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PISTON AND METHOD OF MAKING THE SAME

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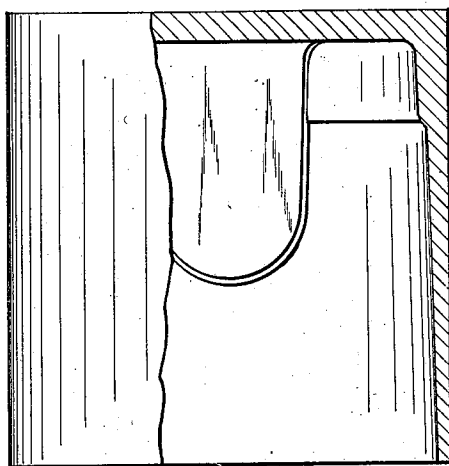


Fig 1

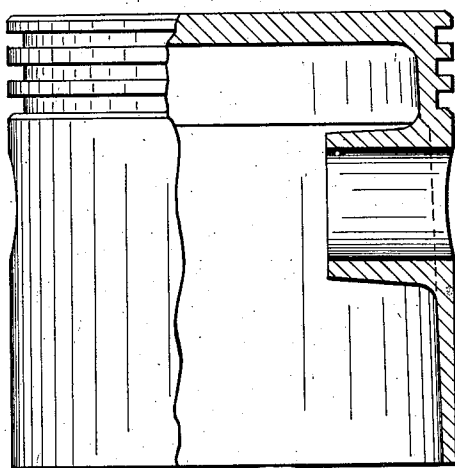


Fig 2

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PISTON AND METHOD OF MAKING
THE SAME

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Application June 22, 1932, Serial No. 618,644

7 Claims. (Cl. 75—1)

Our invention relates to the manufacture of pistons for internal combustion engines. It is particularly directed to a new process for fabricating such pistons, and to the entirely novel product of this process.

Since the development of molds and methods whereby light alloy pistons could be successfully cast in chill molds, there has been an increasing trend in the industry towards the use of these light weight pistons until at present millions are made and used every year. Of the light metals, aluminum base alloys have been most widely used up to the present time. For the purposes of this invention it is unnecessary to describe in detail the advantages of light alloy pistons which mainly have their source in low specific gravity and high heat conductivity. This invention is more particularly concerned with improvement of light alloy pistons in certain respects wherein their potentialities have not been fully developed heretofore.

Under the conditions usually obtaining in automotive engines, an aluminum base alloy piston reciprocates within a ferrous metal cylinder. Because of the difference in the coefficients of thermal expansion of the cylinder and piston, if the piston is fitted closely when the motor is cold, it will seize at operating temperatures, and if it is to be designed with sufficient clearance so that it will fit properly at operating temperatures the clearance when cold is so great that "piston slap" is experienced when starting and during the period necessary to bring the parts to working temperature.

Various means have so far been devised in an attempt to meet this difficulty. One line of development has been to slit or otherwise design the skirt of the piston to give a pliable bearing surface calculated to fit snugly at all temperatures. Others have devised "control" methods wherein a ferrous metal insert is integrally cast or otherwise connected to the light metal skirt to restrain its expansion so as to approximate the expansion of the ferrous metal cylinder. A multitude of these and similar devices have already been furnished to the trade, some of but little value and some with a fair measure of success. However, the straight trunk type piston, namely, a piston with a cylindrical skirt unslotted and integral with the head, is considered most desirable if only the expansion differential can be reduced or eliminated.

The most successful attempt heretofore made, so far as we are advised, to produce a low expansion light alloy for pistons is disclosed in U.

S. Patent No. 1,799,837 to R. S. Archer and L. W. Kempf. This patent discloses a series of alloys, of which the preferred composition has a coefficient of thermal expansion of .000019 per degree centigrade. The previous preferred aluminum base alloy for pistons had a coefficient of expansion of .000022 and since the coefficient of expansion of cast iron is .000011 it is seen that the alloy of U. S. Patent No. 1,799,837 has reduced the differential by about 27%. Because of complications resulting from the inclusion of constituents calculated to lower the thermal expansion, further improvements in this direction are handicapped by operative difficulties, for instance increasing casting and machining troubles. As a consequence while it is desirable to still further decrease the expansion, it has been economically impracticable to fabricate the pistons until the date of the present invention.

