per million electrons, and the figures that will hereafter be used in Table A as representative of tube vacuum, represent the number of ions formed per million electrons.

In measuring the vacua in tubes gettered with several of the compositions shown in Table A, it is found that small additions of strontium have no great effect on the vacuum. As the proportion of strontium to barium increases, however, there is an increase in the vacuum, which reaches an optimum value when the barium and strontium are substantially equal. As the amount of strontium exceeds the barium, the vacuum again goes down, until finally with only strontium and magnesium in the getter, the vacuum produced is substantially the same as with only barium and magnesium. The results obtained in two representative tests of alloys number 1, 6, and 7 of Table A are shown in Table B.

Table B

Alloy No.	Composition			Relative gas pressures	
	Ba	Sr	Mg	Test #1	Test #2
	Percent	Percent	Percent		
1	25	75	75	18.43	31.3
6	15	10	75	6.75	6.35
7	25	25	75	28.40	14.55

It is apparent from the above Table B that the gas pressure produced by the barium-strontium-magnesium ternary is both lower and more consistent than that produced by either the barium-magnesium or the strontium-magnesium binary alloy getter.

Another series of tests compared the relative amounts of gas, measured as the pressure in microns on a Pirani pressure gage attached to the device being evacuated, evolved by tablets of the several alloys during flashing or vaporizing. The gage was not calibrated against an absolute standard, and the readings are therefore the relative pressures. Table C gives data obtained in these tests.

Table C

Alloy No.	Composition			Relative gas pressures		
	Ba	Sr	Mg	Test #1	Test #2	Test #3
	Percent	Percent	Percent			
1	25	75	75	4	10	11
6	15	30	70	6	2	6
7	25	10	75	3.5	3.5	3.0

The pressure readings in Table C were taken as though the gas were dry air, and the figures are expressed in microns; but the gage was not calibrated, and the pressure figures are therefore only relative.

It is further found that relatively stable ternary alloys containing very high percentages of barium and strontium may be made. Table D shows the

gain in weight of a number of binary and ternary alloys after exposure to the air for various lengths of time, and further illustrates the relative stability of the ternary alloys.

Table D

Alloy No.	Composition			Percentage gain in weight	Length of exposure
	Ba	Sr	Mg		
	Percent	Percent	Percent	Percent	Days
8	15	20	65	.26	17
9	35	65	.51	.51	17
10	35	65	.31	.31	17
11	20	20	60	1.58	14
12	15	25	60	1.66	14
13	40	60	5.9	5.9	7
14	40	60	2.4	2.4	7
15	20	25	55	2.66	14
16	50	50	50	8.1	7
17	50	50	50	57.4	7

It is thus to be seen that the use of the ternary alloys has the further advantage of permitting an increase in the percentage content of the active alkaline earth metal with no great decrease in air stability.

The vacuum produced in tubes by alloy number 8 of Table D has been determined to be about 2.48 on the same scale as that used in Table B. Thus the ternary alloy of magnesium containing about 35% of barium and strontium produced a vacuum in which the pressure was only about one-third that obtained by the use of a ternary alloy of magnesium (No. 6 of Table B) containing about 25% of barium and strontium.

It is further observed that the ternary alloys are in general more friable than the binary barium-magnesium alloys. The ternary alloys may be crushed to a powder more readily than the binary alloys, and with the evolution of less heat. There is thus less necessity for protecting the alloys with an inert gas during their manufacture to minimize deterioration and the hazards of fire and explosion. These factors are of particularly great importance in handling the alloys containing the higher percentages of alkaline earth metals.

It is thus to be seen that by replacing part of the barium in the binary barium-magnesium alloys containing from about 5% to 50% or more barium, by strontium, improved getter materials are obtained. A small percentage of strontium, say 1% to 5%, is sufficient to increase markedly the air stability of the alloy without decreasing its effectiveness as a getter. By using sufficient strontium to replace approximately half of the barium, the air stability is greatly improved, and the effectiveness of the material as a getter is markedly increased. An alloy containing a total of about 35% of barium and strontium in approximately equal proportions has an air stability not inferior, and a gettering effectiveness notably superior, to a binary alloy of barium and magnesium containing about 25% of barium.

While for most practical purposes the alloy should contain at least 50% magnesium, for some special uses and under certain conditions a lower content of magnesium may be desired.

By suitably proportioning the components as indicated above, desired properties of air stability and clean-up action may be attained. For example, a composition consisting of about 15% barium, 10% strontium, and 75% magnesium, has great stability in air, and good clean-up powers; and a composition consisting of about 15% barium, 20% strontium, and 65% magnesium, 15%

has moderate air stability and exceptionally strong clean-up powers.

All percentages used herein and in the appended claims are percentages by weight.

5 I claim:

1. Ternary alloy of magnesium, barium, and strontium, containing substantially 5% to 49% barium, 45% to 1% strontium, and the balance magnesium; the magnesium being at least about 50% of the alloy.

2. Ternary alloy of magnesium, barium, and strontium, containing substantially 5% to 45% barium, 45% to 5% strontium, and the balance magnesium; the magnesium being at least about 50% of the alloy.

3. Ternary alloy of magnesium, barium, and

strontium, containing substantially 10% to 45% barium, substantially 40% to 5% strontium, and the balance magnesium; the magnesium being at least about 50% of the alloy.

4. Ternary alloy of magnesium, barium, and strontium, containing substantially 50% to 85% magnesium and 7.5% to 25% each of barium and strontium, the barium and strontium being present in approximately equal percentages.

5. A clean-up agent for use in producing high vacua, comprising a pellet of a ternary alloy of magnesium, barium, and strontium, containing substantially 50% to 85% magnesium, and 7.5% to 25% each of barium and strontium.

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