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M. G. WHITFIELD

2,793,922

LIGHT METAL PISTON WITH REINFORCEMENT, AND THE LIKE

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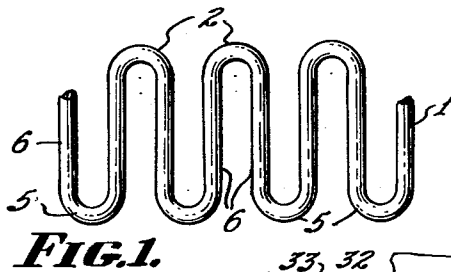


FIG. 1.



FIG. 12.

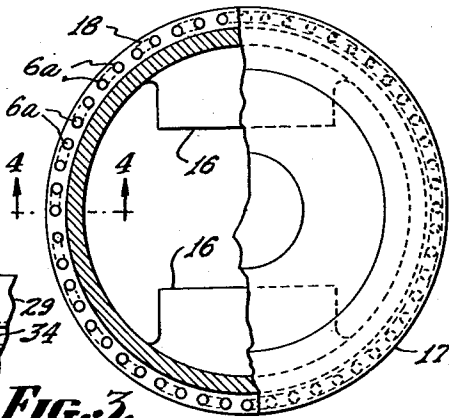


FIG. 3.

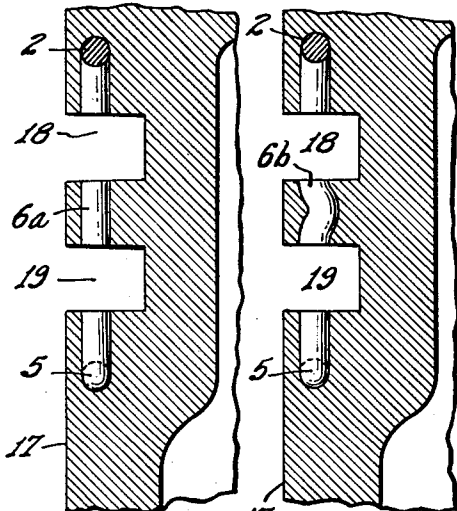


FIG. 4.

FIG. 5.

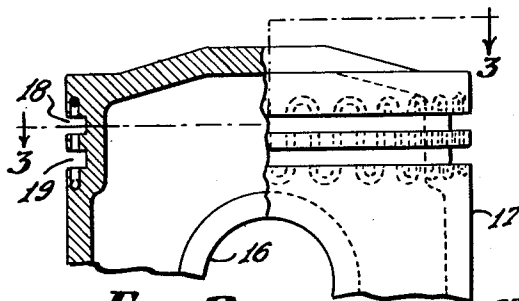


FIG. 2.

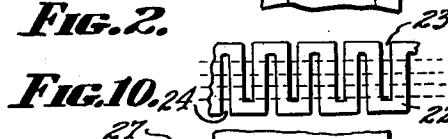


FIG. 10.

FIG. 11.

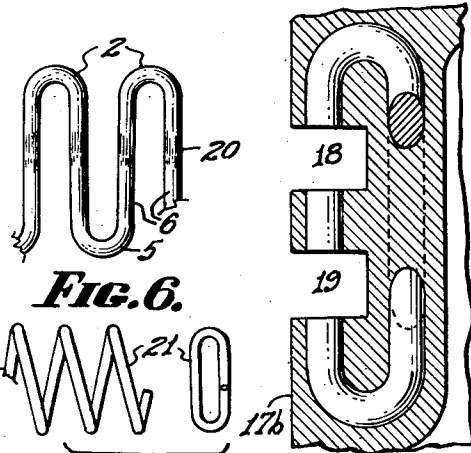


FIG. 6.

FIG. 7.

FIG. 8.

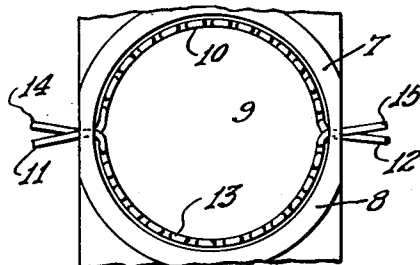


FIG. 9.

