March 10, 1964 A. TOWNHILL 3,123,899

PISTON AND METHOD OF MAKING SAME

Filed April 17, 1959

2 Sheets-Sheet 1

Fig. 1

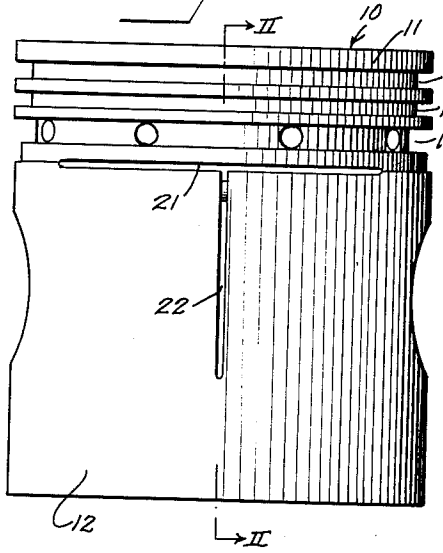



Fig. 2

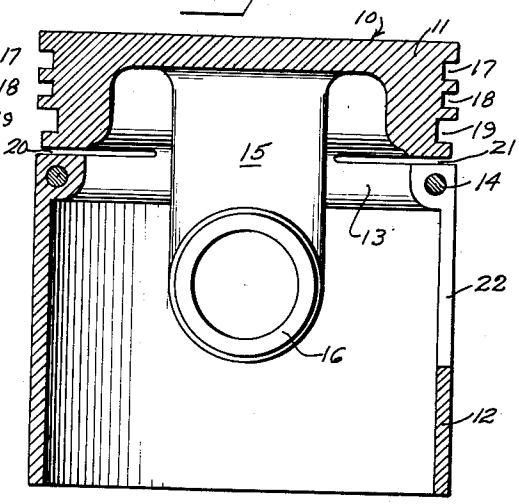



Fig. 3

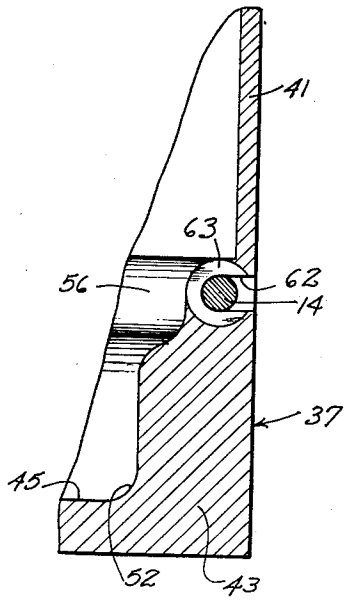
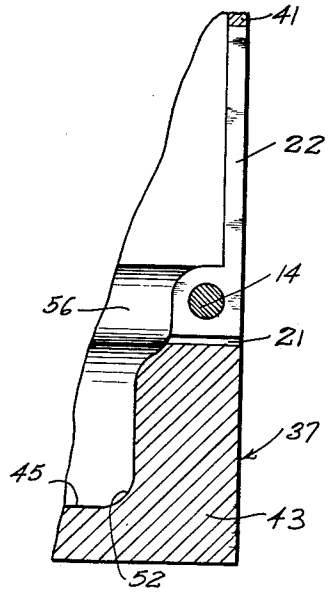



Fig. 4




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March 10, 1964 A. TOWNHILL 3,123,899

