March 14, 1944. A. H. KING 2,344,358

METHOD OF MAKING FORGED PISTONS

Filed Feb. 13, 1940 2 Sheets-Sheet 1

Fig. 1

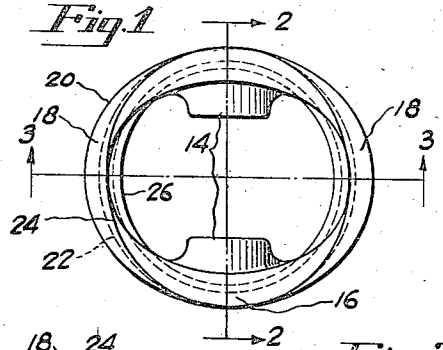


Fig. 2

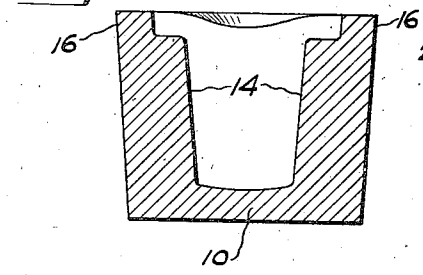


Fig. 3

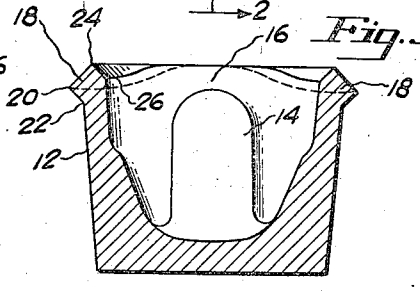


Fig. 4

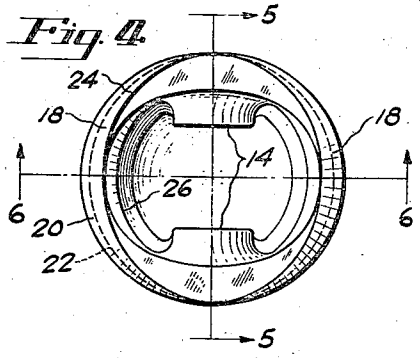


Fig. 5

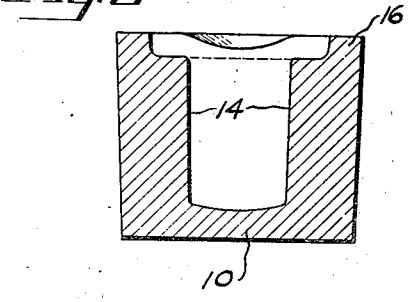
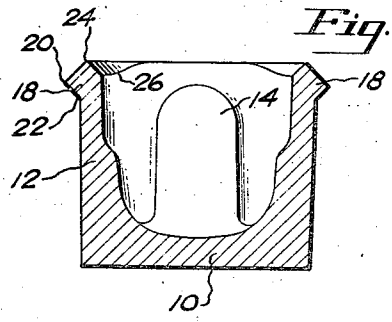


Fig. 6



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Filed Feb. 13, 1940 2 Sheets-Sheet 2

