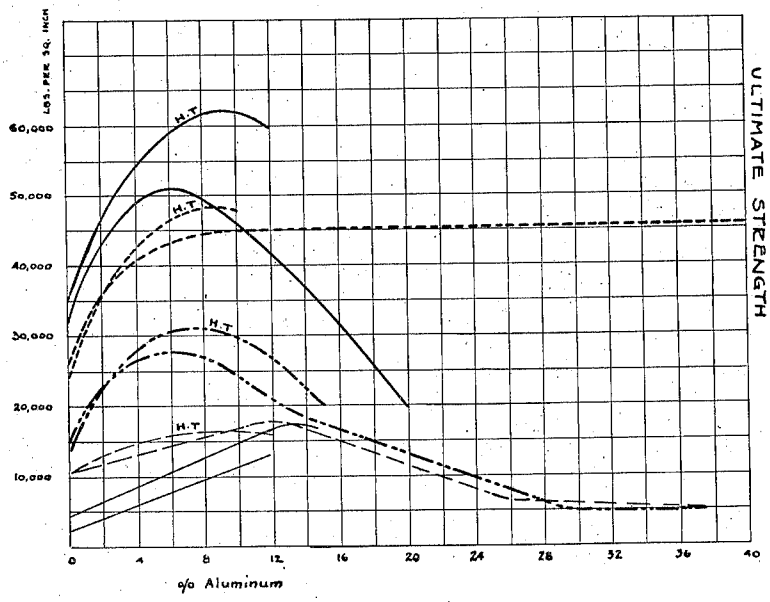
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TREATMENT OF LIGHT METAL ALLOYS

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Fig. 1



TRANSVERSE ————————

COMPRESSION - - - - - - - - - - -

TENSION ——·——·——

SHEAR — — — — — —

H.T = HEAT TREATED.

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TREATMENT OF LIGHT METAL ALLOYS

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FIG. 2

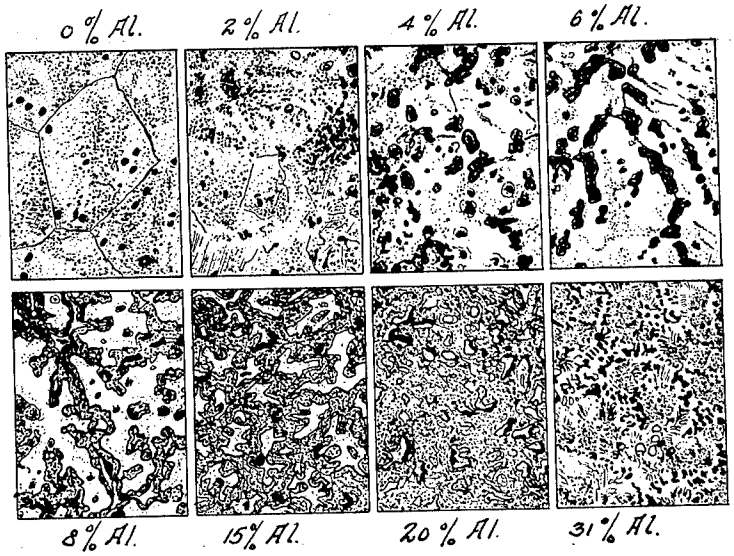
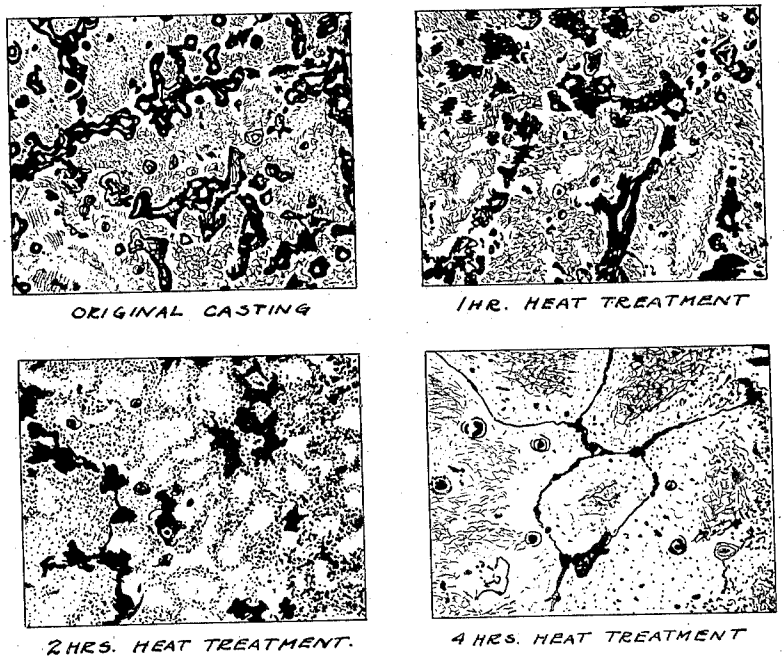