INVENTOR.
MARSHALL G. WHITFIELD,

BY *Allen & Allen*

ATTORNEYS.

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LIGHT METAL PISTON WITH REINFORCEMENT AND THE LIKE

Marshall G. Whitfield, Garden City, N. Y.

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11 Claims. (Cl. 309—14)

Pistons for internal combustion engines have long been made advantageously from light metal such as aluminum and its alloys. Such pistons are normally grooved for the acceptance of piston rings which operate to seal the pistons against the walls of the cylinders in which they operate. It has also been realized that the piston rings tend to enlarge the grooves in which they are located by wear, the wear being especially rapid in the light metals used for the formation of the pistons. As a consequence, much work has been done in the field of the formation of composite pistons having a light metal body and various forms of inserts of harder metal, more resistant to wear. A common form of such inserts is an annulus or ring of cast iron which was caused to form that part of the piston structure in which the piston ring grooves are machined. The composite structure could be made in various ways as by locating an iron or steel annulus in a mold suitable for casting a piston and then introducing the molten light metal into the mold in such a way as to cast a piston body in which the annulus was embedded in a proper position. Again a light metal piston body could be formed separately as by casting or forging, an iron or steel annulus could be assembled to the body, and with both parts located in a suitable mold, molten light metal could be cast between the annulus and the piston body.

The formation of light metal pistons with hard metal inserts involves a number of problems. For one thing the inserts are themselves a matter of some expense. For another they add significantly to the total weight of the piston. In the third place inserts such as cast iron are under some circumstances subject to breakage. In the fourth place it has been found exceedingly difficult to produce such a bond between the light metal of the piston body and the harder metal of the insert as will maintain integrity of the structure under conditions of use. It will be understood that continuous annular inserts which are grooved to accept the piston rings not only are subjected to severe mechanical strains which tend to separate them from the piston bodies, but also that under conditions of substantial differences in rates of thermal expansion, severe forces are set up tending to disrupt any bond which may be formed.

The primary object of my invention is the provision of a structure and method of making it in which the problems set forth above are solved or ameliorated, while the wear advantages of previous structures are retained. More specifically it is an object of my invention to provide a reinforced piston in which differences in thermal expansion do not tend to free the inserts from the body of the piston. It is an object of my invention to provide a reinforced piston which is lighter, less expensive to make and safer to use because insertion elements cannot be freed from the piston body to damage the piston or the cylinder walls.

These and other objects of my invention which will be set forth hereinafter or will be apparent to one skilled

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in the art upon reading these specifications I accomplish by that construction and arrangement of parts of which I shall now describe certain exemplary embodiments. Reference is made to the accompanying drawings herein:

Figure 1 is an elevational view of a part of a reinforcing element which I may employ.

Figure 2 is a view of the upper portion of a piston made in accordance with my invention, a part of the view being in elevation and a part in section.

Figure 3 is partially a sectional and partially an elevational view of a piston taken along the line 3—3 of Figure 2.

Figure 4 is an enlarged, partially sectional view taken along the section line 4—4 of Figure 3.

Figure 5 is a similar enlarged sectional view showing the use of another form of the reinforcing element.

Figure 6 is a partial plan view of the reinforcing element used in forming the structure of Figure 5.

Figure 7 is an enlarged, partially sectional view similar to that of Figures 4 and 5, but showing yet another form of reinforcing structure.

Figure 8 is a combined side and end elevational view of the type of reinforcement employed in the structure of Figure 7.

Figure 9 is a transverse sectional view of a mold structure illustrating a method of positioning my reinforcement structures prior to casting.

Figure 10 is a partial plan view of yet another type of sinuous metal reinforcement.

Figure 11 shows in perspective a reinforcement of expanded sinuosity making for elongated, though comparatively widely interspaced, areas of reinforcement in the grooves.

Figure 12 is a similar view of a reinforced structure wherein the areas of reinforcement, while elongated, are less widely spaced.