PISTON AND METHOD OF MAKING SAME

Filed April 17, 1959 2 Sheets-Sheet 2

Fig. 5

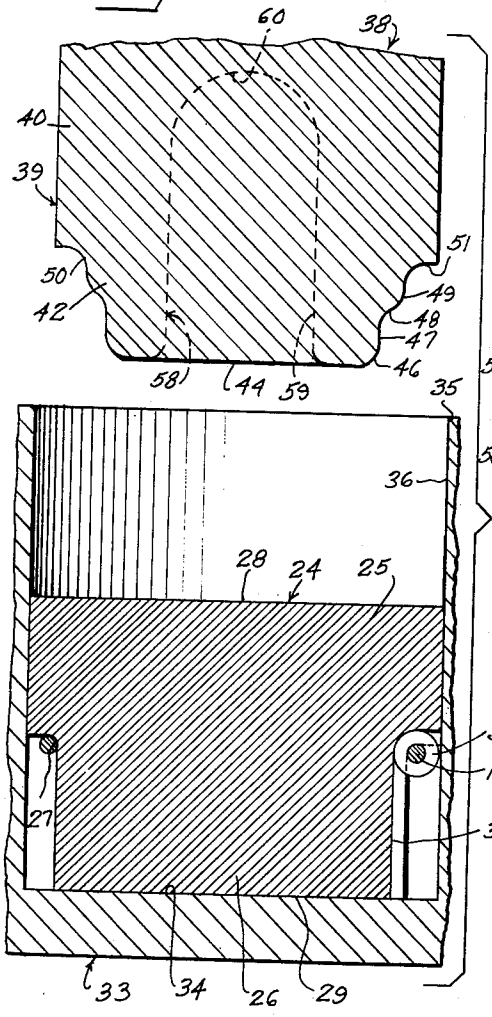



Fig. 6

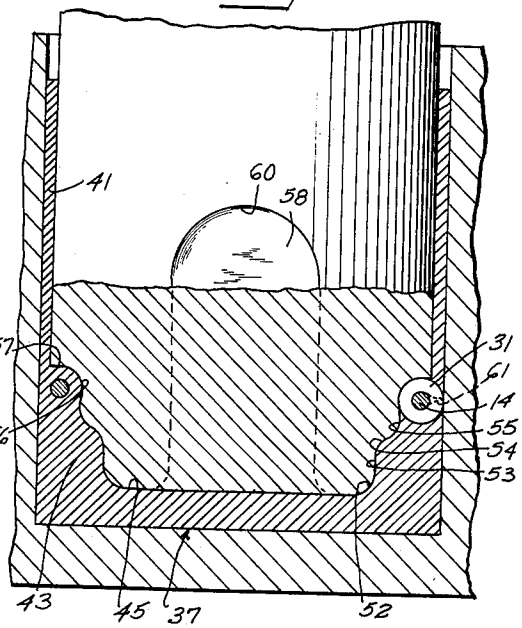
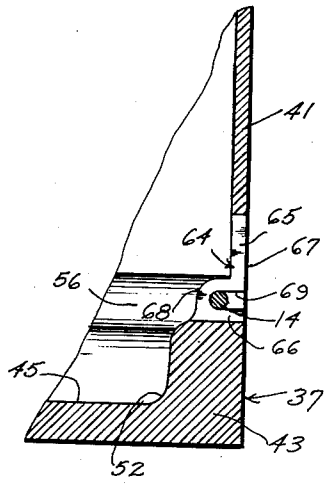



Fig. 7




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3,123,899

# PISTON AND METHOD OF MAKING SAME

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8 Claims. (Cl. 29—156.5)

The present invention relates broadly to the art of piston manufacture, and is more particularly concerned with a novel piston forming method and the article produced thereby featuring impact extrusion of a cast slug mounting thereon a control band about which the slug metal is flowed during the extrusion operation.

It is known in the art to control the thermal expansion of aluminum pistons in cast iron cylinders by locating in the upper end of the piston skirt a ring or belt or band of steel or like materials. In this manner, a piston having a proper fit with the cylinder at room temperature does not stick or score at any operating temperature in the engine. A conventional technique for forming a piston with a control band in the skirt portion thereof is to support the band upon four lugs projecting upwardly from the core portion of the mold in which the piston is to be cast and thereafter pouring the molten aluminum into the mold, whereupon when the cast structure has cooled, the steel band or ring is firmly embedded in the skirt portion at its juncture with the piston head portion. While the method described has enjoyed substantial commercial success, it is recognized that were it possible to produce an extruded piston of this character, there would result an article having improved physical properties generally obtained from extrusion. However, insofar as applicant is aware, there has not been developed to date a completely successful commercial method of extruding or forging a piston with the control band in the piston skirt.

It is accordingly an important aim of the present invention to provide a piston and method of making the same, wherein a control ring or belt is supported by a cast piston slug, and by relative movement between punch and die members, the metal mass in the slug caused to flow into surrounding relation with the belt or ring and said belt or ring thereby firmly embedded in the piston skirt portion.