Although the advantages of employing compositions having a low coefficient of thermal expansion are obvious and although many attempts have been made to obtain such compositions in usable form, no success has been had in decreasing the coefficient of thermal expansion below about .000019 per degree centigrade, when using a light alloy base in making pistons.

We have discovered that the problem of obtaining a satisfactory coefficient of expansion with a light alloy base can be solved by avoiding casting methods and by using a method in which comminuted metals are compressed to form either the finished article or a blank from which the finished article may be machined. The difficulties connected with casting may thus be eliminated and a wide range of compositions is made available which heretofore has not proven successful by any casting method. Thus certain alloying constituents which serve to lower the thermal expansion of aluminum base or magnesium base alloys may successfully be used and a coefficient of thermal expansion attained which has not heretofore been approximated with light alloy cast pistons.

Accordingly, one of the objects of the present invention is to devise a method whereby light metal pistons of a wide variety of compositions may be successfully fabricated.

A further object of this invention is the provision of a method of making a piston of low specific gravity.

A further object of this invention is the provision of a method of making a light alloy piston of exceptionally low thermal expansivity.

This invention is further concerned with a pis-

ton of low specific gravity, exceptionally low coefficient of thermal expansion, high heat conductivity and good wearing qualities fabricated by a process novel in the art.

5 Other objects and advantages will become apparent from the hereinbelow description of the invention and from the attached drawing wherein Figure 1 is an elevation with parts broken
10 away to illustrate the piston blank as initially formed according to my invention. Figure 2 is a view similar to Figure 1 showing the piston blank after being machined. In general our invention deals with alloy compositions which in the cast
15 condition prove unsatisfactory but which when used according to our disclosed process prove eminently satisfactory. The invention is specifically concerned, of course, with the method of making such pistons and with the product of that method.

20 While it has heretofore been known that certain alloying constituents serve to lower the coefficient of thermal expansion of aluminum or magnesium alloys, practical production difficulties have prevented the attainment of the full
25 potentialities of such alloys in the cast form. For instance although further additions of the metalloid silicon reduces the coefficient of thermal expansion of an aluminum alloy, it has been found commercially inexpedient to add more
30 than about 25 per cent of silicon to the aluminum. Beyond this figure the primary silicon particles increase in number and size to such an extent that, particularly from a machining standpoint, the alloy cannot economically be
35 handled. We have discovered, however, that by procuring comminuted mixtures of aluminum or magnesium with silicon or beryllium or combinations of these or other metals of any desired composition outside of the useful casting range, and compressing these mixtures in dies designed
40 to produce either the approximate piston contour or such a convenient briquette that a piston may be made therefrom, we secure a product which is characterized by the advantages of low
45 specific gravity, low coefficient of expansion, and other advantages as herein set forth.

For example, silicon may be used in the mixture of comminuted metallic powders in an amount substantially in excess of 25 per cent and
50 uniformly divided into extremely small particles of about 200 mesh or finer. After a piston or briquette has been formed by compression of the powders the silicon particles disposed in the mixture will be no greater than the size originally introduced into the mixture. In casting,
55 however, it is found that the size of the silicon crystals increases with an increase in the percentage of silicon in the alloy, and that when the silicon percentage approaches as much as 25 per cent the maximum size of the silicon crystals is substantially greater than 200 mesh. Furthermore; in chill casting pistons a uniform fine grained structure is obtained from an aluminum alloy containing no silicon or relatively small
60 percentages of silicon, but if the silicon is increased to as much as 25 percent or more, the molten alloy will be relatively sluggish and this characteristic in connection with the tendency of the silicon to crystallize out in large crystals
70 hinders or prevents the proper filling of a mold. Furthermore, after the article is cast the presence of large silicon particles makes it difficult, if not impossible, to machine the article smoothly and accurately. The silicon particles are relatively hard and cannot be cut by a cutting tool
75

as easily as the softer aluminum matrix. The result is that the excessively large silicon particles tend to catch the cutting tool and roll or slide within the aluminum matrix leaving rough spots and depressions in the surface of the article. This difficulty is obviated by the method
5 of the present invention, since the maximum size of the silicon particles can be initially predetermined regardless of the percentage of the silicon introduced into the mixture. As a consequence articles may be produced in accordance
10 with this invention containing silicon in excess of 25 per cent divided into particles, none of which exceed a size of about 200 mesh which may be machined as readily as aluminum castings
15 containing only extremely small quantities of silicon and far more easily and accurately than castings produced from alloy containing substantial quantities of silicon approaching as much as 25 per cent. In this connection reference is
20 made to the copending application of Louis W. Kempf et al., Serial No. 615,028, filed June 2, 1932, now patented, No. 1,944,183, dated January 23, 1934, wherein certain specific alloys are
25 claimed.

