

Nov. 28, 1961

A. TOWNHILL
PISTON MANUFACTURE

3,010,186

Filed Jan. 14, 1954

5 Sheets-Sheet 1



Fig. 1

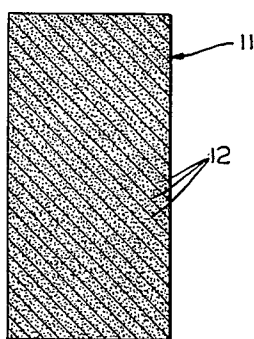


Fig. 2

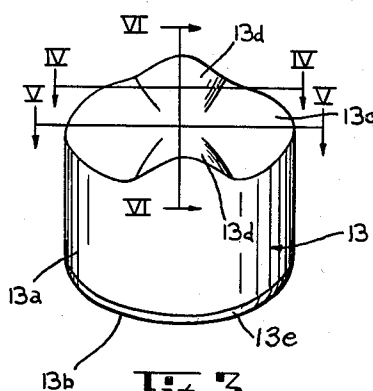


Fig. 3

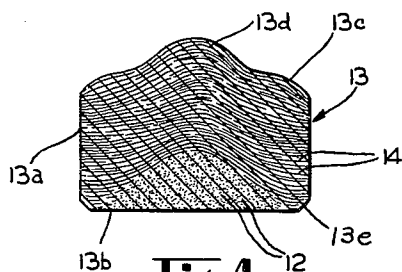


Fig. 4

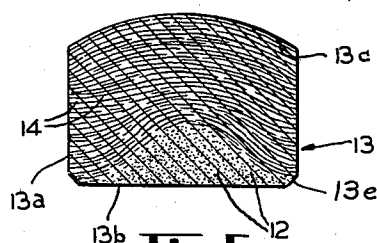


Fig. 5

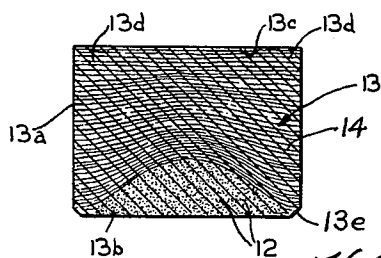


Fig. 6

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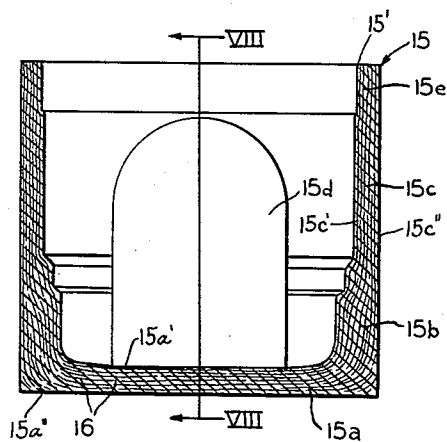