Another object of this invention lies in the provision of a piston forming method featuring the use of a cast aluminum slug having a reduced diameter end portion providing a shoulder on the slug for seating a control ring thereagainst, and in which method the cast slug with ring thereon is bottomed in a die and by movement of a punch member relative thereto the piston head and skirt portions formed and the metal mass essentially simultaneously moved and wrapped about the ring or belt.

Still another object of this invention is to provide a forged piston having head and skirt portions and a control ring embedded in the skirt portion at a location adjacent the head portion, the control ring effectively reducing if not eliminating creep tendencies in the piston when pressures are applied thereagainst.

A further object of the instant invention is to provide a method of forming a piston with a control ring in the skirt portion thereof, which comprises forming a slug with a reduced diameter end portion and shoulder portion connecting therewith, locating a control ring in close surrounding relation with said end portion and in abutment with the shoulder portion, and moving a punch member relative to a die member containing the slug to move the metal mass of said slug axially and radially to form the piston head and skirt portions and essentially surround the control ring with the metal mass forming said skirt portion.

A still further object of the invention lies in the provision of a piston formed in accordance with the method steps of the preceding paragraph.



Other objects and advantages of the invention will become more apparent during the course of the following description, particularly when taken in connection with the accompanying drawings.

In the drawings, wherein like numerals designate like parts throughout the same:

FIGURE 1 is a side elevational view of a piston constructed in accordance with the principles of this invention;

FIGURE 2 is a vertical sectional view taken substantially along the line II—II of FIGURE 1;

FIGURES 3 and 4 are detail sectional views showing steps in the formation of the piston subsequent to the impact extrusion or forging operation;

FIGURE 5 is a vertical sectional view of punch and die apparatus which may be used in the method of this invention.

FIGURE 6 is a side elevational view, with parts in section, showing the die apparatus after extrusion of a piston from the formed slug of FIGURE 5;

FIGURE 7 is a detailed sectional view of a modified form of washer means which may be used to initially form the vertical expansion slot of the formed piston.

Referring now first to FIGURES 1 and 2, there is shown a piston constructed in accordance with the principles of this invention and comprising a head portion **11** and skirt portion **12** having an annular embossment **13** containing a control ring or belt or band **14**, the latter being preferably formed of steel, whereas the head and skirt portion of the piston **10** are of aluminum or alloys thereof. Diametrally opposed raised portions **15** are formed on the inner surfaces of the head and skirt portions, and downstream of the vertical ribs or raised portions **15** are wrist pin bosses **16**. The head portion **11** of the piston is provided with conventional grooves **17**, **18** and **19** to receive the piston rings, and at opposed diametral locations upon the piston pin the head and skirt portions are separated by horizontal slots **20** and **21** which, as is shown in FIGURE 2, are circumferentially spaced from one another and are separated by the vertical ribs or raised portions **15**. Connecting with the horizontal slot **21** and extending axially downstream therefrom to a point short of the open end of the skirt **12** is a vertical or contracting slot **22**. Although the slot **22** severs the upper portion of the skirt **12**, the control band **14** embedded in the top of the skirt is continuous and extends unbroken across the slot.

As is known, the control ring or belt essentially entirely eliminates an imperfect fit between the aluminum piston and cast iron cylinder caused by a thermal rate of expansion of aluminum which is more than twice that of cast iron. This expansion differential, in the absence of the steel control ring, causes the aluminum piston to be too loose under cold engine conditions while the fit is perfect under full power conditions. The customary method of forming pistons with the control band embedded in the skirt upper portion is to support the band upon lugs projecting out from the core portion of the mold and then cast the piston around the control ring or band. While efforts have been made to impact extrude or forge a piston with a control ring therein, it has heretofore been found essentially impossible to extrude this type of piston at costs considered reasonable in a productive operation.