Fig. 7

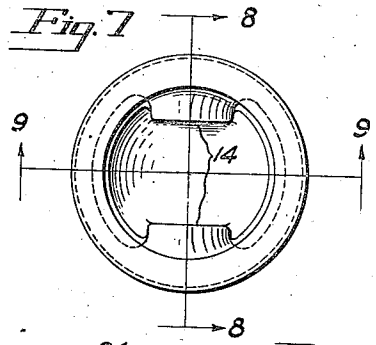


Fig. 8

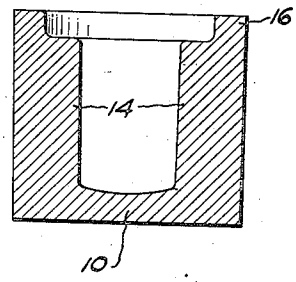


Fig. 9

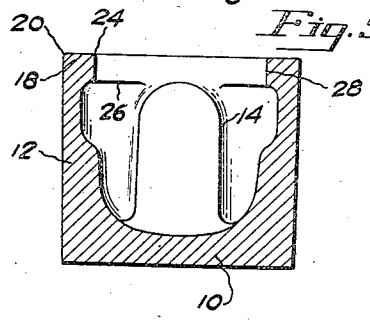


Fig. 10

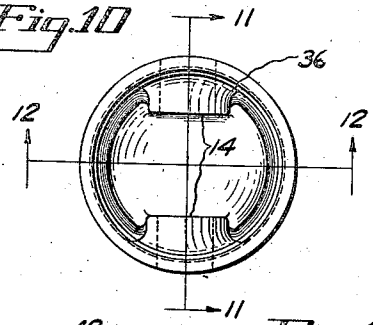


Fig. 11

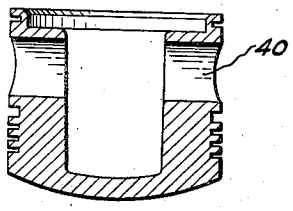
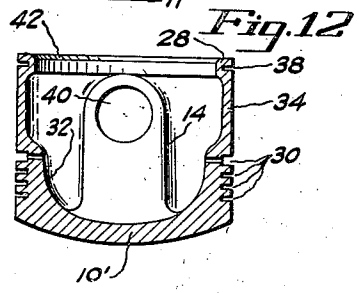


Fig. 12



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UNITED STATES PATENT OFFICE

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METHOD OF MAKING FORGED PISTONS

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Application February 13, 1940, Serial No. 318,721

6 Claims. (Cl. 29—156.5)

This invention relates to improvements in methods of making engine pistons and has particular reference to improvements in the construction and manufacture of forged pistons such as are ordinarily used in internal combustion engines.

An object of the invention resides in the production of an improved piston of the character indicated in which there are present no sharp folds or bends such as might initiate a failure of the piston material.

A further object resides in the production of forged pistons of the character indicated in which the shape of the major portion of the interior of the piston is formed by the forging dies thus eliminating difficult and expensive machining operations on the interior of the piston.

A still further object resides in the provision of a simple and efficient method of manufacturing pistons of the character indicated without folding or bending the material thereof enough to unduly strain the piston material.

Other objects and advantages will be more particularly pointed out hereinafter or will become apparent as the description proceeds.

In the accompanying drawings, in which like reference numerals are used to designate similar parts throughout, there is illustrated several different steps in the method of producing an improved piston of the character indicated, and a finished piston embodying the improvements of this invention. The drawings, however, are for the purpose of illustration only and are not to be taken as limiting the invention as it will be apparent to those skilled in the art that variations in the method illustrated and additional steps as may be necessary or desired may be utilized and modifications in the piston construction may be resorted to without in any way exceeding the scope of the invention.

In the drawings,

Fig. 1 is a bottom plan view of a piston blank in an early stage of the production method.

Fig. 2 is a longitudinal sectional view taken on the line 2—2 of Fig. 1.

Fig. 3 is a longitudinal sectional view taken on the line 3—3 of Fig. 1.

Fig. 4 is a bottom plan view of the piston blank at a later stage in the forging process.

Fig. 5 is a longitudinal sectional view taken on the line 5—5 of Fig. 4.

Fig. 6 is a longitudinal sectional view taken on the line 6—6 of Fig. 4.

Fig. 7 is a bottom plan view of the piston blank at a still later stage in the forging process.

Fig. 8 is a longitudinal sectional view on the line 8—8 of Fig. 7.

Fig. 9 is a longitudinal sectional view on the line 9—9 of Fig. 7.

Fig. 10 is a bottom plan view of the finished piston.

Fig. 11 is a longitudinal sectional view on the line 11—11 of Fig. 10, and

Fig. 12 is a longitudinal sectional view on the line 12—12 of Fig. 10.

As is well known to the art, an internal combustion engine piston is a generally cup-shaped member having a cylindrical wall or skirt portion open at one end and closed at the other end by the piston head. Internally this wall or skirt is provided with diametrically opposed thickened portions, ordinarily referred to as bosses, through which the apertures for the end portions of the wrist pins for connecting the piston to its respective connecting rod extend.

Good practice requires that the piston be made as light as possible consistent with adequate strength and sealing ability and an adequate bearing surface opposed to the wall of the cylinder within which it operates. In order to obtain a condition of minimum weight such pistons are conveniently made of a relatively light material, such as an aluminum alloy, and are made as short as possible, keeping in view the above mentioned requirements of strength, sealing ability and sufficient bearing area. This condition frequently necessitates extending the wrist pin bosses to near the open end of the piston. In addition to being made as short as convenient it is a further requirement that the pistons contain no excess material over that required to provide the necessary strength and the necessary bearing areas and grooves for the piston rings. In thus reducing the total amount of material in the piston the head portion is frequently made relatively thin and reinforced by spaced ridges or fins which also serve as heat transfer elements and the walls of the skirt portions between the wrist pin bosses are in general, the thinnest portions of the piston since these portions of the piston are subjected to very little stress. Practically all pistons of the character indicated are provided about the head end with a series of circumferential grooves for carrying sealing rings to seal the space between the piston and the cylinder within which it operates. Good practice has indicated the necessity of also providing an oil control ring near the open end of the piston. Since the skirt portion of the piston may be made much thinner than the thick-