Briefly in the practice of my invention I employ for reinforcement purposes one or a series of elements formed from wire, rod or other similar stock configured to have sinuosity at least in the direction of the general extent of the element. The reinforcing elements characterized by the sinuosity just referred to will be configured so as to conform to the curvature of the periphery of a piston. At the ends of the elements, the wire or rod stock may be bent outwardly or inwardly to provide projections by means of which the elements may be definitely and positively located in the mold as hereinafter explained. The reinforcing elements may be employed with light metal piston bodies preformed by casting or forging in an operation in which light metal is cast into the mold to join the preformed structure with the reinforcing element or elements. Again, and more usually, the reinforcing element or elements will be located in the mold, and the light metal body formed complete in the same mold by casting. In either event, in accordance with the practice of my invention in its preferred form, the reinforcing element or elements will be entirely embedded in the portion of the structure formed by the introduction of molten metal into the mold. By the term "entirely embedded," I mean to indicate a preferred condition in which the reinforcing element or elements will be encased within the cast metal after such finishing operations as may be applied to the piston prior to use, such as turning, grinding, and the like. It will be understood that any projecting ends of the reinforcement element or elements will be removed as a part of such finishing operations. Furthermore, in accordance with my invention a piston ring retaining groove or grooves will be machined in the piston structure in such a way as to cut across the embedded reinforcement, as will be hereinafter more fully explained.

To illustrate one form of the invention, reference is

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made to Figure 1 wherein I have illustrated a portion of a structure formed of wire 1 bent in a sinuous fashion to present oppositely directed loops 2 and 5 with straight portions of the wire between them as at 6. This is one convenient form of sinuous structure which can readily be made on a wire bending machine. In the form shown in Figure 1 the sinuosities lie in a single plane and the structure may be formed continuously in such lengths as may be desired for convenient handling. The exemplary structure is formed of drawn steel wire of circular cross-section; but it might be formed of rod stock, of extruded or drawn shapes which are not circular in cross section, or even of narrow strips cut, as by slitting, from sheet or strip stock. An additional advantage of using reinforcing structures made of drawn or rolled products lies in the toughness of the metals as distinguished from the brittleness which is frequently a characteristic of cast structures. The thickness or diameter of the wire or other element used to form the structure of Figure 1 may be widely varied and may be determined by such factors as cost and weight. Normally it will be determined also, at least as to a maximum, by the thickness of the piston walls at the place where the reinforcement is to be used, since the preferred practice of my invention the reinforcement is to be entirely embedded in the cast metal as explained. The nature of the convolutions or sinuosities formed by the wire or the rod in the structure may be considerably varied. I prefer that the straight parts or legs 6 of the structure (or any portions connecting the loops 2 and 5, irrespective of their shape) be spaced from each other by a distance at least as great as the diameter or thickness of the wire or rod and preferably from two to about five times the diameter. This also is for the purpose of permitting the positive embedding of the reinforcement within the cast metal under circumstances where it is necessary for the cast metal to flow through the sinuous structure.

The transverse distance between the loops 2 and 5 at opposite sides of the sinuous structure may be varied as desired. The sinuous structure will be embedded in the wall of a piston and normally at least one piston ring groove will be machined or ground into the piston wall in such a way as to cut across the reinforcement. If a given reinforcement is to be cut by only one groove the loops 2 and 5 may be close together and the intermediate parts 6 very short. If, however, two or more grooves are to be cut with respect to any one reinforcing structure, then the loops 2 and 5 will be separated by a suitable distance for the purpose, the intermediate parts 6 being relatively long.

Having formed a structure such as that shown in Figure 1, where it is to be embedded in the circular side wall of a piston, I next curve the structure to a radius conforming to the curvature of the piston wall and cut it to a desired length. In doing this, provision is made for projecting end portions of the wire or rod at the extremities of a reinforcing element. These may be bent outwardly at the time of the formation of a reinforcing element from a continuous length of the structure shown in Figure 1. Again the wire bending machine used to form the structure of Figure 1 may be so operated as to form sinuous structures of a predetermined length with extending portions initially formed at their ends.