Briefly stated, the method conceived by applicant comprises first casting an aluminum slug with a reduced diameter end portion which provides an abutment shoulder at the juncture of the reduced and full diameter portions. A groove of relatively short axial length is formed in the outer diameter of the slug at the abutment shoulder extending parallel with the slug axis. A washer is then located on the control ring and the ends of the ring welded one to the other. The control ring with washer thereon is thereupon pressed onto the reduced

diameter end portion of the slug with the ring in abutment with the shoulder and the washer seated in the axially extending vertical slot. The slug with ring assembly thereon is next positioned in a generally cylindrical female die with the reduced diameter portion of the slug on end against the bottom surface of the die, and the full diameter portion in contact with the side walls of the die.

A punch member having an active end shaped to form the piston head portion and to urge the metal mass outwardly around the control ring is then lowered into contact with the upper surface of the slug in the female die. The punch member further is formed with diametrally opposed recesses to provide the raised portions or vertical ribs on the piston inner diameter. The slug is heated to the desired forging temperature, and upon impact pressures exerted by the punch member on the heated slug, the metal mass of the slug is moved axially upwardly around the punch outer diameter to form the piston skirt portion, and essentially simultaneously the metal mass in the reduced diameter end portion of the slug is forced radially outwardly into surrounding or enveloping relation with the control ring to embed said ring in the upper end of the skirt portion. By drilling or other techniques a slot or opening is cut in the washer to a diameter generally corresponding to the diameter of the control ring, and the washer punched out. The vertical slot is then machined downstream into the skirt portion, and the conventional final machining steps performed on the piston.

The method steps summarized in the preceding paragraphs will now be described in detail with reference being made first to FIGURES 5 and 6. A preferred configuration of slug 24 is shown in FIGURE 5, and it may be seen that the slug comprises a generally cylindrical full diameter portion 25 and essentially cylindrical reduced diameter end portion 26 which together provide an abutment shoulder 27 which may be slightly rounded or curved as shown. The slug 24 is formed of any of the preferred aluminum alloys, and is cast by known metallurgical techniques into the configuration shown to provide the reduced and full diameter portions and essentially flat and parallel end surfaces 28 and 29. While variations may of course be practiced, in the exemplary form of slug 24 shown the full diameter or body portion 25 and reduced diameter or end portion 26 of the slug have generally the same axial length.

Machined or otherwise formed into the outer diameter of the reduced end portion 26 of the slug 24 is a vertically or axially extending slot 30, which may be seen to have a length beginning at the end surface 29 of the reduced portion 26 and terminating axially inwardly from the surface 29 at a point beyond the abutment shoulder 27 to form a pocket in the shoulder. The vertical slot 30 has generally a constant depth in both its axially and radially outwardly extending portions.

Seated in the vertical slot 30 is spacer member or washer means 31, provided mainly for the purpose of establishing, after piston extrusion, a pilot hole from which a vertical contraction slot 22 may be machined. The washer 31 surrounds the control ring 14, and the assembly of the control ring 14 and washer 31 is formed by butt welding opposite ends of the ring 14 together after the washer 31 has been placed thereon. The control ring 14 has a diameter no greater than the outer diameter of the reduced end portion 26, and preferably the diameters are such that the ring 14 must be pressed on the reduced diameter end portion to provide a tight fit therewith. When the ring and washer assembly are located on the slug 24 as shown in FIGURE 5, the washer 14 is firmly seated in the vertical slot 30.

The washer 31 has an outer diameter preferably substantially the same as the distance from the bottom of the vertical slot 30 to the outer diameter of the full diameter portion 25 of slug 24. Further, the inner diameter



of the washer 31 is generally the same as the outer diameter of the control ring 14. Also, it will be noted that the difference between the outer and inner diameters of the washer 31 is essentially the same as the depth of the vertical slot 30. By way of the example, the washer may have an inner diameter of 3/16 inch, an outer diameter of 5/16 inch, and a thickness of about 1/8 inch. The washer 31 is desirably formed of steel or the like.

To perform the forging or impact extrusion steps of this invention, there is provided a female die member 33 having an essentially flat bottom wall 34 and upstanding or vertical side walls 35 which define a generally cylindrical forming cavity 36. The axial length or depth of the cavity 36 is of course sufficient to permit extrusion or extension of the piston skirt portion to the length desired. It is to be seen from FIGURE 5 that when the slug 26 with ring and washer assembly pressed thereon are located in the die 33, the end surface 29 of the reduced end portion 26 lies flush against the bottom wall 34 of the die, and the outer diameter of the body or full diameter portion 25 of the slug 24 is in close fitting contact with the side walls 35 defining the cavity 36.