FIG. 3



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UNITED STATES PATENT OFFICE.

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TREATMENT OF LIGHT-METAL ALLOYS.

Application filed November 28, 1921. Serial No. 518,142.

The present invention, relating, as indicated, to the treatment of light metal alloys, has more particular regard to the treatment of alloys in which magnesium is the predominant element. It is known that articles of magnesium and aluminum, for example, wherein such first metal constitutes 80 per cent and upwards of the total, possess valuable characteristics when in the form of cast articles, and it has also been found practical to heat and forge, or otherwise work, an alloy of this constitution as described and claimed in U. S. Patent No. 1,374,968 to W. R. Veazey, dated April 19, 1921. The German inventor Wilm has also proposed, (see U. S. Patents Nos. 868,383, 1,083,903 and 1,261,987) various methods for improving allows containing aluminum and magnesium, but these methods all relate to alloys in which the aluminum is the predominant constituent, and the process in each instance is one more or less analogous to that employed in the heat treatment of so-called alloy steels.

In investigating the characteristics of various light metal alloys of the type above referred to, in which magnesium is the predominant constituent, I have found that there is a close relationship between the physical properties of such alloys and their micro-structure, and that in order to obtain an alloy best suited for certain purposes, as for example for use in pistons in internal combustion engines, their physical properties are governed by two factors, viz, a definite eutectic structure and a considerable, if not maximum, amount of obtainable solid solution coupled with such eutectic structure. I have further found that both these factors may be modified with highly desirable results by a regulated heat treatment of such alloys, whereby the eutectic structure found in the original casting may be modified and the amount of solid solution present in the allow increased. As a result of the foregoing discovery it is no longer necessary to be contented with the amount of solid solution obtained in such original casting, but much better properties can be obtained by increasing the amount of the solid solution without completely destroying the desired eutectic structure.

Having regard to the accomplishment of the foregoing and related ends, the invention, then, consists of the steps hereinafter fully described and particularly pointed out in the claims, the annexed drawing and the following description setting forth but one of the various ways in which the principle of the invention may be used.

In said annexed drawing:—

Fig. 1 is a diagram illustrating the changes in tensile strength and other physical characteristics imparted by my method or process to binary magnesium-aluminium alloys of varying constitution; Fig. 2 illustrates the micro-structure of pure magnesium and a series of binary alloys thereof with aluminum in which the percentage of the latter varies from 2 per cent to 31 per cent; and Fig. 3 similarly illustrates the change produced in the micro-structure of an 8 per cent aluminum alloy by my method of treatment.

As indicated above, the present improved process has to do with light metal alloys in which magnesium is the predominant ingredient. The alloy must furthermore include at least one ingredient capable of forming a solid solution with such magnesium to a limited extent and existing beyond as a eutectic structure, or two different ingredients may be thus alloyed with the magnesium, one of which is thus capable of forming a solid solution and the other a eutectic structure. What I accomplish by the present method or process is so to regulate and limit the heat treatment of such an alloy that the desired amount of solid solution results, and, in addition, a definite eutectic structure is secured. While in the drawings (Fig. 1) I have illustrated the effect of such regulated heat treatment on the physical characteristics of a binary magnesium-aluminum alloy, and (Fig. 3) the changes in micro-structure that result from such heat treatment, it will be understood that the process may be advantageously applied to more complex magnesium alloys.

