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J. E. HOY

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FABRICATING MAGNESIUM

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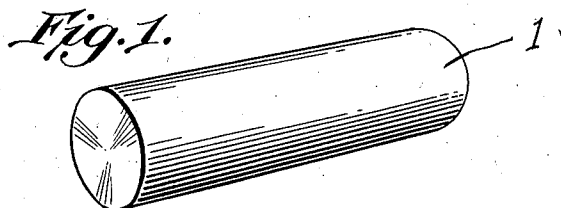


Fig. 3.

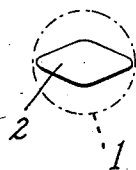


Fig. 2.

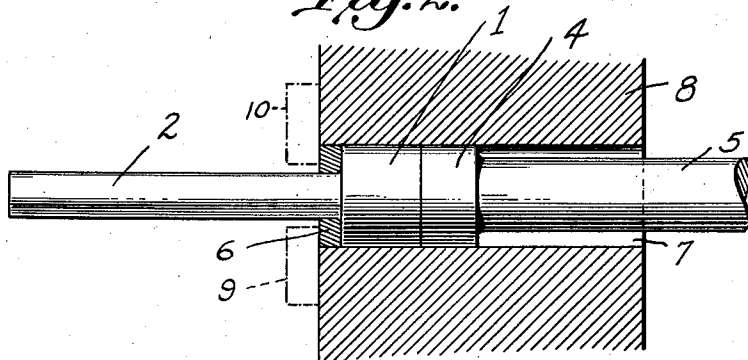


Fig. 4.

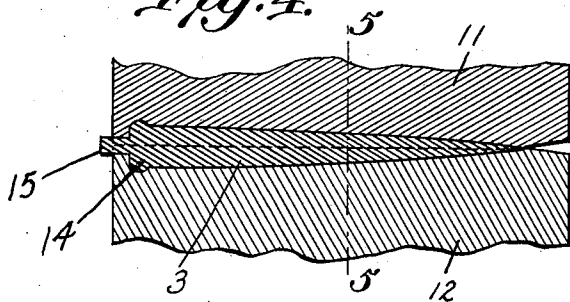


Fig. 5.

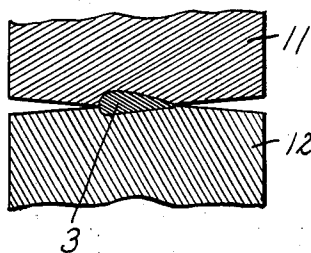
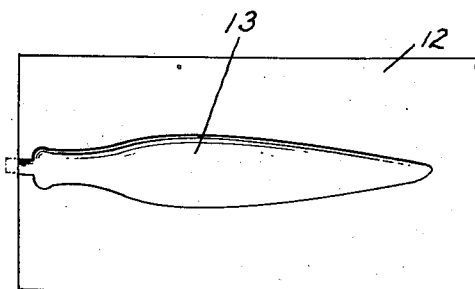


Fig. 6.

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FABRICATING MAGNESIUM

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My invention relates to methods of fabricating magnesium, or alloys in which magnesium is the predominating constituent, and more particularly to the fabrication of parts from magnesium which are to be highly stressed in service, such, for example, as airplane propellers and the like.

The object of my invention is to provide a method of fabrication whereby a structure is imparted to the metal characterized by elongating the grains in the direction of the longitudinal axis, such structure possessing great strength and rigidity and being adapted to withstand relatively great stresses, more especially when said stresses are so applied that the major component thereof is in a longitudinal direction with reference to the member stressed. A further object is to produce, as a new article of manufacture, an improved metallic airplane propeller, or like mechanical element, possessing the aforesaid structure, which by reason of its lighter weight and great strength has an important advantage over other types of metallic propellers now in common use. Other objects and advantages will appear from the description as hereinafter set forth. To the accomplishment of the foregoing and related ends, said invention, then, consists of the features hereinafter fully described and particularly pointed out in the claims.