Cooperating with the die 33 to extrude the slug 24 into piston shape 37 of FIGURE 6 is punch member 38. The punch member may be seen to have an active end generally designated by the numeral 39 and comprising a generally cylindrical upstream portion 40 forming skirt portion 41 of the piston shape 37, and a downstream portion 42 of smoothly stepped configuration to form head portion 43 of the piston shape and cause metal flow around and about the control ring 14. The downstream portion 42 of the punch active end 39 includes a generally flat base surface 44 shaping inner surface 45 of the rough piston 37, and generally rounded corner surface 46 which connect with a substantially vertical wall portion 47 downstream of rounded shoulder portions 48. The downstream portion 42 of the punch 38 is further provided with a generally rounded corner portion 49 and a radially upwardly swept wall portion 50 which terminates in a smoothly curved shoulder portion 51. In cooperation with the female die 33, the surfaces or portions 46–51 on the punch member 38 form complementary surfaces 52–57, respectively, on the piston shape 37, as shown in FIGURE 6.

At diametrally opposed locations on the active end 39 of the punch member 38 is a pair of axially extending recesses or pockets 58 which during the extrusion step form the raised ribs 15 and pin bosses 16. It is to be seen from FIGURES 5 and 6 that the rib and boss forming grooves or recesses 58 open at the end surface 44 of the punch active end 39 and have axially extending generally parallel side surfaces 59 which merge with a smoothly rounded upstream surface 60. The downstream ends of the grooves 58 may flare outwardly as shown, if desired.

Relative movement between the die 33 and punch member 38 is preferably accomplished by application of forging pressures to the punch member 38 to force the same downwardly against the slug 24 with ring and washer thereon, the slug 24, ring 14 and washer 31 having previously been heated to a preferred temperature of about 930° F. The punch 38 and die 33 may also be heated, and lubrication may be employed in accordance with the best forging practice.

During pressurized lowering of the punch member 38 into the die cavity 36, and forced downward movement of the base surface 34 and shoulder and wall surfaces 46 and 47 of the punch into the heated slug 24, the metal mass in the full diameter portion 25 of the slug 24 is moved upwardly along the cavity walls 36, and upon continuance of the punch downward movement, preliminary formation of the punch skirt portion takes place. As the punch surfaces 46–51 continue penetration into the metal mass of the slug 24, further elongation of the skirt portion occurs, accompanied by movement of the metal mass

in the reduced diameter end portion 26 generally radially outwardly until, when the punch has reached the extent of its stroke, the metal mass is completely flowed about the control ring 14, in the manner shown in FIGURE 6. The metal mass movement which occurs during embedding of the control ring 14 in the upper portion of the skirt 41 may partake of both axial and radial direction, or a component thereof.

It will be seen from FIGURE 6 that upon completion of formation of the piston shape 37 there is essentially no wall thickness between the washer member 31 and outer diameter of the head and skirt portions 43 and 41 of said piston shape. Stated otherwise, the wall thickness of the upper end of the skirt portion between the surface 56 and the outer diameter of the shape 37 is generally equal to the outer diameter of the washer 31. In fact, radially outwardly of the control ring 14 at the location of the washer 31 there may be present an opening identified by the numeral 61 in FIGURE 6. As will be noted in the next paragraph, this opening 61 facilitates removal of the washer 31.

After the piston shape 37 of the FIGURE 6 is formed, the washer means 31 is removed. The punch member 38 is of course raised and the piston shape 37 removed from the die 33. Knockout means may be employed for this purpose.

Referring now to FIGURES 3 and 4, washer removal may be effected by drilling or punching an opening 62 radially inwardly against the outer circumference of the washer means 31, and the opening hole 62 may be initiated by expanding the opening 61 resulting from only partial closure of the wall thickness during the extrusion described in connection with FIGURE 6. The partial washer 63 of FIGURE 3 may then be knocked radially inwardly away from the control ring 14, or may be pulled therefrom by plier means or the like.