Fig. 7

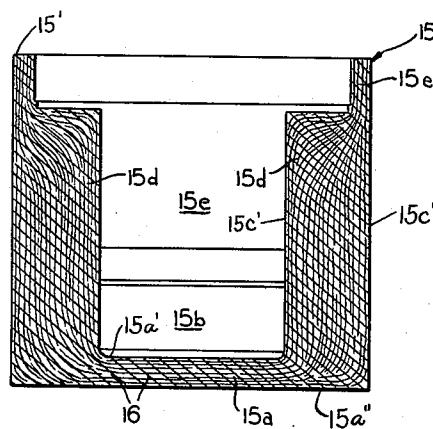


Fig. 8

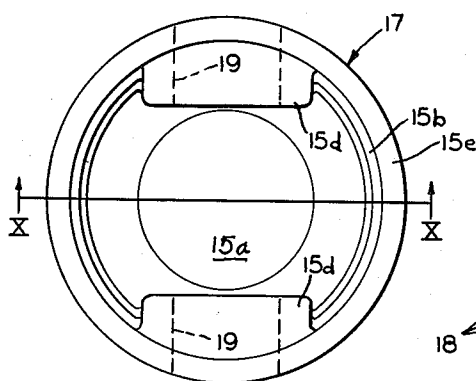


Fig. 9

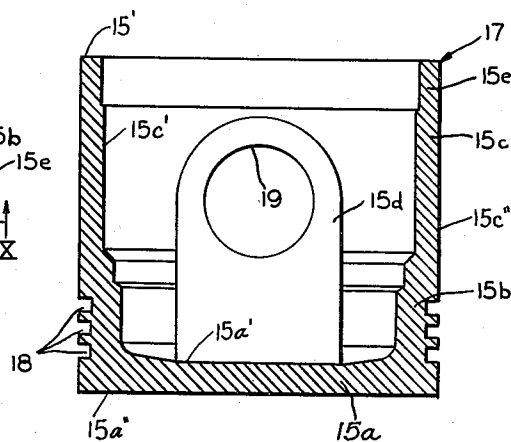


Fig. 10

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3,010,186

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5 Sheets-Sheet 3

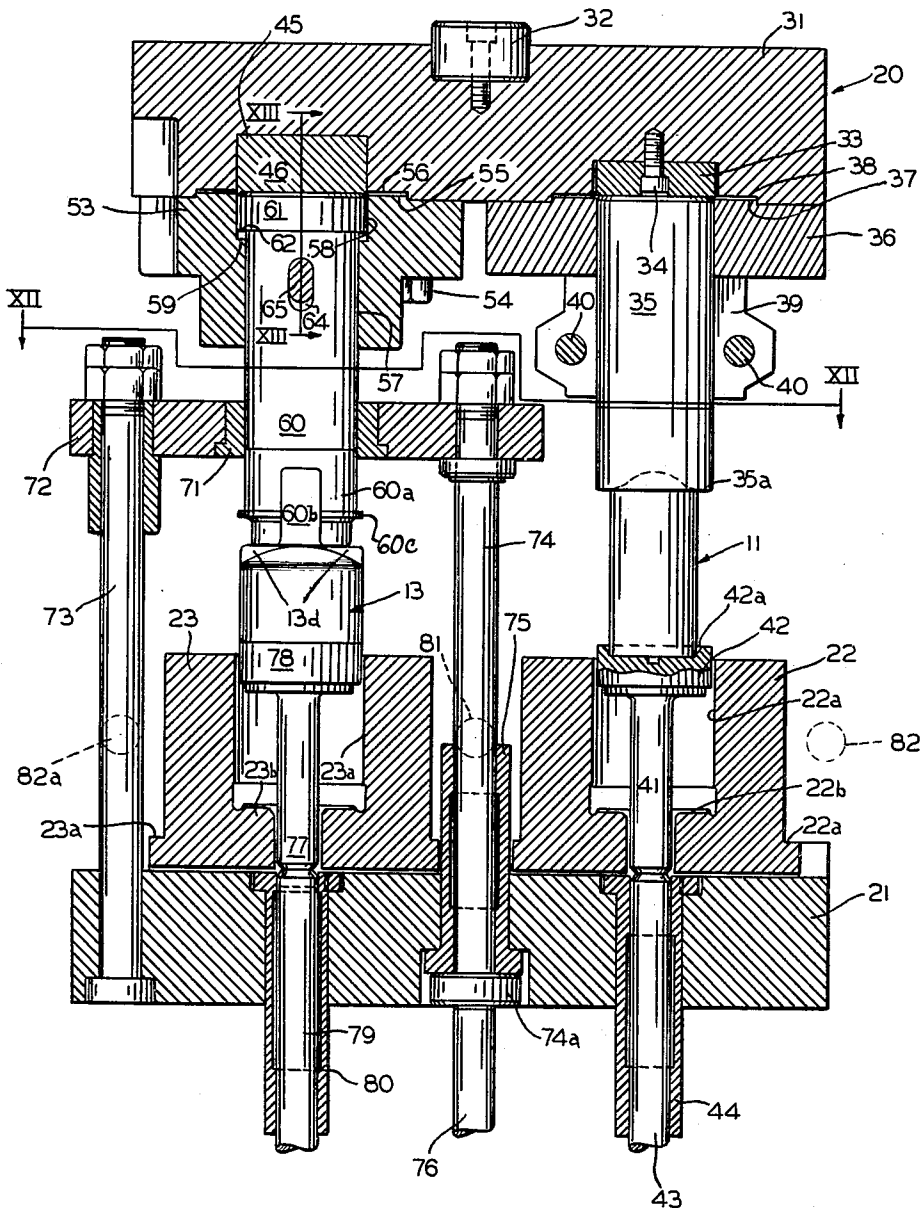


Fig. 11

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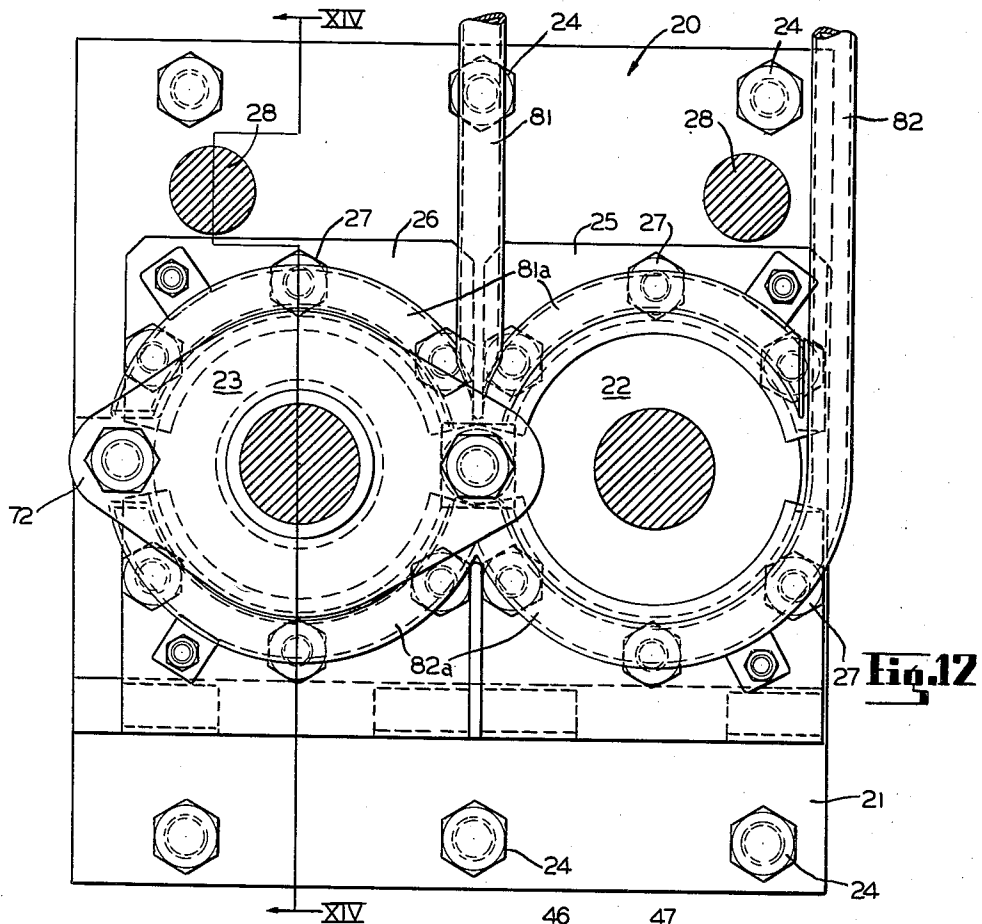