The nature of an exemplary finished form of the reinforcement element will be appreciated from Figure 9. Here I have shown a mold (for a piston) in section as comprising opposed parts 7 and 8 which, being brought together, define a mold cavity 9 in which molten metal may be poured or cast. Within the mold I have shown a sinuous reinforcing element at 10. This sinuous element is so shaped as to follow the contour of the mold wall in the part 7. At the ends of the reinforcing element 10 I have shown projecting portions of the wire at 11 and 12. These pass through appropriate orifices in the mold at the meeting lines of the mold parts 7 and 8 and serve to

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support the reinforcing element 10 within the mold in its proper position. The preferred position is one in which the reinforcing element 10 follows the contour of the walls of the mold part 7 but is supported out of contact with them so that the molten casting metal in filling the mold can lie between the reinforcing element 10 and the mold walls, whereby entirely to embed the reinforcing element.

In Figure 9 I have also shown located within the mold a similar oppositely disposed reinforcing element 13 having projecting portions 14 and 15 at its ends whereby it is supported in the mold cavity. A piston cast within the mold illustrated in Figure 9 will have a band or zone of reinforcement extending throughout its circumference, as will be understood from the figure. I shall hereinafter refer to this as continuous circumferential reinforcement without implying, however, that the reinforcing element itself is continuous circumferentially. Two reinforcing elements have been used to make up the continuous circumferential reinforcement in Figure 9, and more could be used if desired. Under some circumstances less than full circumferential reinforcement may be found preferable. The wear in pistons is primarily at opposite ends of a line drawn perpendicular to the axis of the wrist pin by which the piston is pivoted to the so-called connecting rod. As a consequence, in many pistons it may be found sufficient to reinforce only about 120 degrees of arc of the piston circumference at each side of the piston, i. e., 60 degrees of arc at each side of each end of the aforesaid line perpendicular to the axis of the wrist pin. Such relatively short sections of reinforcement may be supported by projecting wire ends such as those hereinabove described, passing through appropriate perforations in the mold parts. It may be pointed out that bosses for accepting the wrist pins are illustrated in Figures 2 and 3 at 16.

When the light metal is cast in the mold it will wholly embed the reinforcement or reinforcements excepting for the projecting ends thereof which in the finishing operation will be cut away. The embedded condition of the reinforcement will be evident in Figures 2, 3 and 4, the piston as a whole in these figures being indicated by the numeral 17. It will be usual in the finishing of the piston for use to mill one or a plurality of piston ring grooves. Two of these grooves have been indicated at 18 and 19 in Figures 2 and 4. In this instance both grooves have been milled or turned in the piston body across the area occupied by the reinforcement. The result is that the loop elements 2 of the reinforcement lie above the groove 18 while the loop elements 5 of the same reinforcement lie below the groove 19. Between the grooves a portion of the straight-away parts of the reinforcement remains as at 6a in Figure 4. It will be evident that the opposed side edges of the grooves are reinforced and faced in part by cut end portions of the reinforcing structure, which being harder and more durable than the light metal cast around them, impart added durability to the grooves and diminish wear, thus serving the general purpose of reinforcements heretofore used, but without many of their disadvantages.

With reinforcements of the wholly embedded type herein taught, the matter of bond between the reinforcement, and the light metal cast around it becomes of relatively much less importance. Various expedients may be adopted to secure bond if desired. Thus, the wire used to form my reinforcement may be iron or steel wire which has been continuously coated with aluminum by hot dipping. When this is done, a bond can readily be formed between the hot dipped coating already on the wire and the aluminum or aluminum alloy cast against the wire. Even better bonds can, in many instances, be secured by first coating the iron or steel wire with a thin layer of a metal such as tin, zinc or nickel. Since only very thin applications of such metals are necessary, they are conveniently applied by electroplating, although in the case

of zinc, hot dipping may be practiced. In casting the light metal against the reinforcement I may, with advantage, practice teachings set forth in my copending application, Serial No. 309,773, filed September 16, 1952 and entitled Casting Light Metal Against Iron, and Article Formed Thereby. The use of a casting procedure in which the molten cast metal is caused to flow against the surfaces of the reinforcement for a substantial length of time is of advantage in eliminating the effect of oxides which may be found either on the surface of the treated wire or on the surface of the molten light metal as it contacts the wire; and where the light metal is an alloy high in elements such as silicon, such for example as "vanasil," the temperature conditions may be so arranged that the reinforcement has a chilling effect on immediate adjacent portions of the molten metal, resulting in a precipitation of some of the silicon or other alloying ingredient in a very finely divided form with consequent improvement of the bond.