Although the alloying constituents which we may use in addition to aluminum, magnesium, or beryllium with or without silicon, may be completely or only partially soluble in each other in the liquid state, and although failure of constituents to be soluble in each other in the liquid state is a practical bar to their use in any casting method, we are enabled by our method to form
30 to any desired shape, and without depending on a casting method, any desired mixture of alloying constituents which, though they are partially soluble in each other in the liquid state, may not be completely so within the composition range which we desire to use for the obtainment of the advantageous properties which are inherent characteristics of the alloy combination.

Our novel product may best be obtained by compression in preheated dies although this preheating can be avoided by the use of greater pressure. For the manufacture of a piston of, say, 60 per cent aluminum and 40 per cent silicon we have used a pressure of 40,000 pounds per square inch when the dies were preheated to about 430° C. It is at present commercially impracticable to obtain a sound, dense casting of
50 an alloy of this composition although its coefficient of thermal expansion is only .000015 per degree centigrade and its specific gravity is less even than that of pure aluminum, its desirability is instantly evident. This thermal expansion represents a reduction of more than 60 per cent of the differential between iron and the ordinary aluminum base piston alloy, and a reduction of more than 50 per cent of the differential between iron and the low expansion alloy
60 disclosed in U. S. Patent 1,799,837 referred to hereinabove.

These figures illustrate the improvement effected in one case alone. Unlike the casting method, our process permits us to make a piston substantially as easily with any composition as with any other, and to choose any useful and desirable alloy constituent to any preferred amount. We can consequently prearrange the particle size of the alloying elements, and the specific gravity
70 and coefficient of thermal expansivity of the final product.

Since low specific gravity is desirable in a piston we prefer to use at least 25 per cent of aluminum or magnesium, or a combination of both to 75

a minimum of about 25 per cent, with from at least 25 per cent up to a maximum of about 75 per cent of silicon by reason of its effect on the specific gravity and coefficient of thermal expansion of the combination. Beryllium may be added up to such amount as is economically practicable, since though at present fairly expensive its specific gravity and coefficient of thermal expansion are lower than either aluminum or magnesium. Lesser quantities of the heavier metals are contemplated for the practice of the invention since the principal object of the present invention is the combination of low specific gravity and coefficient of expansion. For instance, we may use less than 20 per cent of nickel, iron, chromium, manganese, antimony, copper, molybdenum, titanium, tungsten or zinc. However, since the invention is directed specifically to a novel product and the process for producing it, the disclosure of specific compositions is in no sense limiting but is included as an indication of some useful combinations to which the invention may be directed.

With relatively high pressures the process as disclosed herein may be effected at room temperature but with pressures in the neighborhood of 50,000 pounds per square inch we prefer to preheat the dies to between 350° C. and 450° C. At times it is even permissible to exceed to a slight extent, say 5° or 10° centigrade, the fusing temperature of the lowest melting point constituent of the alloy composition of the mixture, but under ordinary conditions it is expected that the temperature of minimum fusibility will not be exceeded. In addition to quite satisfactory articles being thus produced, we find that the homogeneity of the article may sometimes be improved by a final treatment at a fairly elevated temperature after fabrication. Using as an example an alloy of 60 per cent aluminum and 40 per cent silicon a favorable treatment is carried out at about 565° C. for 24 hours. Test bars from alloys thus fabricated and heat treated and of the composition aluminum 70 per cent and silicon 30 per cent, have had a compression strength of 31,300 pounds per square inch after fabrication, and a compression strength of 47,300 pounds per square inch after heat treatment. This compares most favorably with the present commercial aluminum base piston alloys and the alloy has a lower coefficient of thermal expansivity and a lower specific gravity, the other physical properties being adequate, for instance for service in an internal combustion engine piston.