Fig. 12

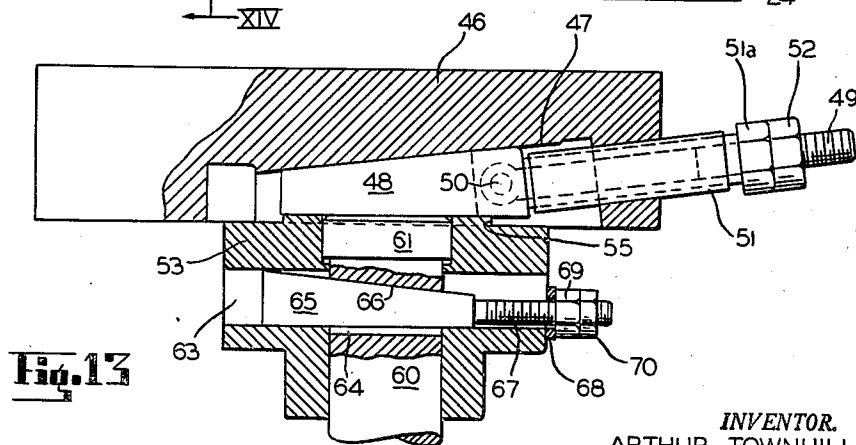


Fig. 13

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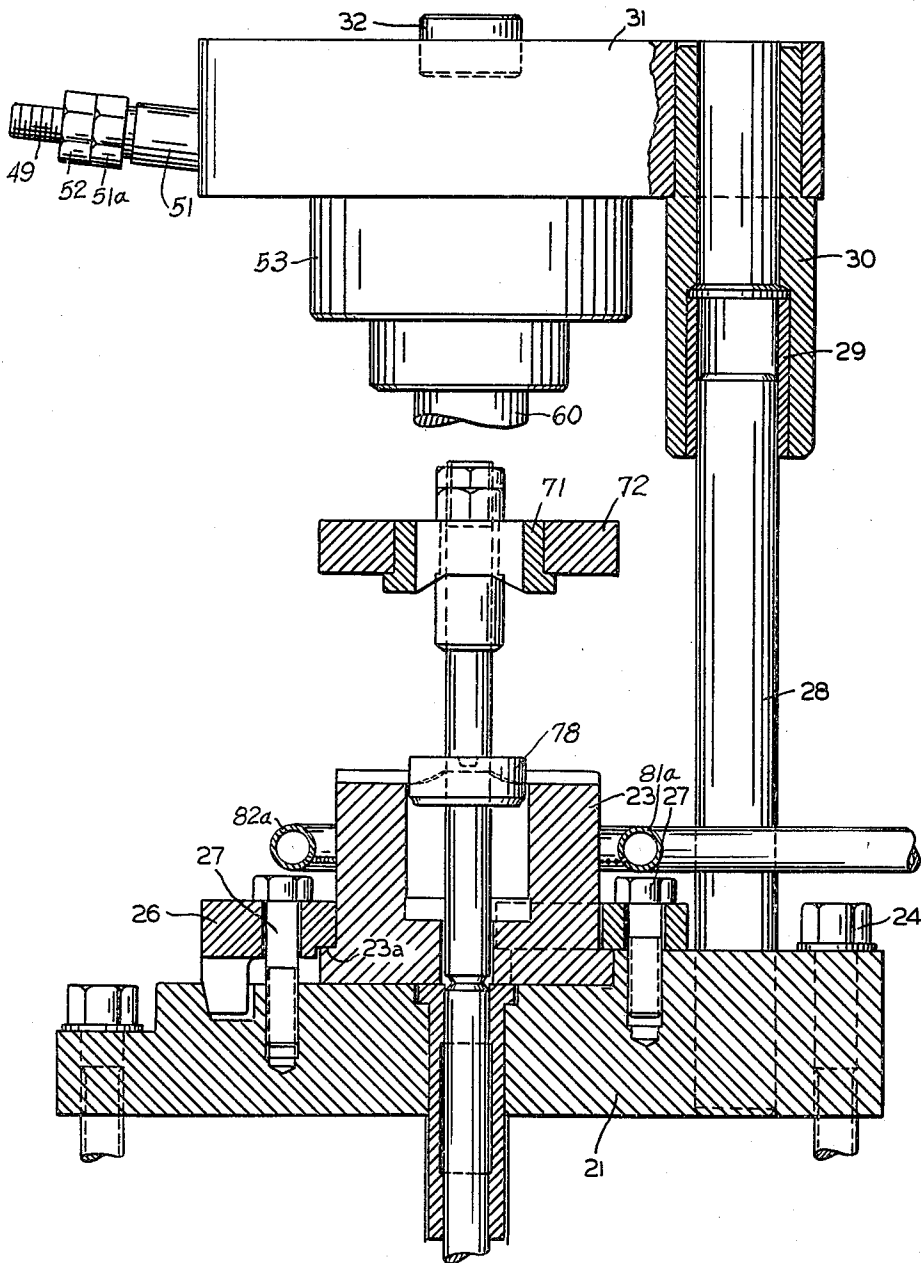