ness necessary to receive the groove for such a ring, this necessitates an internal flange around the open end of the piston to reinforce the piston end to provide sufficient material for the ring carrying groove. According to one well known method of forged piston production, the piston skirt between the wrist pin bosses is made of a uniform thickness from the head to the open end of the piston and some material between the bosses is machined away below the bottom ring groove to lighten the piston. This machining operation, however, is difficult and expensive and does not remove all of the material in excess of that required for necessary piston strength. It is, therefore, apparent that it would be of great advantage to shape the interior of the piston to the correct contour during the forging operation. Heretofore, considerable difficulty has been experienced in forging pistons so that they will have the correct interior shape without machining, the difficulty arising mainly from the necessity of providing the internal flange for the bottom ring groove which flange renders it difficult to remove the forming dies from the interior of the piston. It has also been known to reduce this difficulty by forming the material for this internal flange on the outside of the piston during earlier steps of the forging method and to turn this material in to form the internal flange when the forging is nearly complete. While this method has certain advantages and may be used successfully with pistons of certain favorable shapes and dimensions, for pistons of the general character indicated above, it tends to result in sharp bends and folds in the material of the bottom flange with consequent local highly stressed portions which tend to initiate fatigue cracks and ultimate failure of the piston.

It is among the objects of the present invention to provide a piston with an interior shaped entirely by the forging operation and which at the same time is free of localized high stresses, cold-shuts, and other irregularities in the piston material which might be inducive to piston failure.

Referring now to the drawings in detail, Figs. 1, 2 and 3 show a piston blank at an early stage in the forging operation. Figs. 4, 5 and 6 show the same blank after additional forging operations have been performed upon it, Figs. 7, 8 and 9 show the same blank after still further forging operations and Figs. 10, 11 and 12 show the finished piston after the forging and machining operations have been completed. These groups of figures are intended to show merely certain stages in the forming of the piston and do not necessarily include all of the forging and machining steps or operations as there may be several steps between the initial billet and the blank shown in Figs. 1, 2 and 3, a number of steps between the form of the blank shown in Figs. 1, 2 and 3 and the form shown in Figs. 4, 5 and 6 and several steps between the form shown in Figs. 4, 5 and 6 and the form which the billet has taken at the stage illustrated in Figs. 7, 8 and 9 and additional forging and machining operations may be performed on the blank between the stage illustrated in Figs. 7, 8 and 9 and the finished piston illustrated in Figs. 10, 11 and 12. These illustrations, however, show certain important stages in the forming of the finished piston from the original billet.

At the stage shown in Figs. 1, 2 and 3 the blank has been given a generally cup-shaped form rather sharply tapered from the closed end to the open end to facilitate the removal of the forming dies and has been provided with a head portion 10, skirt portions 12 and wrist pin bosses 14. The bosses are provided with extensions at the open end of the piston, as indicated at 16, which extensions are thicker than the skirt portions between the bosses but not as thick as the bosses themselves and a ridge 18, of excess material has been formed on the outside of the skirt at the open end in each space between the thickened portions 16. As particularly shown in Fig. 1, these extensions or ridges of excess material 18 are of a generally crescent shape having their greatest thickness at the point midway between the bosses 14 and tapering in each direction toward the bosses the shape being particularly indicated by the space between the outer line 20 and the dotted line 22 in Fig. 1 which lines indicate respectively the outer edge of the excess material and the line at which this material joins the main portion of the piston skirt. These bodies of excess material disposed on diametrically opposite sides of the piston between the bosses 14 are given a definite cross sectional shape so that they will conform to the piston shape when folded in by later forging operations. The surface between the lines 22 and 20 is flared outwardly with respect to the skirt 12, the surface between the line 20 and the top line 24 is disposed substantially at right angles to the surface portion between the lines 22 and 20 so that when the excess material is folded in until the portion between the lines 22 and 20 constitutes a continuation of the skirt the portion between the lines 20 and 24 will constitute the end surface of the piston and the surface portion between the line 24 and the line 26, indicating the upper end of the inner surface of the skirt, is disposed substantially at right angles to the surface between the lines 20 and 24 and substantially parallel to the surface between the lines 22 and 20 so that, when the excess material is folded in, the surface between the lines 24 and 26 will constitute the inner surface of the end flange as will later appear. An inspection of Fig. 1 indicates that the lines 20 and 24 constitute substantially concentric ellipses and that beveled areas between the lines 20 and 24 and between the lines 24 and 26 fair at their ends into the piston end surface portion adjacent the bosses 14.