The principle involved in this regulated heat treatment, however, it very well illustrated by such magnesium-aluminum alloys. Thus referring to Fig. 2, which shows the micro-structure of several such alloys in the form of original castings, it should be stated that the maximum tensile strength is obtained with 6 per cent aluminum. The strength in these alloys is apparently dependent on the arrangement and amount of eutectic and on the amount of solid solution,

the function of such eutectic being comparable to that of the re-enforcing steel in re-enforced concrete. However, when there is so much eutectic present, as in the 15 per cent aluminum alloy, that it completely surrounds the magnesium crystals, the strength goes down.

If now we take such alloy with higher aluminum content than that giving the proper micro-structure for maximum tensile strength and subject the same to the proper heat treatment, the eutectic is gradually dissolved and results in the formation of an increased amount of the solid solution. Thus in the case of the 8 per cent aluminum alloy, shown in Fig. 3, after one hour of heat treatment at from 800° to 820° F. the amount of eutectic has been materially reduced, and after four hours of such treatment such eutectic has practically entirely disappeared, indicating that the ingredients are present wholly in the form of a solid solution, presenting a formation very similar to that shown by pure magnesium, (see Fig. 2). The maximum tensile strength, however, is reached after one hour's treatment, increasing from 25,000 pounds per square inch in the original casting to from 31,000 pounds to 32,000 pounds per square inch after such treatment. The maximum temperature which can be employed is determined by the melting point of the eutectic, which, in the case of magnesium and aluminum, is 824° F. Accordingly the range of from 800° to 820° indicated above is the highest that can be safely employed. Any material lowering in such temperature greatly increases the length of time it is necessary to continue the treatment; for example, in the case of such 8 per cent aluminum alloy, if the temperature employed be only 750° F. it will take approximately 24 hours to secure the result illustrated as having been obtained by four hours' heat treatment at the higher range.

A comparison of the 6 per cent aluminum alloy in Fig. 2 with the one hour heat treated 8 per cent aluminum alloy in Fig. 3 shows that both have the same general type of structure, and in both cases this type of structure gives a maximum tensile strength. Such increased tensile strength, (from 28,000 pounds per square inch for the 6 per cent untreated aluminum alloy to from 31,000 to 32,000 pounds per square inch for the treated 8 per cent aluminum alloy) can best be attributed to the increased amount of solid solution present since the amount of eutectic in the two structures is roughly the same.

Rigidity, hardness and many other physical properties are also dependent on the type of the micro-structure present in the alloy. From the standpoint of the above mentioned properties the structure of the one-hour heat treated specimen is more desirable than that of the four-hour heat treated specimen, although the latter may show the same tensile strength.

The production of the required micro-structure consisting of both eutectic and solid solution can be brought about by regulating the heat treatment according to various possibilities as follows: viz, (1) regulated heat treatment of a binary magnesium alloy of which magnesium-zinc or the above described magnesium-aluminum alloy is an example, such alloy being capable of yielding both a solid solution and eutectic type of structure; (2) regulated heat treatment of ternary or more complex magnesium alloys in which at least part of the added metals form eutectics with the magnesium and one or more of said eutectics dissolve in the magnesium to form solid solutions while the other, or others, form the basis of the desired eutectic structure in the final heat treated product; an example of such being found in the magnesium-aluminum-copper alloys in which the aluminum can be dissolved, leaving a residual magnesium-copper eutectic structure; and (3) regulated heat treatment of ternary or more complex magnesium alloys in which at least part of the added metals form eutectics with the magnesium and said eutectics have different melting points and vary as to the case with which they dissolve in the magnesium to form solid solutions whereby one or more of the added metals are caused to be present, both as solid solution and eutectic, while the other, or others, are present either as solid solution or eutectic. As an example of the latter, magnesium-aluminum-zinc-copper-cadmium alloys may be cited, in which the heat treatment may be such that aluminum and zinc are present as both solid solutions and eutectic, while the copper is present as eutectic and the cadmium is completely in solid solution.