Fig. 14

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3,010,186

PISTON MANUFACTURE

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Filed Jan. 14, 1954, Ser. No. 404,089

7 Claims. (Cl. 29—156.5)

This invention relates to the manufacturing of pistons by impact forging metal slugs in a plurality of stages to knead the metal and develop a grain structure which enhances the strength and wear capacity of the finished product. More specifically, this invention relates to method and apparatus for impact forging trunk type internal combustion engine pistons from cast aluminum slugs by first kneading the cast metal to develop a grain band construction adapted for plastic flow in an extrusion die thereby producing a finished piston having a continuous unbroken slip plane crystalline structure extending from the head portion and parallel with the inner and outer faces of the side wall portions of the piston.

In accordance with this invention, cast aluminum slugs either formed individually or cut from a cast rod are heated to forging temperatures of about 750° to 950° F. These slugs are subjected to endwise impact for kneading the cast crystalline structure of the metal and for initiating a grain band or slip plane configuration which can be extruded without tearing the metal. This initial treatment increases the diameter and decreases the length of the slugs to produce a solid cylindrical billet preferably having a domed top with a transverse rounded central rib or projection. The thus formed billet is then subjected to impact extrusion in a die by a punch which will shape the hollow interior of the piston. The transverse rib is engaged by the plunger and is displaced 90° from the pin bosses formed by the plunger so as to provide sufficient extra metal to complete the extrusion of the skirt in the regions remote from the pin bosses. The resulting extruded piston will have a skirt of uniform height around its entire periphery. These resulting extruded pistons are then subjected to a solution heat treatment and are quenched. If desired, they can be precipitation heat treated. The extruded pistons are in substantially finished form and need only be subjected to machining operations for cutting in the ring grooves and for drilling the wrist pin holes through the pin bosses.

A feature of this invention resides in the provision of extrusion apparatus which simultaneously kneads a cast slug into billet form while extruding a second billet into finished piston form. This apparatus exerts a higher pressure per square inch on the billet than on the slugs.

Another feature of this invention resides in the provision of the desired kneading and extrusion temperatures in the apparatus for eliminating scoring and sticking of the metal.

A still further feature of this invention is to provide a method of forming extruded pistons from aluminum alloys which have heretofore only been usable to produce cast pistons.

It is then an object of this invention to provide improved pistons from cast slugs.

Another object of this invention is to provide a method of making extruded metal pistons from cast slugs by initially kneading the slug to start the development of a grain band formation receptive to plastic flow during the extruding step.

A still further object of the invention is to provide a method of making extruded aluminum pistons from cast aluminum slugs that have heretofore been considered to be unforgeable.

A still further object of the invention is to provide a

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method of making internal combustion engine trunk type pistons from cast aluminum alloy slugs in a two-stage hot forging procedure involving an initial kneading deformation and a final extrusion of the kneaded billet.

A still further object of the invention is to provide apparatus for simultaneously kneading a slug and extruding a kneaded billet to produce trunk-type pistons.

A still further object of this invention is to develop a slip plane formation in cast slugs to produce stronger pistons than were heretofore capable of being produced.

A specific object of the invention is to provide a method of kneading cast aluminum slugs into billet shapes for extruding a trunk type piston so that the extruded metal will rise to a uniform level.

Another object of this invention is to provide hot forging apparatus adapted to impact hot solid metal slugs for producing trunk type pistons.

Other and further objects of the invention will be apparent to those skilled in the art from the following detailed description of the annexed sheets of drawings which, by way of a preferred embodiment, illustrate the method and apparatus of this invention.

On the drawings:

FIGURE 1 is a side elevational view of a cast aluminum alloy rod from which the pistons of this invention are made.

FIGURE 2 is an enlarged longitudinal cross-sectional view of a cut off length of the rod of FIGURE 1 to form the starting slug piece for the pistons of this invention.

FIGURE 3 is an isometric view of a kneaded billet formed from the slug piece of FIGURE 2.

FIGURE 4 is a vertical cross-sectional view taken along the line IV—IV of FIGURE 3.

FIGURE 5 is a vertical cross-sectional view taken along the line V—V of FIGURE 3.

FIGURE 6 is a vertical cross-sectional view taken along the line VI—VI of FIGURE 3.

FIGURE 7 is a longitudinal cross-sectional view of a trunk type piston blank formed according to this invention and showing the grain band formation of the blank.

FIGURE 8 is a view similar to FIGURE 7 but taken along the line VIII—VIII of FIGURE 7.

FIGURE 9 is a bottom plan view of a finished piston made from the blanks of FIGURES 7 and 8.

FIGURE 10 is a vertical cross-sectional view of the piston taken along the line X—X of FIGURE 9.

FIGURE 11 is a vertical cross-sectional view, with parts in front elevation, of an impact forging apparatus according to this invention.

FIGURE 12 is a horizontal cross-sectional view, with parts in top plan, taken along the line XII—XII of FIGURE 11.

FIGURE 13 is an enlarged transverse cross-sectional view, with parts in elevation, and with parts added taken along the line XIII—XIII of FIGURE 11.

FIGURE 14 is a vertical cross-section taken along the line XIV—XIV of FIGURE 12.

As shown on the drawings:

The solids cast aluminum rod 10 of FIGURE 1 has a diameter of around 3", preferably 2 $\frac{1}{16}$ " and a length which is convenient to cast and handle. This rod 10 is preferably formed of a Red X aluminum alloy of the following general composition:

Copper	1 to 2%.
Magnesium	0.3 to 1%.
Manganese	0.3 to 0.9%.
Silicon	6 to 20%.
Aluminum	Balance.