At the stage illustrated in Figs. 4, 5 and 6 the taper of the piston skirt portion has been somewhat reduced but the bodies of excess material 18 are still present on the exterior of the open end portions of the skirt and up to this stage the forging operations may be performed by solid die members since there is no return bend either interiorly or exteriorly of the piston blank which would necessitate a separation of either the external or internal die.

At the stage illustrated in Figs. 7, 8 and 9 the bodies of excess material 18 have been turned in to constitute parts of an upset internal flange 28 and the walls of the skirt portion have been substantially straightened so that only a slight taper is present. In reaching this stage substantially all of the piston material that has been moved is between the bosses 14 so that the thickened skirt portions 16 immediately over the bosses have not been changed. This improved method particularly avoids the presence of a sharp return bend or fold immediately over the ends of the wrist pin bosses such as would be present if excess material were applied to the

exterior of the skirt all around and then forced inwardly over the ends of the bosses. Between the bosses there is little danger of setting up excessive strains or producing flaws in the material since there is sufficient space in this area for the material to flow and even out so that no strain will be present which will not be substantially eliminated in subsequent annealing operations. The blank may be changed from the form shown in Figs. 4, 5 and 6 to the form shown in Figs. 7, 8 and 9 by forcing it inwardly upon a multi-part internal die. Such a die is well known to the prior art and may have a central portion and detachable side portions which may be removed from under the flange 28 after the central portion has been removed. In this operation the former elliptical contour of the open end of the blank is changed to a circular contour, the skirt, as mentioned above, is straightened and the blank is put into shape for machining after such annealing or heat treating steps, as may be necessary or desired, have been performed.

It is to be particularly noted that in applicant's improved method the skirt material at the ends of the wrist pin bosses is not moved after the bosses are formed and there are therefore no return bends between this material and the end portions of the bosses and that the material that is moved decreases uniformly in thickness from a point midway between the bosses towards the ends of the bosses so that when this material is turned in very little material is moved in those portions of the skirt which are stiffened by the presence of the integral wrist pin bosses, the main movement occurring midway between the bosses where the skirt is relatively thin and flexible and where there is ample room to provide an easy return bend between the thickened portion and the interior surface of the skirt wall. By this improved method applicant is able to forge a piston having a thin walled skirt between the bosses and one which has forged therein the optimum internal contour for strength over weight characteristics and in which no excessive stresses or strains are set up in any part of the material.

After the stage illustrated in Figs. 7, 8 and 9 the piston blank, after suitable annealing and/or heat treating steps, may be machined to produce the finished piston illustrated in Figs. 10, 11 and 12. This finished piston may be provided with a flat or dome shaped head 10' and a series of circumferential grooves, as indicated at 30, adjacent the head for the piston sealing rings. Over the portion including the ring grooves 30 the piston wall is thickened as indicated at 32 to provide sufficient material for the grooves but between this thickened portion 32 and the bottom flange 28 and between the bosses 14 the piston skirt is quite thin, as indicated at 34, and this thin section runs up substantially to the bosses 14 where it is faired into the bosses by suitable fillets, as indicated at 36 in Fig. 10. A bottom ring groove 38 is provided in the bottom flange 28 and suitable wrist pin apertures 40 are provided through the bosses 14 but no machining operations on the interior of the piston are required except the minor lathe operations for rounding the inner surface of the flange 28 and, if desired, providing the bevel 42 around the interior of this flange.

While a particular piston construction and certain selected stages in the process of manufacturing such a piston have been hereinabove described and illustrated in the accompanying drawings for the purpose of disclosing the invention, it is to be understood that the invention is not limited to the particular construction and process stages so illustrated and described but that various changes in both the construction and the process may be resorted to as come within the scope of the appended claims.

Having now described the invention so that others skilled in the art may clearly understand the same, what it is desired to secure by Letters Patent is as follows:

1. The method of manufacturing a blank for an engine piston which comprises, forging a billet to a cup-shaped blank having a closed end, a flared annular portion, and integral wrist pin bosses on the interior of said annular portion extending to near the open end thereof, said annular portion including skirt portions between said bosses, portions over the ends of said bosses thicker than said skirt portions and external radial extensions at the open end thereof between said thickened portions over the ends of said bosses, said blank having in general an elliptical contour at its open end, and reforging said blank to reduce the flare of said annular portion, change the elliptical contour of said open end to a substantially circular contour and move said external radial extensions into substantial circumferential alignment with the thickened portions of said annular portion over said bosses without materially disturbing the material of said thickened portions, to provide a blank having an open end portion thicker than said skirt portion the parts of which between said bosses are constituted by flange portions having a return bend and the parts of which over said bosses are constituted by said thickened portions without a return bend.

