June 10, 1941. A. LENZ ET AL 2,244,954

METHOD OF MANUFACTURING PISTONS

Filed Oct. 30, 1936 3 Sheets-Sheet 1

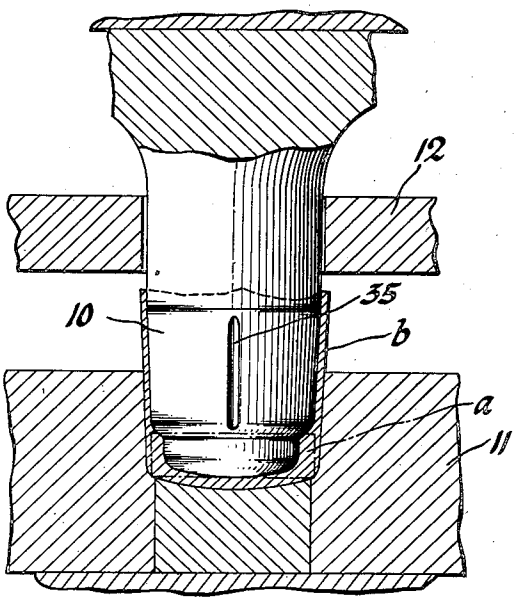


Fig. 1

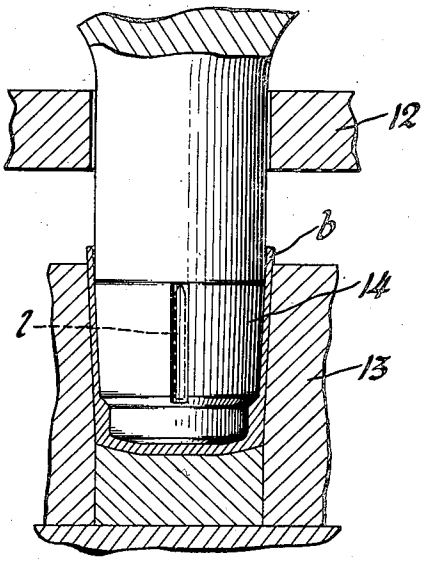


Fig. 2

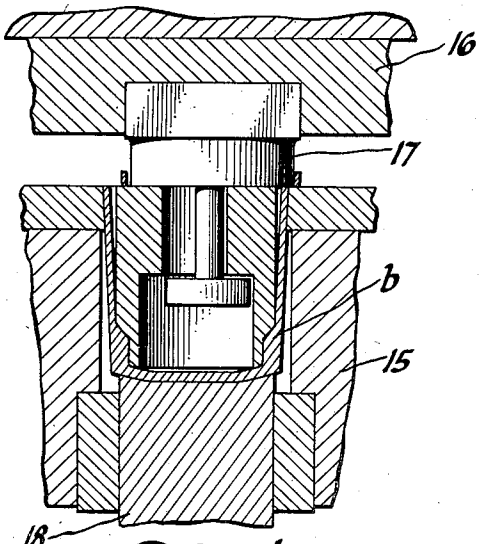


Fig. 4

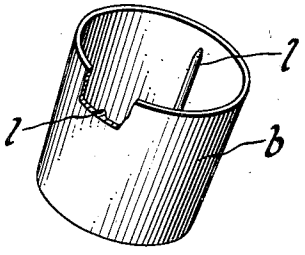


Fig. 5

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METHOD OF MANUFACTURING PISTONS

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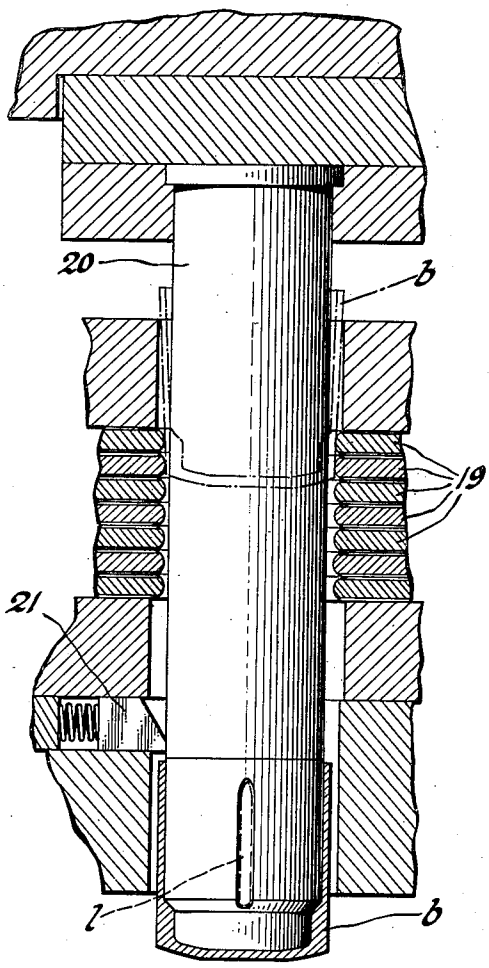