Impurities such as the following, may also be included in the alloy:

Iron-----	1.2% max.
Zinc-----	0.4% max.
Nickel-----	.07% max.
Titanium-----	0.2% max.

A preferred specific alloy for forming the pistons of this invention is cast Red X-20 of the following composition:

Copper-----	1.38%.
Magnesium-----	0.55%.
Manganese-----	0.42%.
Silicon-----	16.72%.
Zinc-----	0.29%.
Iron-----	0.54%.
Nickel-----	.06%.
Aluminum-----	Balance.

Slugs, such as 11, of FIGURE 2 are cut from the rod 10 and preferably have a length of 5". As shown in the cross-sectional view of FIGURE 2, these slugs have a cast crystalline structure 12 relatively free from grain bands or slip planes since the metal is in its as-cast condition. In the first step of this process, the slug 11 is kneaded to form the billet 13 of FIGURE 3. This billet has a shorter height and a greater diameter than the slug 11, and is preferably about 2" high and about 3 3/8" in diameter. The billet has a cylindrical side wall 13a with a flat bottom 13b and a convex domed top 13c. This top 13c has a fragmental spherical contour with a pair of fragmental cylindrical ears 13d, 13d radiating from the apex of the sphere on one diameter thereof. These ears provide additional metal at the periphery of the dome for forming the skirt of the piston in the regions thereof normal to the wrist pin bosses. A bevel 13e is preferably provided between the cylindrical side wall 13a and the flat bottom 13b.

As shown in FIGURES 4 to 6, in the billet 13, the crystalline as-cast microstructure 12 of the slug 11 is largely replaced with a grain band or slip plane structure 14. The grain bands 14 generally follow the spherical dome shape of the top 13c and terminate in the side walls 13a of the billet. These grain bands are developed by the kneading operation in collapsing the long slug 11 into the shorter billet shape 13. It will be noted that the bottom 13b of the billet retains some of the as-cast crystalline structure 12 in the central portion thereof and this crystalline structure may extend up into the body of the billet for some depth. The majority of the metal, however, has been worked to develop a very desirable grain band formation.

The billet 13 of FIGURES 3 to 6, is, in accordance with the method of this invention, subjected to an impact extrusion step for forming the piston blank 15 of FIGURES 7 and 8. As therein shown, a trunk type piston has a head 15a with a depending ring flange 15b and a thinner skirt 15c. Wrist pin bosses 15d, 15d extend from the head 15a on opposite sides of the ring flange and skirt and terminate in rounded ends inwardly from the open end of the skirt. These pin bosses are thicker than the skirt and ring flange. The extremity of the skirt preferably has a reduced thickness portion 15e which provides a larger diameter cavity in the interior of the piston.

As shown, the extruded piston 15 has slip planes or grain bands 16 extending continuously across the top of the head and thence through the ring flange and skirt and through the pin bosses so that all exterior and interior surfaces of the piston are defined by the sides of the grain bands. The grain flow is developed from the grain band formation 14 of the billet 13 and in addition, the as-cast crystalline structure 12 of this billet, is also worked to develop a slip plane formation in the head 15a

of the piston. The grain bands are substantially parallel to the inner and outer surfaces of the piston and these surfaces are relatively free from grain band ends. This construction provides a very strong, wear-resistant, and corrosion-resistant piston because the metal is worked in the direction of operation of the piston and the surfaces do not have the pits normally attendant with grain band ends.

The blanks 15 of FIGURES 7 and 8, need not be machined or ground on the inside thereon to produce the finished piston 17 of FIGURES 9 and 10. The blanks are finished by cutting the piston ring grooves 18 in the ring flange 15b thereof, by drilling the wrist pin holes 19 in the pin bosses 15d thereof, by finish grinding the outside diameter, by machining the top of the head, and, in some instances, by slotting for size control.

In summary, it will be perceived that a forged metal, hollow piston 15 has been provided including the head portion 15a and the skirt portion 15c (the term "skirt portion" including the ring portion 15b). The head portion includes axially inner and axially outer radially extending surfaces 15a', 15a'', the axially outer surface 15a'' arranged to be presented to the action of explosive forces operating within an engine. The skirt portion 15c has axially extending radially inner and outer surfaces 15c', 15c'' and with the skirt portion having an open end defined by a generally radially extending annular edge 15'. The piston is composed of metal in which the majority of the lines of grain flow 16 in the head portion are transverse to the vertical axis of the piston and which lines of grain flow are turned at the juncture of the head portion with the skirt portion and extended axially away from the head portion and further extended through the skirt portion with the ends of the lines of grain flow terminating at the radially extending annular edge 15' defining the open end. The sides of said grain bands 16 define the axially inner and axially outer radially extending surfaces 15a', 15a'' as well as the axially extending radially inner and radially outer surfaces 15c', 15c''.