2. The method of manufacturing an engine piston having an annular reinforcing portion around the open end thereof and wrist pin bosses which extend to a location spaced from the open end of said piston by a distance substantially the same as the width of said annular portion, said method comprising, forging a metal billet into a cup shaped blank having a closed end section and a flared annular section including said wrist pin bosses, skirt portions between said bosses having a thickness less than the thickness of said annular portion, extensions from the ends of said bosses to the open end of said blank having outer surfaces lying in the plane of the external surface of said flared section and having a thickness greater than the thickness of said skirt portions, and external outwardly disposed ridges at the ends of said skirt portions also having a thickness greater than the thickness of said skirt portions, and reforging said blank to reduce the external surface of said annular section to a substantially cylindrical shape and bend said skirt ridges inwardly to constitute with said boss extensions the said annular reinforcing portion around the interior of the open end of said piston.

3. The method of manufacturing an engine piston having an annular reinforcing portion around the open end thereof and wrist pin bosses which extend to a location spaced from the open end of said piston by a distance substantially the same as the width of said annular portion, said method comprising, forging a metal billet into a cup shaped blank with a closed end section and a flared annular section including said wrist pin bosses, skirt portions between said bosses having a thickness less than the thickness of said annular portion, extensions from the end of said bosses to the open end of said blank having a thickness greater than the thickness of said skirt portions

and having outer surfaces lying in the plane of the outer surface of said flared section, and ridges on the ends of said skirt portions extending radially outward at their center portions beyond said skirt portion and having their end portions faired into said boss extensions, said ridges also having a thickness greater than the thickness of said skirt portions, and reforging said blank to reduce the external surface of said flared section to a substantially cylindrical shape and bend said ridges inwardly to constitute with said boss extensions the said annular reinforcing portion around the interior of the open end of said piston.

4. The method of manufacturing an engine piston which comprises, forging a metal billet into a cup shaped blank having a closed end and a flared annular portion including a pair of internal diametrically opposed wrist pin bosses extending to near the open end of said blank, skirt portions between said bosses, extensions from the ends of said bosses to the open end of said blank of a thickness greater than the thickness of said skirt portions, and external ridges on said skirt portions between said boss extensions, the interior of said blank having no overhanging portions which would interfere with the removal of a solid die therefrom, reforging said blank to reduce the external surface of said annular portion to a substantially cylindrical shape and, without materially disturbing the metal in said extensions, converting said ridges on said skirt portions into internal flange portions of a thickness greater than the thickness of said skirt portions sufficient to receive a piston ring groove and forming with said wrist pin boss extensions a smooth annular reinforcing portion at the open end of said blank.

5. A forged blank for an engine piston comprising, a cup-shaped member having a generally cylindrical skirt portion open at one end and closed at the opposite end by an integral head portion, integral wrist pin bosses on the interior of said skirt portion, the ends of said bosses being spaced from the open end of said skirt portion, and thickened portions at the open end of said skirt portion, said thickened portions including sections over said bosses thicker than said skirt disposed generally in the plane of said skirt and sections between said bosses thicker than said skirt disposed outwardly at an angle to the plane of said skirt to form ridges overhanging the exterior surface of said skirt between said bosses, said ridges being adapted to be swaged inwardly to form with said sections over said bosses a continuous annular thickened portion which is machined to provide a circular reinforcing flange around the open end of said skirt.

6. In a method of forging engine pistons, the steps of: forging a metal billet to form a cup-shaped blank comprising an annular section having a head closing one end thereof, said annular section including internal bosses and skirt portions between said bosses, a reinforcing annulus of greater thickness than said skirt portions extending around said annular section at the open end thereof, said reinforcing annulus comprising, first sections over said bosses no part of which overhangs the interior surface of said annular section and the outer surface of which forms a continuation of the outer surface of said annular section, and second sections over said skirt portions no part of which overhangs the interior surface of said annular section and the outer surface of which overhangs the outer surface of said annular section; and reforging said blank, without materially working the metal of said first sections, to bend said second sections inwardly to a position where they overhang the interior surface of said annular section and their outer surfaces form a continuation of the outer surface of said annular section to provide with said first sections a continuous circular flange of greater thickness than said skirt portions around the open end of said annular section.

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