Even in the case where one of the minor constituents of the alloy is a metal such as cadmium, which in casting at once forms a maximum solid solution with the magnesium, heat treatment of the regulated character hereinbefore prescribed may be advantageously employed, inasmuch as it will insure a more uniform distribution of the two metals in such solution with resulting increase in tensile strength and other desirable qualities.

As hereinbefore indicated, the temperature required in carrying out the present improved method will vary within certain limits, such temperature being contingent in the first place, of course, upon the ingredients that enter into the particular alloy and upon the melting point of the eutectic structure that is formed. As a general rule to be observed in this matter of temperature, it may accordingly be stated that it should not

exceed the melting point of such eutectic and the more nearly it approaches such melting point, the shorter the time that will be required in order to effect the desired result. The prescribed range of temperature which may be thus defined as one approaching the melting point of the particular eutectic involved will ordinarily lie within from 100 to 150 degrees below the melting point of the latter to such melting point.

Other forms may be employed embodying the features of my invention instead of the one here explained, change being made in the form or construction, provided the elements stated by any of the following claims or the equivalent of such stated elements be employed, whether produced by my preferred method or by others embodying steps equivalent to those stated in the following claims.

I therefore particularly point out and distinctly claim as my invention:—

1. The process of modifying the properties of magnesium base alloys comprising subjecting the solid metal to heat treatment at a high temperature for a period of hours but below the melting temperature of the most fusible constituent of the alloy.

2. The process of improving the strength of magnesium base alloys containing aluminum comprising subjecting the solid metal to heat treatment at a high temperature for a period of hours but below the melting temperature of the most fusible constituent.

3. The process of modifying the properties of alloys having magnesium as the principal ingredient and containing one or more metals capable of dissolving in solid magnesium in larger amounts than are found in solution in the alloys as cast, comprising subjecting the said alloys to heat treatment at a high temperature but below the melting temperature of the most fusible constituent to cause increased solution of the other metal in the solid magnesium and to bring about equalization of composition.

4. The process of modifying the properties of alloys having magnesium as the principal ingredient and containing a quantity of aluminum capable of dissolving in the solid magnesium in larger amounts than are found in solution in the alloys as cast, comprising subjecting the said alloys to heat treatment at a high temperature but below the melting temperature of the most fusible constituent to cause increased solution of the aluminum in the solid magnesium and to bring about equalization of composition.

5. In the art of making alloy articles having magnesium as the principal ingredient and containing one or more metals capable of dissolving in solid magnesium in larger amounts than are found in solution in the alloys as cast, the improvement consisting in increasing the strength of the articles by subjecting them to a heat treatment at a high temperature but below the melting temperature of the most fusible constituent of the alloy to cause increased solution of the other metal in the solid magnesium.

6. In the art of making alloy articles having magnesium as the principal ingredient and containing a quantity of aluminum capable of dissolving in the solid magnesium in larger amount than is found in solution in the alloys as cast, the improvement consisting in increasing the strength of the articles by subjecting them to a heat treatment at a high temperature but below the melting temperature of the most fusible constituent of the alloy to cause increased solution of the aluminum in the solid magnesium.

7. In the art of making alloy articles having magnesium as the principal ingredient and containing one or more metals capable of dissolving in the solid magnesium in larger amounts than are found in solution in the alloys as cast, the improvement consisting in increasing the strength of the articles by subjecting them to a heat treatment at a high temperature but below the melting temperature of the most fusible constituent of the alloy for at least four hours to cause increased solution of the other metal in the solid magnesium.