The annexed drawing and the following description set forth in detail but one of the various ways in which the principle of the invention may be employed.

In said annexed drawing:

Fig. 1 is a perspective view of a cast billet of a magnesium alloy; Fig. 2 is a central vertical section through an extrusion die illustrating the cast billet in the process of being extruded; Fig. 3 is an end elevation of an extruded billet; Fig. 4 is a central vertical section through a hammer or press forge; Fig. 5 is a section on line 5—5 of Fig. 4; and Fig. 6 is a plan view taken from above of the lower die block of the forge illustrated in Fig. 4.

It is known that magnesium can be extruded within a temperature range of 650°

to 800° F. (U. S. 1,570,868, Templin), and further that magnesium base alloys can be mechanically worked by forging or similar methods at temperatures between 500° and 700° F. (U. S. 1,374,960, Veazey). Still further it has been stated that forging can be successfully accomplished at somewhat higher temperatures up to 788° to 800° F. or above. (Cf. Ind. & Eng. Chem. 19: 1199, Oct. 1927). It has not hitherto been pointed out, however, that by combining the operations of extrusion and forging, or compressing, in successive steps a greater improvement is imparted to the structure and physical properties of magnesium-base alloys than is obtained by means of either operation alone.

For example, an alloy well adapted to undergo improvement by means of the aforesaid operations has the composition: Copper 4 per cent., aluminum 2 per cent., cadmium 2 per cent., manganese 0.20 per cent., magnesium 91.80 per cent. The following table gives the tensile strength and elongation for said alloy, in the extruded, forged and both extruded and forged forms, respectively:

	Tensile strength, lbs. per sq. in.	Per cent elongation
Extruded.....	36,850	6.0
Forged.....	39,000	7.0
Forged and extruded.....	40,490	8.5

It will be seen that the greatest strength and elongation is as the result of the combined operations.

A particularly useful and valuable application for magnesium-base alloys possessing a high degree of strength and rigidity as produced by my process is in propellers for aircraft. At the present time metallic propellers are in use which are forged from aluminum alloys, these being preferred to wood propellers formerly used on account of their much greater strength and durability. A disadvantage of such metallic propellers is that they are much heavier than wood propellers, and this excessive weight entails a corre-

sponding sacrifice in the useful load which the plane is able to carry. Owing to the fact that magnesium-base alloys possess a lower specific gravity than the commercial aluminum alloys, in general weighing only two-thirds as much as the aluminum alloys, their use for propellers effects an important advantage in the saving of weight of an airplane.

10 In carrying out my process I start with a cast ingot of magnesium or magnesium-base alloy, one illustrative example of which has hereinbefore been given. There is, however, a wide range of composition within which
15 magnesium-base alloys are capable of undergoing improvement according to my process, and such compositions may include other metals as minor constituents, instead of or in addition to those in such example. I, therefore, do not limit myself to the aforementioned alloy, which is chosen only by way of illustration, but wish it understood that I may use any suitable magnesium-base alloy
20 which in general will contain from 85 to 90 per cent., or more, of magnesium. The terminology "any suitable magnesium base alloy" is used herein, in the sense well understood by those skilled in the art of plastic deformation of magnesium alloys, to cover various magnesium base alloys, the exact composition of which depends both upon the nature of the compression steps and upon the alloying ingredients to be used. The exact percentage of the ingredients to be used is
25 chosen so that all of the constituents of the alloy, when in condition for compression, will have melting points above the temperatures employed in the compression steps. The addition of relatively large amounts of alloying ingredients, as is well understood, usually decreases the ease of plastic deformation of the alloy, although a higher percentage of alloying ingredients may be present
30 when the alloy is to be compressed by operations such as press forging or rolling than when the alloy is to be compressed by hammer forging. For instance, in the magnesium-aluminum series, heat treated alloys containing 6 per cent or less of aluminum are best adapted for hammer forging, while those containing
35 10 per cent or less of aluminum may be press forged or rolled. In like manner, in the magnesium-zinc series, heat treated alloys containing 2 per cent or less of zinc may be hammer forged, while those containing 6 per cent or less of zinc may be press forged or rolled.