As indicated the matter of bond is of relatively less importance in my structures due to the form of the reinforcement. It will be understood from Figure 4 that the reinforcement portions 2 and 5 are of loop shape so that they cannot be dislodged even if the bond is poor, because of their wholly embedded condition. The portions 6a of the reinforcement illustrated in Figure 4 are the only portions which would be subject to any movement in the event of bond failure. These portions may be so shaped, if desired, as to prevent axial displacement. One way of doing this is to subject the reinforcement elements, such as shown in Figure 1, to dies or rollers so shaped as to impart a kink or bend to the portions 6 connecting the loops 2 and 5. This is illustrated in Figure 6, the bends being illustrated at 20. Figure 5 shows such a reinforcement embedded in a piston 17a. The loop members 2 and 5 are as before; but the bend in the intermediate portions 6b is such as to prevent axial displacement.

It has been stated that the thickness of the wire or other stock used to form my reinforcements may be considerably varied depending upon the extent of reinforcement desired, and upon the thickness of the piston walls in the reinforced portion. Thus, it is possible to form reinforcing elements having such thickness or location that the milling or turning of the piston ring grooves does not cut entirely through them, in which event also the reinforcing elements will not be liable to displacement upon bond failure.

While I have shown a reinforcing element cut by two piston ring grooves, it will be understood that the reinforcement may be so shaped and proportioned that a greater number of grooves may be formed across it, or that the reinforcement may be so shaped and proportioned as to accept only one groove. In the latter event, if more grooves are desired in reinforced condition, a plurality of reinforcements may be employed lengthwise of the piston.

My reinforcements may take other forms than those hereinabove described. By way of illustration, I have shown in Figure 8 a reinforcement 21 which is formed of wire in the shape of a flattened spring. Such a reinforcement is shown wholly embedded in a light metal piston 17b in Figure 7. In this instance, in the formation of the piston ring grooves 18 and 19, the spring-like reinforcement may cut through at one side only.

In Figure 10 I have shown a type of reinforcement which may be made of sheet metal or strip by a stamping or cutting operation. The reinforcement is indicated at 22 and is characterized by alternately extending slits 23 and 24 which give sinuosity to the structure. The slits should be of sufficient width to permit ready flow of the metal between them.

In Figure 11 a piston 25 is shown as provided with reinforcing elements 26 and 27 of expanded sinuosity. Here where a piston ring 28 is formed in the cast body so as to intersect the crests of the sinuous reinforcements,

relatively longer areas of reinforcement will be formed, as will be evident from the figure, although these areas of reinforcement will be comparatively widely spaced.

Another shape of reinforcement is illustrated in Figure 12 where the piston 29 has reinforcements 30 and 31. It is characteristic of this form of reinforcing structure that the wire or similar elements are provided with alternately wide loops 32 and narrow loops 33. If the wide loops are located in such fashion that they can be intersected by the groove 34, elongated areas of reinforcement will be formed but these will be comparatively closely spaced. It is, of course, characteristic of the types of reinforcement shown in Figures 11 and 12 that they must be accurately located in the mold and positioned with respect to the places where the grooves will be formed in order to serve their purpose to the best effect.

My reinforcements as cast into the piston body are sinuous in a direction circumferentially thereof, and may be sinuous also (as shown in Figure 7) in a direction radial of the piston. In either event, it will be seen that even where the material of the reinforcement has a thermal coefficient of expansion widely different from that of the surrounding light metal, this condition is not likely to result in bond failure or separation of parts.