8. In the art of making alloy articles having magnesium as the principal ingredient and containing a quantity of aluminum capable of dissolving in the solid magnesium in larger amount than is found in solution in the alloys as cast, the improvement consisting in increasing the strength of the articles by subjecting them to a heat treatment at a high temperature but below the melting temperature of the most fusible constituent of the alloy, for a period of at least four hours to cause increased solution of the aluminum in the solid magnesium.

9. In the art of making alloy articles having magnesium as the principal ingredient and containing one or more metals capable of dissolving in the solid magnesium in larger amounts than are found in solution in the alloys as cast, the improvement consisting in increasing the strength of the articles by subjecting them to a heat treatment at a temperature about 10–50 degrees C. below the melting temperature of the most fusible constituent of the alloy.

10. In the art of making alloy articles having magnesium as the principal ingredient and containing a quantity of aluminum capable of dissolving in the solid magnesium in larger amount than is found in solution in the alloys as cast, the improvement consisting in increasing the strength of the articles by subjecting them to a heat treat-

ment at a temperature about 10–50 degrees C. below the melting temperature of the most fusible constituent of the alloy.

11. In the art of making alloy articles having magnesium as the principal ingredient and containing 3 to 15% aluminum, the improvement consisting in increasing the strength of the articles by subjecting them to a heat treatment at a high temperature but below the melting temperature of the most fusible constituent of the alloy to cause increased solution of the aluminum in the solid magnesium.

12. In a method of improving the qualities of a light metal alloy in which magnesium is the predominant constituent, said alloy also containing more than six per cent of aluminum, the step which consists in subjecting said alloy as thus cast to a temperature approaching the melting point of eutectic present for a sufficient time to effect a substantial increase in the amount of aluminum in solid solution with the magnesium at the expense of the eutectic, in which latter form it exists at least to a limited extent in such casting.

13. In the art of making alloy articles having magnesium as the principal ingredient and containing 3 to 15% aluminum, the improvement consisting in increasing the strength of the articles by subjecting them to a heat treatment at a temperature about 10–50 degrees C. below the melting temperature of the most fusible constituent of the alloy.

14. In the art of making alloy articles having magnesium as the principal ingredient and containing 3 to 15 per cent aluminum, the improvement consisting in increasing the strength of the articles by subjecting them to a heat treatment at a temperature of 400–440 degrees C., for at least four hours.

15. In a method of improving the qualities of a light metal alloy in which magnesium is the predominant constituent, said alloy also containing approximately 8 per cent of aluminum with resultant presence of eutectic structure, the step which consists in heating a casting composed of such alloy at a temperature approaching the melting point of such eutectic for a sufficient time to cause the micro-structure of the resultant product to approximate that of an untreated alloy containing approximately 6 per cent of aluminum.

16. In a method of treating a light metal alloy in which magnesium is the predominant constituent, said alloy also containing approximately eight per cent of aluminum, the step which consists in heating a casting composed of such alloy at from 800° to 820° Fahr. for approximately one hour.

17. A heat-treated light metal alloy article, wherein magnesium is the predominant constituent, such treated article being characterized by having an amount of added constituent in solid solution with the magnesium in excess of that present in an untreated article of identical composition.

18. As an article of manufacture, a heat-treated light metal alloy casting, in which magnesium is the predominant constituent, such treated casting being characterized by having a definite eutectic structure and an amount of added constituent in solid solution with the magnesium in excess of that thus present in an untreated casting of identical composition.

19. As an article of manufacture, a heat-treated light metal alloy casting, in which magnesium is the predominant constituent and aluminum is a minor constituent, such treated casting being characterized by having a definite eutectic structure and an amount of aluminum in solid solution with the magnesium in excess of that thus present in an untreated casting of identical composition.

20. As an article of manufacture, a heat-treated light metal alloy casting, in which magnesium is the predominant constituent and aluminum is present in excess of six per cent, such treated casting being characterized by having a definite eutectic structure and an amount of aluminum in solid solution with the magnesium in excess of that thus present in an untreated casting of identical composition.

Signed by me this 23rd day of November, 1921.

JOHN A. GANN.