Various mechanical means may be used for the manufacture of pistons by my process. Dies to define the contour of a piston may be made and the comminuted metal mixture forced into such dies with a hydraulic ram to produce a piston blank as shown in Figure 1. Methods have recently been developed for upsetting pistons from solid metal and such upsetting machines, with some alterations are adaptable to the present process. We have successfully produced blanks in a converted extrusion press provided with a plunger moving in a closed cylinder and we have machined the pistons to final dimensions to provide ring grooves and wrist pin bearings as illustrated in Figure 2 from these blanks. The weight of the finished article gives some indication of the weight of the metallic powders to be introduced into the dies.

We have machined a set of 6 pistons from blanks of the composition 60 per cent aluminum

and 40 per cent silicon, an alloy which under service temperatures has a coefficient of expansion of about .000015 per degree centigrade. Using a straight trunk type piston and a substantially lower clearance than could be used with even the latest type low expansion aluminum base alloys heretofore available a block test was made on a commercial six cylinder motor. For the first 12 hours the motor speed was gradually increased up to 3500 R. P. M. (open throttle). The speed was maintained at 3500 R. P. M. for one hour and then gradually decreased in the succeeding 7 hours to 3000 R. P. M. The pistons were then removed and found to be in excellent condition. During the test a higher horsepower was developed than could be attained with the ordinary pistons in use in this motor.

One of the advantages connected with the use of our process is that it enables us to predetermine the particle size of the various alloying constituents which go to make up our piston. Although good results can be had with 40 mesh or finer we have found the best cohesion to take place with 90 mesh or finer as measured with the U. S. standard screen. We have obtained very excellent results with 170 mesh or finer. The metal powder should be clean and oxides are to be particularly avoided. Since the granules of the various elements are mixed thoroughly and compressed into a coherent solid mass no trouble is encountered with alloying elements which might be immiscible or insoluble in the molten or solid state if attempts were made to cast an article of the specific composition. Under high pressure and especially in the presence of heat the particles weld together to form a homogeneous whole. The coefficient of expansion of the final article will be proportional to the relative volume of the various constituents and the coefficient of expansion of each constituent. In this way any desired expansion effect can be attained.

Pistons made from comminuted metals in the manner herein described have an excellent bearing surface in relation to a ferrous metal cylinder. Their coefficient of expansion and specific gravity is limited only by the inherent characteristics of the alloying materials used. Casting troubles are eliminated and with uniform temperature and pressure conditions easily obtainable there should be only an insignificant number of rejections for imperfections.

In this specification and the appended claims the term "piston blank" denotes a body compressed from comminuted metals, and being of such adequate shape and size that a piston may be machined therefrom.

We claim:—

1. As a new article of manufacture a piston for an internal combustion engine compressed from a comminuted mixture of metallic particles containing at least 25 per cent of aluminum and at least 25 per cent of silicon.

2. As a new article of manufacture a piston for an internal combustion engine compressed from a comminuted mixture of metallic particles containing at least 25 per cent of magnesium and at least 25 per cent of silicon.

3. As a new article of manufacture, a piston for an internal combustion engine composed of a light metal containing at least 25 per cent aluminum and at least 25 per cent of silicon, the silicon being interspersed through the metal and divided into substantially separated portions, the maxi-

num size of said portions being the equivalent of about 200 mesh or finer.

4. As a new article of manufacture, a piston for an internal combustion engine consisting of a homogeneous, sound, uniform metallic structure containing at least 25 per cent of a metal of the group consisting of aluminum, magnesium and beryllium and at least 25 per cent of silicon, the silicon being divided into portions substantially uniformly distributed throughout the structure and the maximum size of the silicon portions being about 200 mesh or finer.

5. A method of making a piston blank which method consists in compressing to form said blank a mixture of comminuted metallic powders containing 25% or more of aluminum and/or magnesium, and at least 25% of silicon.

6. A method of making a piston for an internal combustion engine, the method consisting in placing a substantially homogeneous mixture of com-

minuted metallic powders including at least 25% of a light metal of the group consisting of aluminum, magnesium and beryllium and at least 25% of silicon in a die conforming approximately to the external contour of the piston, mechanically compressing said mixture under the influence of elevated temperatures into a blank of substantially the piston shape, and subsequently performing finishing operations on said blank.

7. A method of making a piston, the method consisting in compressing to form said blank a mixture of comminuted metallic powders under the influence of heat, said comminuted metallic powders including at least 25% aluminum and at least 25% of silicon, the silicon being interspersed through the mixture and divided into substantially separated portions, the maximum size of said portions being about 200 mesh or finer.

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