The billet 13 and the piston blank 15 are formed, according to this invention, in the impact forging apparatus 20 of FIGURES 11 to 14. This apparatus includes a bed or base 21 on top of which are secured a pair of cup-shaped dies 22 and 23 in side-by-side relation. Stud 24 secure the base plate 20 to a hydraulic press (not shown) and apertured clamping plates 25 and 26 fit around the dies 22 and 23 to engage shoulders 22a and 23a thereof. Stud 27 connect the plates 25 and 26 to the bed plate 21 for locking the dies on the bed. Upright pins or posts 28 extend upwardly from the back of the bed plate 21 in spaced parallel relation and, as shown in FIGURE 14, have a sliding fit in cylindrical bearings such as 29 carried by depending hollow guides 30 on a punch head 31. This head 31 has a replaceable impact stud 32 in the center thereof adapted to be engaged by an impact hammer or punch head of a hydraulic or mechanical ram or the like (not shown). The head 31 is thus slidably guided on the posts or pins 28 and is engaged by an impact apparatus (not shown) striking against the stud 32.

The bottom face of the head 31 is recessed above the die 22 to receive a spacer disk 33 held therein by a stud 34. This disk has a predetermined thickness to control the level of a punch 35 which abuts thereagainst. A clamp ring 36 has a pilot portion 37 seated in a recess 38 surrounding the bottom portion of the disk 33 and this clamp ring 36 carries a pair of depending ears 39 drawn together by clamping bolts 40 for fixedly securing the punch 35 therein. The top of the punch is engaged by the disk 33 to determine the exact level for the active end face 35a of the punch. As shown, this end face 35a has a contour to form the spherical dome and the ears of the billet 13.

The die 22 has a cylindrical cavity 22a with an apertured bottom 22b receiving an ejector piece 41 there-through. The piece 41 has a head 42 with a recess 42a in the top face thereof for receiving the bottom of the

slug 11. This recess 42a forms the beveled bottom of the billet 13.

An ejector pin 43 is slidably mounted in a guide 44 carried by the base plate 21. This pin 43 engages the bottom of the ejector piece 41 after the forging operation to raise the billet 13 out of the die cavity 22a.

The punch head 31 has a recess 45 in the bottom face thereof above the die 23. This recess 45 receives a block 46 also shown in FIGURE 13. The block 46 has a cavity in the bottom face thereof provided with an inclined top wall 47. A wedge block 48 is positioned in this recess to engage the top wall 47 and an eye stud 49 is attached to the front end of the wedge block 48 by a dowel pin 50. The adjusting stud 49 extends through an adjusting hollow screw 51 threaded in the front face of the block 46 and having a nut head 51a on the end thereof for abutting a lock nut 52 on the eye stud 49. The wedge block is accurately positioned along the incline of the wall 47 by the adjusting screw 51 and the bolt 49.

A punch holder 53 is secured on the bottom face of the head 31 by means of studs such as 54 and has a pilot portion 55 fitted in a recess 56 around the recess 45. This holder 53 has a bore 57 therethrough with an enlarged countersunk top end 58 providing a shoulder 59. A punch 60 snugly fits in the bore 57 and has a head 61 snugly fitting in the counterbore 58 to provide a shoulder 62 for preventing the punch 60 from dropping out of the holder.

The holder 53, as shown in FIGURE 13, has a horizontal slot 63 therethrough and the punch 60 has a mating slot 64 therethrough just below the head 61. A wedge block 65 fits in the slots 63 and 64 and has an inclined top face 66 engaging the inclined top face of the slot 64. A threaded stud 67 on the block 65 projects through the front of the slot 63 and through a washer 68 abutting the front face of the holder 53 to receive an adjusting nut 69 and a jam nut 70 thereon.

The punch 60 is accurately positioned in the holder 53 so that its active end 60a will be at the exact desired level by adjusting the wedge block 48 on its wedge wall 47 to place above the bottom of the block at the desired level the top of the punch head 61. The wedge block 65 is then adjusted so that its top face 66 will engage the top of the slot 64 to raise the head 61 against the bottom of the wedge block 48. Manipulation of the two wedge blocks 48 and 65 will provide a micrometer adjustment for the level of the punch in the holder 53.

The punch extends snugly through a stripping collar 71 carried by a stripper plate 72 slidably mounted on an upright stay bolt 73 carried by the bed plate 21 and a slidable pin 74 slidably through a bearing bushing 75 in the bed plate 21. A head 74a on the bottom of the pin 74 is engaged by an actuator pin 76 during the stripping operation.

The die 23 has a cylindrical side wall 23a and an apertured bottom 23b as shown in FIGURE 11. The apertured bottom slidably receives an ejector piece 77 with a head 78 supporting the billet 13 in the die. An ejector pin 79 slides through a bushing 80 in the bed 21 to actuate the piece 77.

The dies 22 and 23 are heated by means of gas burners 81 and 82 having perforated burner heads 81a and 82a of arcuate shape which together, almost completely surround both dies 22 and 23 as shown in FIGURE 12. These burner heads direct jets around the dies to heat them to forging temperatures of about 750° to 950° F. Temperatures of about 900° F. are preferred.

Operation

The slugs 11 are cut from the cast bar 10 as by sawing or the like, and are then heated to forging temperatures of between 750° to 950° F. Temperatures of around 910° to 920° F. are preferred. The dies 22 and 23 and the active ends of the punches 35 and 60 are also heated to these same forging temperatures by the burner heads 81a and 82a. At the start of the opera-

tion, the punches 35 and 60 are retracted and a heated slug 11 is placed on the ejector head 42 while a heated billet 13 is placed on the ejector head 78. The heads can be in the position shown in FIGURE 11 or can be retracted into the bottoms of their dies. Before the forging impact, however, the ejector pieces are firmly seated in the bottoms of their respective dies. The impact apparatus then strikes the center piece 32 and the punches 35 and 60 are thereupon forced in their dies to act against the tops of the slug 11 and billet 13.