The opening 62 provided by drilling from the outer diameter to the inner diameter of the washer means 31 provides a pilot hole from which to start machining to produce the vertical contraction slot 22 of FIGURES 1–3. The machining of course proceeds axially downwardly away from the head portion 43 the desired distance to produce vertical slot 22 of the proper axial length, and subsequent to machining of the slot 22 the intersecting horizontal slot 21 may be cut therein. If desired, a pilot hole can be drilled at the point of intended intersection of the slot 21 and 22 as an aid in the milling operation. Thereafter, the final machining steps may be performed to produce the final piston article 10 of FIGURES 1 and 2.

The washer means 31 which is positioned on the control ring 14 and provides a pilot hole to initiate drilling of the contacting slot 22 is shown in the FIGURES 1 to 6 as essentially round. This configuration may be varied, and in FIGURE 7 a washer 64 of somewhat different shape is shown. The washer 64 may be stamped from steel, and in the exemplary form shown in FIGURE 7 comprises an upstanding elongated leg portion 65 connecting with a body portion 66 and having a generally flat or straight outer surface 67. The body portion 66 further may be seen to be smoothly rounded along inner surface 68, and is thereby of generally the contour of the rounded shoulder 51 on the active end 39 of punch 38. To remove the washer member 64 after completion of the extrusion operation, a radially inwardly extending hole or opening 69 is drilled therein to the control ring 14, and by use of punch press or other suitable means the washer 64 may be pressed out. The outer structure of the piston shape 37 of the earlier described figures is the same as in FIGURE 7, and accordingly, like numerals have been employed in the latter view.

It may be seen from the foregoing that applicant has provided a novel article and method which now permits the production of a forged or extruded piston with a control ring or band in the upper end of the skirt portion,



whereby there is now obtained the advantages of an extruded structure. Further, any tendency toward creep or shape change under pressure which occasionally characterizes a forged structure is now eliminated by the control band, which at the same time functions in the normal manner to control thermal expansion of the piston. Experience has indicated that during the extruding operation the steel ring 14 displays sufficient strength properties so that it resists expansion and the desired flow of the aluminum is accomplished thereabout. As an illustration, at a temperature of about 800° F., the yield strength of the control ring disclosed is about 18,000 p.s.i., while the aluminum has a yield strength of approximately 3,700 p.s.i. It may thus be seen that expansion of the steel band during extrusion will not occur to an extent sufficient to effect the results desired.

Various changes and modifications may of course be effected in the structures and procedures herein disclosed without departing from the novel concepts of the instant invention, and it will be immediately apparent to those skilled in the art that other applications exist for the concepts herein disclosed. As for example, utilizing the techniques described, it is possible to forge piston ring wear plates which are normally cast upon one of the radially outwardly extending wall surfaces defining the piston ring grooves 17–19 of FIGURES 1 and 2. As is known, the wear plate is generally a material such as cast iron or high nickel iron, and functions to reduce wear of the piston ring groove when the ring is forced thereagainst during the explosion pressure. Forging the wear plate by the present method is productive of a final structure not possessed of the disadvantages of cast metal bodies.

I claim as my invention:

1. A method of forming a piston with a control ring in the skirt portion thereof, which comprises forming a slug with a reduced diameter end portion and shoulder portion connecting therewith, forming an axially extending slot in the end portion of the slug, locating a control ring having a washer member thereon in close surrounding relation with said end portion and in abutment with the shoulder portion with the washer member seated in the axial slot, moving a punch member relative to a die member containing the slug to move the metal mass of said slug axially and radially to form the piston head and skirt portions and essentially surround the control ring with the metal mass forming said skirt portion, and removing the washer member from the metal mass and from the control ring.

2. A method of forming a piston with a control band in the skirt portion thereof, which comprises forming a generally cylindrical slug with a shoulder portion intermediate reduced and full diameter end portions, forming a pocket in the shoulder portion, locating a control band with washer means thereon about the reduced diameter end portion and in abutment with the shoulder portion with the washer means seated in the pocket, locating the slug in a generally cupshape die cavity with the full diameter portion generally conforming with the cavity diameter portion abutting the bottom of the cavity, moving a male die member relative to the die cavity to move the metal mass in the slug axially and radially outwardly, thereby forming the piston skirt portion on the male die member and embedding the control ring in said skirt portion, and removing the washer means from the metal mass and from the control band to provide a radially extending opening in the skirt portion terminating at the control band and providing a starting point for subsequent cutting of the vertical contracting slot in the finished piston skirt portion.