For simplicity, the term "magnesium" as used hereinafter and in the claims is to be understood to cover not only magnesium but structural magnesium alloys wherein the magnesium is present in amount in excess of 85 per cent, as hereinbefore set forth.

65 The cast ingot 1 is first subjected to a heat treatment or annealing at a temperature be-

tween 750° to 900° F. for eight hours. It is then extruded at the same temperature into a bar or billet, preferably round, although illustrated as having a diamond or grid shape for easier formation of a propeller, whereby it undergoes a reduction in cross-section of approximately 50 per cent. The extruded billet 2 is thereupon subjected to further heat treatment for four hours at 750° to 850° F., in order substantially to remove any strains that may have been set up due to the extrusion. The billet is then forged, either by a hammer or press 11 and 12, into approximately its final form, starting at a temperature between 800° and 880° F. In so doing, the metal is drawn out longitudinally in order to increase the effective working in such direction as originally produced in the extrusion operation, and thereupon shaped to the form of the propeller blade, or other mechanical part, which is to be fashioned. It is then finished by machining according to the usual methods.

As worked according to the several steps herein described, the grain structure of the metal is caused to assume a characteristic elongated form, which imparts the valuable and improved properties claimed in my process. The formation of an article by my improved procedure is illustrated in the annexed drawing, of which Fig. 1 is a perspective view of a cast billet which upon being heated is ready for the extruding operation. This operation takes place in the mechanism illustrated in Fig. 2, wherein a container 8 is shown as having a bore 7 of slightly larger diameter than the cast billet 1. The heated billet 1 is placed in the bore 7 after which it is extruded through the extrusion die 6 by means of the ram 5, which has the head 4 of slightly smaller diameter than the bore 7. End blocks 9 and 10 prevent displacement of the extrusion die 6 and assist in absorbing most of the load imposed upon the extrusion die by the ram. It is, of course, to be understood that the extruded billet 2 may have any particular cross section as long as this cross section is a uniform area throughout the longitudinal extent of the billet. As illustrated herein, the extruded billet is given a grid shape in order that a propeller may be more easily fashioned. However, it is to be understood that the shape may vary with the particular article to be manufactured.

In Fig. 4 the step of forging is illustrated as taking place between an upper die block and a lower die block 12, which may have complimentary recesses, one of which, 13, is shown in Fig. 6. The forging operation causes the extruded billet 2 to assume approximately the final form of propeller having a body portion 3, a hub 14 and a small projection 15. As understood by those skilled in the art, the projection 15 has the function of providing a gripping end for operat-

ing purposes. From this it will be seen that the steps involved in my improved process comprise casting a billet 1, then extruding said billet, then forging or otherwise shaping said billet, to approximately its final form and finally machining the forged article. As is well known to those versed in the science of metallography, a greater degree of grain refinement in a metal almost invariably predi-
 5 cates a correspondingly greater degree of strength in the absence of other deciding factors. In the case in hand, such elongated structure and greater refinement of grain is directly the result of the method of working disclosed.

While I have described my invention in terms of making a product having an elongated grain structure (based on the specific working of the alloy cited and the appearance of its microstructure), I do not wish to be limited to that exact description since ob-
 20 viously the production of the improved article is the important thing regardless of any statement as to exactly what happens during its production.

Obviously my process is equally adapted to the manufacture of other articles as well as airplane propellers, wherein equivalent prop-
 30 erties are to be obtained, such as, for example, a connecting rod for an internal combustion engine, and I wish to include within the scope of my invention any such further applica-
 35 tions, structures, structural members or parts made from magnesium or magnesium-base alloys in so far as their fabrication shall involve the steps herein described.