As shown in FIGURE 11, the ears 13d, 13d of the billet 13 are offset 90° from the pin boss forming portions 60b of the punch 60. This provides metal for extruding the skirt in the region opposite the pin bosses so that the metal will rise to the same level all around the skirt. In the extrusion operation, there is a tendency for an easier flow of metal in the thicker regions between the die and punch provided for formation of the pin bosses. As a result, the regions opposite the pin bosses are "starved" for metal and this deficiency is filled by the metal from the ears 13d. The slug 11 and billet 13 are preferably preheated in an electrical induction furnace although any suitable heating furnace can be used.

The dies and punch are lubricated, preferably prior to each impact, by suitable heat-resistant lubricants such as graphite in petroleum oils, silicones, molybdenum sulfide, and the like. Each impact of the apparatus 20 simultaneously produces a kneaded billet 13 from a slug 11 and a finished piston blank 15 from a billet 13. After the impact, the ejector apparatus is actuated to raise the ejector pieces 41 and 77 to lift the impacted billet and blank out of the respective dies. As the punch 60 retracts from the die and passes through the stripper collar 71, the finished piston blank 15 will be stripped off of the punch head 60a. In this manner, the dies and punches are freed from the products produced thereby.

The apparatus accurately centers the punches in the dies since the guide posts of FIGURE 14 firmly maintain the punch head 31 and the bed 21 in exact alignment. The levels of the bottoms of the punches are accurately controlled and the device of FIGURE 13 provides a micrometer adjustment for the active end 60a of the punch 60.

The impact load on the punch head 31 is preferably of the order of 40 to 50 tons per square inch and the punches preferably travel at the rate of about 120 feet per minute.

If desired, the billets 13 could be formed directly in the die 22 by pouring the molten aluminum alloy therein and by then impacting the resulting cast slug after it solidifies and while it is still at forging temperatures. This impacting of the solid slug is necessary to knead the cast metal structure for forming the grain band arrangement illustrated in FIGURES 3 to 6. The feature of casting directly into the dies will eliminate the steps of making the bar or rod 10, together with the cutting and re-heating steps to form the slug 11.

After the blank 15 is formed by the apparatus of this invention, it is subjected to a heat treatment at temperatures of about 940° to 1000° F. for 2 to 4 hours in a furnace. This effects a solution treatment. The solution-treated pistons are then quenched in water and then subjected to a precipitation hardening cycle at temperatures between 350° F., to 450° F., preferably 390° F., for a period of from 6 to 20 hours, preferably 9 hours. After the precipitation hardening treatment, the pistons are air-cooled to room temperatures. If desired, the solution treatment can be eliminated and the heated piston blanks 15 from the forging operation, can be directly quenched and then subjected to a precipitation hardening treatment.

The punch diameter 60a of the punch 60 may have a slight draft angle in the order of 1° or less, or alternately it may have straight slightly undercut side walls with a diameter determining lip 60c near the bottom thereof as illustrated.

From the above description it will be understood that this invention provides a method of making trunk type pistons and an apparatus for carrying out said method whereby cast slugs are impact forged in two stages to produce a crystalline structure with grain bands defining the top, sides and interior walls of the piston with their sides only. The slip planes extend continuously from the head of the piston down through the ring flange, the skirt, and the pin bosses.

It will be understood that variations and modifications may be effected without departing from the scope of the novel concepts of this invention.

I claim as my invention:

1. The method of making a trunk type piston having a head, a depending ring flange, a thinner skirt depending from the ring flange, and diametrically opposed wrist pin bosses inside the ring flange and skirt extending from the head and terminating inwardly from the end of the skirt, said wrist pin bosses being thicker than the ring flange and skirt, which comprises the steps of heating a cast aluminum alloy slug to forging temperatures from about 750° to about 950° F., impact forging said heated slug to decrease the length thereof more than 50% and to increase the lateral dimension thereof sufficiently to accommodate the decrease in length and to provide diametrically opposed axially raised ears at the radial periphery of the slug, said decrease in length and increase in lateral dimension developing a grain band formation in the metal having the bands extending generally laterally, impact extruding the resulting flattened billet in a die around a punch having diametrically opposed recesses positioned at 90° relative to said ears to flow metal of the billet to form the thickened wrist pin portions in the punch recesses and to flow metal of the billet between the punch and die to form the ring flange and skirt with a metal grain band formation extending axially therethrough to define the inner and outer sides of the formed portions with their sides only, solution heat treating the resulting piston blank at temperatures from about 940° to about 1000° F. for two to four hours, quenching the solution treated blank, heating the quenched blank to temperatures from about 350° F. to about 450° F. for a period of from six to twenty hours, air cooling the hardened blank, cutting piston ring grooves in the ring flange, drilling wrist pin holes in the pin bosses, finish grinding the outside diameter of the blank, and machining the top of the head.

2. The method of making trunk type pistons having a head, a depending ring flange, a thinner skirt depending from the ring flange, and diametrically opposed wrist pin bosses extending from the head inside the ring flange and skirt in integral relation therewith and being substantially thicker than the ring flange and skirt, which comprises the steps of heating a cast aluminum alloy slug to forging temperatures of from about 750° to about 950° F., forging the heated slug to substantially decrease the length thereof and increase the lateral dimension thereof and to provide diametrically opposed axially raised ears at the radial periphery of the slug while kneading the metal sufficiently to develop a grain band formation having the bands extending generally laterally of the slug, extruding the kneaded heated slug in the die around a punch contoured to shape the interior of the piston and having recesses positioned at 90° relative to said ears for forming the pin bosses and flowing the metal between the die and punch to develop a continuation of the grain bands through the ring flange, pin bosses and skirt in an axial direction to define the inner and outer faces thereof with their sides only, cutting piston ring grooves around the ring flange, drilling wrist pin holes through the pin bosses, and finishing the outside diameter of the skirt and the top of the head.