3. A method of forming a piston with a control band in the skirt portion thereof, which comprises forming a generally cylindrical slug with a shoulder portion intermediate reduced and full diameter end portions, forming a pocket in the shoulder portion, locating a control

band with washer means thereon about the reduced diameter end portion and in abutment with the shoulder portion with the washer means seated in the pocket, the radial depth of the recess being substantially equal to the difference between the outer and inner diameter of the washer means, whereby said washer means when seated in the recess is generally flush with the full diameter portion of the slug, locating the slug in a generally cupshape die cavity with the full diameter portion generally conforming with the cavity diameter and the reduced diameter portion abutting the bottom of the cavity, moving a male die member relative to the die cavity to move the metal mass in the slug axially and radially outwardly, thereby forming the piston skirt portion on the male die member and embedding the control ring in said skirt portion, removing a segment of the washer means from its outer diameter through to the control band to provide an opening in the washer at least as large as the diameter of the control band, and removing the washer means from the metal mass and from the control band.

4. A method of forming a piston with a control ring in the skirt portion thereof, which comprises forming a slug with a reduced diameter end portion and shoulder portion connecting therewith, forming an axially extending slot in the end portion of the slug, locating a control ring having a washer member thereon in close surrounding relation with said end portion and in abutment with the shoulder portion, moving a punch member relative to a die member containing the slug to move the metal mass of said slug axially and radially to form the piston head and skirt portions and essentially surround the control ring with the metal mass forming said skirt portion, the metal mass in the skirt portion adjacent the washer member and radially outwardly of the control ring having an opening therein formed during metal movement to provide a pilot hole for initiating removal of the washer member, expanding said opening in the skirt portion to approximately the diameter of the control ring, and removing the washer member from the skirt portion and control ring by forcing said member radially inwardly.

5. A cast slug comprising a generally cylindrical full diameter end portion, a generally cylindrical reduced diameter end portion, and a shoulder portion converting said end portions, said reduced diameter portion having an axially extending slot formed therein terminating in the shoulder portion, and a control band carrying washer means thereon pressed upon the reduced diameter portion and abutting the shoulder portion with the washer means in the axial slot, said ring being embedded in the metal mass of the slug when said slug is extruded into piston shape.

6. The method of making a band controlled piston which comprises providing a slug of extrudable metal with a reduced end bottomed by a shoulder, forming a groove extending axially along the reduced end and radially along the shoulder, seating a control band around the reduced end and bottomed on said shoulder, seating a radially extending spacer member in the axial and radial extending portions of the groove and embracing said band, die forging the slug to extrude metal around the control band and to shape the slug into piston shape, and removing the spacer member from the extruded piston and the band to provide a gap in the piston exposing the band.

7. In the method of making a piston with a control band embedded in the ring band area thereof and extending across a contraction gap which comprises forming a slug of extrudable aluminum or the like metal with an outwardly extending annular shoulder, forming a localized groove in the slug extending axially and radially from the shoulder, seating a ferrous metal ring on the shoulder, seating a spacer in the groove and embracing the ring, extruding the slug to flow metal around the ring and to form a piston ring band with the spacer spanning the band thickness, and removing the spacer to provide a gap exposing the ring.

8. In the method of making a piston with a control band embedded in the ring band area thereof and extending across a contraction gap which comprises forming a slug of extrudable aluminum or the like metal with an outwardly extending annular shoulder, forming a localized groove in the slug extending axially and radially from the shoulder, seating a ferrous metal ring on the shoulder, seating a spacer in the groove and embracing the ring, extruding the slug to flow metal around the ring and to form a piston ring band with the spacer spanning the band thickness, and cutting a hole in the spacer member and disengaging the spacer member from the band and forming the piston to provide a gap in the piston exposing the band.

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