Other modes of applying the principle of my invention may be employed instead of the one explained, change being made as regards
 40 the means and the steps herein disclosed, provided those stated by any of the following claims or their equivalent be employed.

In the following claims, it is understood that magnesium includes any magnesium-
 45 base alloy of the character described, containing in general 85 per cent. or more of mag-
 50 nesium.

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

50 1. In a method of fabricating articles of magnesium, the steps which consist in casting a billet of said metal, then extruding said billet to form a billet of uniform cross sectional area, then working and shaping
 55 said billet into approximately its final form by compression.

2. In a method of fabricating articles of magnesium, the steps which consist in casting a billet of said metal, then extruding
 60 said billet to form a billet of uniform cross sectional area, whereby the grain structure is elongated in the direction of the longitudinal axis of said billet, then working and shaping said billet into approximately its
 65 final form by forging to further elongate

such grain structure in the same direction.

3. In a method of fabricating articles of magnesium, the steps which consist in casting a billet of said metal, then extruding
 70 said billet to form a billet of uniform cross sectional area, then working and shaping said billet into approximately its final form by compression, said extrusion and compression steps being performed at a temperature
 75 between 750° and 900° F.

4. In a method of fabricating articles of magnesium, the steps which consist in casting a billet of said metal, then extruding said bil-
 80 let to form a billet of uniform cross sectional area, then working and shaping said billet into approximately its final form by compression, said extrusion and compression steps being performed at a temperature be-
 85 tween 750° and 900° F., and said billet being subjected to heat treatment previously to each step.

5. In a method of fabricating articles of magnesium, the steps which consist in casting a billet of said metal, then extruding
 90 said billet to form a billet of uniform cross sectional area, whereby the grain structure is elongated in the direction of the longitudinal axis of said billet, then working and shaping said billet into approximately its
 95 final form by forging to further elongate such grain structure in the same direction, said extrusion and forging steps being performed at a temperature between 750° and 900° F., and said billet being subjected to
 100 heat treatment previously to each step.

6. In a method of manufacturing a magnesium propeller, the steps which comprise heat treating a billet of said metal, then ex-
 105 truding said billet to a billet having a uniform cross sectional area, then forging said billet to approximately its final shape, and then machining it.

7. In the method of manufacturing a magnesium propeller, the steps which comprise heat treating a billet of said metal, then ex-
 110 truding said billet to a billet having a uniform cross sectional area, then forging said billet to approximately its final shape and finally machining said billet, said forging step being controlled to accentuate the elongated grain structure produced by the ex-
 115 truding step.

8. In the method of manufacturing a magnesium propeller, the steps which comprise heat treating a billet of said metal, then ex-
 120 truding said billet to a billet having a uniform cross sectional area, then further working and shaping said extruded billet to approximately its final form by compression.

9. In the method of manufacturing a mag-
 125 nesium propeller, the steps which comprise heat treating a billet of said metal, then extruding said billet to a billet having a uniform cross sectional area, then forging
 130 said billet to approximately its final shape.

10. In the method of making a propeller, the steps which comprise extruding a magnesium billet to a billet of uniform cross sectional area at a temperature between 750° and 900° F., and then further working and shaping said extruded billet to approximately its final form by compression and at a like temperature.

11. In a method of making a propeller, the steps which comprise extruding a previously heat treated billet of magnesium to a billet of uniform cross sectional area at a temperature between about 750° and 900° F., heat treating the same, and then further working and shaping said billet into approximately its final form by compression and at a like temperature.

12. In a method of making a propeller, the steps which comprise extruding a previously heat treated billet of magnesium to a billet of uniform cross sectional area at a temperature between about 750° and 900° F., heat treating the same, and then further working and shaping said billet, by forging it into approximately its final form and at a like temperature.

Signed by me this 24th day of May, 1928.

JOHN E. HOY.

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