Modifications may be made in my invention without departing from the spirit of it. Having thus described my invention in certain exemplary embodiments, what I claim as new and desire to secure by Letters Patent is:

1. A light metal piston having a heavy metal reinforcement embedded therein, said reinforcement comprising a sinuous wire-like element extending in the direction of the circumference of the said piston and characterized by upwardly and downwardly extending bights.

2. A light metal piston having a heavy metal reinforcement embedded therein, said reinforcement comprising a sinuous wire-like element extending in the direction of the circumference of said piston and characterized by upwardly and downwardly extending bights, and a circumferential groove extending inwardly from the cylindrical surface of said piston, said groove cutting the said wire-like element intermediate its upwardly and downwardly extending bights.

3. A light metal piston having a heavy metal reinforcement embedded therein, said reinforcement comprising a sinuous wire-like element extending in the direction of the circumference of said piston and characterized by upwardly and downwardly extending bights, said wire-like element being additionally characterized by sinuosity in directions radial of said piston.

4. A light metal piston having a heavy metal reinforcement embedded therein, said reinforcement comprising a sinuous wire-like element extending in the direction of the circumference of said piston and characterized by upwardly and downwardly extending bights, a plurality of circumferential grooves extending inwardly from the cylindrical surface of said piston, said grooves cutting the said wire-like element intermediate its upwardly and downwardly extending bights, there being a land between adjacent grooves, said wire-like element providing heavy metal loops on the outer sides of the outermost grooves and intermediate portions passing through the said land.

5. A light metal piston having a heavy metal reinforcement embedded therein, said reinforcement comprising a sinuous wire-like element extending in the direction of the circumference of said piston and characterized by upwardly and downwardly extending bights, a plurality of circumferential grooves extending inwardly from the cylindrical surface of said piston, said grooves cutting the said wire-like element intermediate its upwardly and downwardly extending bights, there being a land between adjacent grooves, said wire-like element providing heavy metal loops on the outer sides of the outermost grooves and intermediate portions passing through said land, the said intermediate portions being characterized by a bend preventing lateral displacement thereof.

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6. A light metal piston having a heavy metal reinforcement embedded therein, said reinforcement being formed of drawn wire extending in the direction of the circumference of said piston and characterized by continuous sinuositities in the said circumferential direction wholly embedded in said piston.

7. A light metal piston having a heavy metal reinforcement embedded therein, said reinforcement being formed of drawn wire coated with a metal coating acting to promote adhesion between the light metal and the heavy metal wire and extending in the direction of the circumference of said piston and characterized by continuous sinuositities in the said circumferential direction wholly embedded in said piston.

8. A light metal piston formed of a material chosen from a class consisting of aluminum and its alloys, said piston having a wholly embedded reinforcement extending peripherally therein, said reinforcement consisting of ferrous wire and characterized by sinuosity at least in the peripheral direction.

9. A process of forming a reinforced light metal piston, which comprises the steps of forming a piece of wire-like material into a curved sinuous reinforcement characterized by upwardly and downwardly extending bights and outwardly projecting end portions, providing a mold, supporting said reinforcement in said mold solely by means of said projecting end portions in such fashion that the sinuous reinforcement is held out of contact with the wall of said mold, casting light metal in said mold in such fashion as wholly to embed said reinforcement excepting for the projecting ends thereof, and cutting a

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circumferential groove in said piston so placed as to sever upwardly and downwardly extending legs of said reinforcement between said bights.

10. The process claimed in claim 9 wherein said wire-like material is formed of ferrous drawn wire, and wherein said ferrous drawn wire, prior to said casting, is coated with a thin layer of an adhesion promoting metal.

11. A light metal piston having, in the as-cast condition, a heavy metal reinforcement of wire-like material embedded therein, said reinforcement extending circumferentially of the body of said piston and characterized by portions projecting beyond the cylindrical body surface of said piston, and portions of said reinforcement intermediate the projecting portions being characterized by sinuosity in the said circumferential direction and being wholly embedded in the body of said piston.

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