3. The method of making a trunk type aluminum piston with a head portion having metal grain bands extending thereacross, a ring flange and a skirt portion depending from the head portion having metal grain bands extend-

ing from the head portion axially through the ring flange and skirt to define the faces thereof with their sides only and diametrically opposed wrist pin bosses depending from the head inside of the ring flange and skirt and integral therewith, which comprises the steps of heating a cast aluminum slug to temperatures of from 750° to 950° F., impact forging the heated slug to materially decrease the height thereof and to increase the lateral dimension thereof sufficiently to develop a kneaded metal structure with laterally extending grain bands and to shape one end of the slug during said impact forging step to form thereon diametrically opposed localized axial projections to provide offset mass areas on said end, impact extruding at temperatures of from 750° to 950° F. the resulting kneaded billet obtained from the impact forging step to form a trunk type piston having a head with a depending cylindrical ring flange and a cylindrical skirt depending from the ring flange together with diametrically opposed thick pin boss portions inside the ring flange and skirt in integral relation therewith, and positioning the axial projections during the impact extruding operation at right angles to the diametrically opposed pin boss portions that are being formed for supplying added metal to form to the desired length the thinner skirt portions normal to the wrist pin bosses.

4. The method of making trunk pistons from cast aluminum alloy slugs to provide piston structure having a head, a ring flange depending from the head, a thinner skirt depending from the ring flange, and diametrically opposed pin bosses depending from the head inside the ring flange and skirt in integral relation therewith and substantially thicker than the ring flange and skirt, which comprises the steps of heating a solid cast aluminum alloy slug of circular cross-section to forging temperatures of not more than about 950° F., impacting the heated slug endwise to decrease the height thereof more than 50%, kneading the metal during said impact to develop a lateral grain band structure and to provide diametrically opposed axially raised ears at the radial periphery of the slug impact forging the resulting billet while at substantially the same temperatures as the heated slug around a punch in a shaping die to form a trunk type piston blank with side walls and pin bosses positioned at 90° relative to said ears having grain bands extending from the head portion between the bottom of the die and the end of the punch and defining the inner and outer faces of the ring flange, the skirt and the pin bosses with their sides only, heat treating the piston blank at temperatures from about 350° to 450° F. for a period of from six to twenty hours, cutting piston ring grooves around the ring flange, drilling wrist pin holes through the pin bosses, and finishing the exterior surface of the skirt and head.

5. The method of making die forged aluminum pistons from cast aluminum slugs which comprises the steps of heating a cylindrical aluminum alloy slug to forging temperatures, forging said slug endwise to decrease the height and increase the diameter thereof and simultaneously to form on one end thereof a domed contour with diametrically opposed axially raised ear portions adjacent the periphery thereof and extending inwardly therefrom toward the apex of the dome, said forging forming in the metal a grain band configuration extending generally laterally of the resulting billet, and forging the resulting billet around a punch in a shaping die to extrude around the punch a cylindrical skirt portion and opposed wrist pin boss portions, aligning the ears of the billet 90° from the pin boss forming portions of the punch prior to the extrusion operation to provide ample metal for completely forming the skirt to a desired axial length all around the circumference thereof and further forming a grain band structure in the resulting piston blank during said extrusion operation to create grain bands extending across the head and through the skirt and wrist pin bosses so as to terminate in the ends of the skirt while defining the skirt surfaces and the head surface with their sides only.

6. The method of making forged aluminum pistons which comprises the steps of heating a cast solid slug of high silicon content aluminum alloy to forging temperatures not exceeding about 950° F., impact forging the slug endwise to substantially decrease the height of the slug and to increase the diameter of the slug and to provide diametrically opposed axially raised ears at the radial periphery of the slug, hot die forging the resulting billet obtained from the slug in a die around a punch at forging temperatures not exceeding about 950° F., simultaneously extruding wrist pin boss portions positioned at 90° relative to said ears and skirt portions aligned with the position of said ears between the punch and die during said hot forging and creating a flow of metal grain bands from the end of the slug to define the inner and outer faces of the skirt and wrist pin bosses with the sides of metal grain bands only, heat treating the resulting piston blank to develop desired metallurgical properties in the aluminum alloy, cutting piston ring grooves in the blank, and finish machining and grinding the blank to produce a finished piston.

7. In the method of making a domed cylindrical metal billet adapted for use in making a forged skirt and wrist pin boss equipped piston which billet has integral ears radiating from the apex of the dome to the periphery of the dome providing additional metal at the dome periphery adapted to form the portion of the skirt of said piston normal to the wrist pin bosses in a subsequent forging operation and to provide metal grain bands in the body of the metal following the contour of the dome and ears to terminate in the cylindrical side wall of the billet, the steps of heating a cast aluminum slug to forging temperatures, impacting the heated slug to knead the metal into a cylindrical billet shape of greater diameter and lesser axial height than the slug, shaping an end wall of the slug

during said impacting to form thereon a convex spherical shaped dome with a pair of axially raised fragmental cylindrical ears radiating from the apex of said spherical shaped dome on one diameter of the spherical dome and providing additional metal at the periphery of the dome along said one diameter whereby metal grain bands are simultaneously formed in the body of the metal following the contour of the dome and terminating in the cylindrical side walls of the billet.

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