Fig. 3

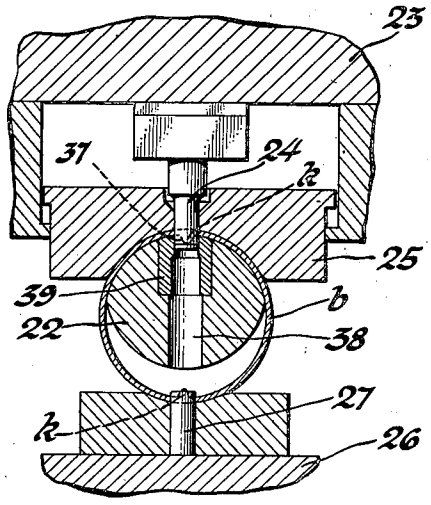


Fig. 6

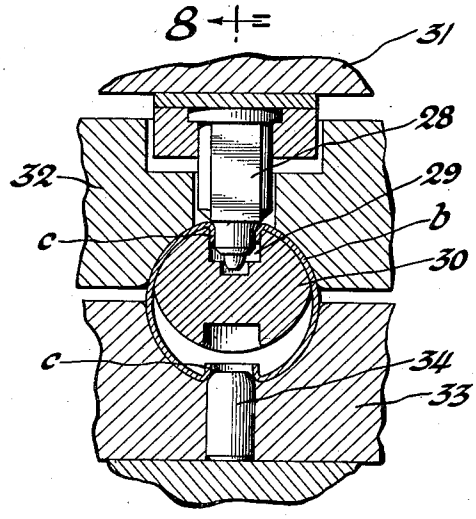


Fig. 7

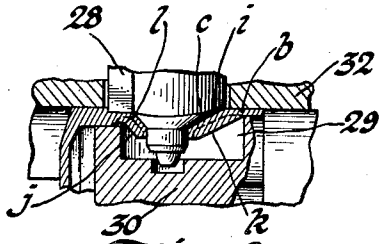


Fig. 8

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METHOD OF MANUFACTURING PISTONS

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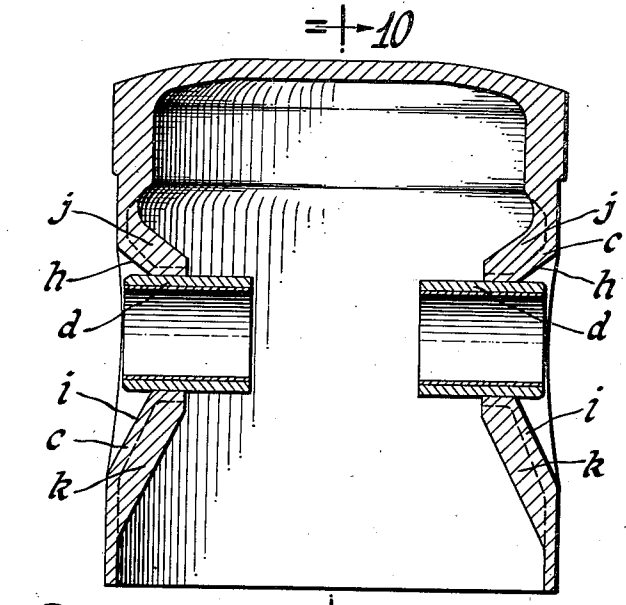


Fig. 9

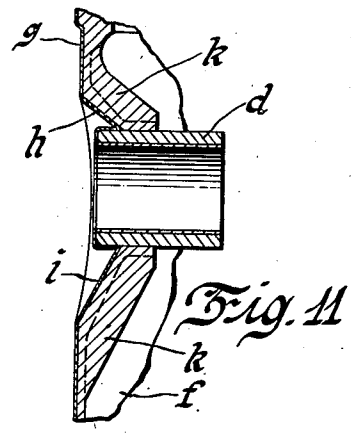


Fig. 11

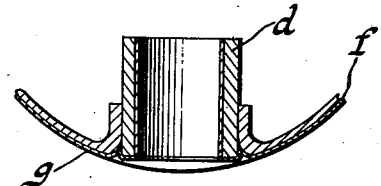


Fig. 12

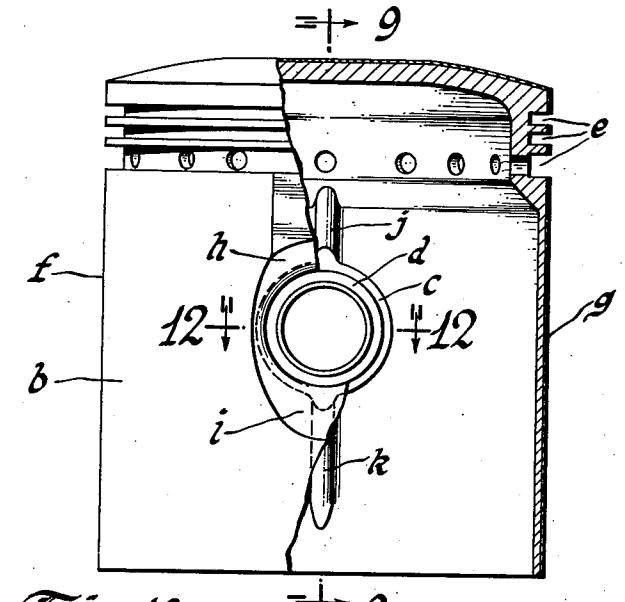


Fig. 10

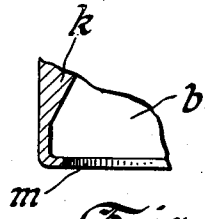


Fig. 13

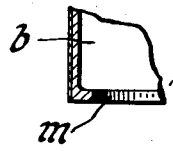


Fig. 14

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UNITED STATES PATENT OFFICE

2,244,954

METHOD OF MANUFACTURING PISTONS

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Application October 30, 1936, Serial No. 108,338

1 Claim. (Cl. 29—156.5)

The desirability of reducing the weight of internal combustion engine pistons has led to the suggestion of many expedients. Because reduction in weight of cast iron pistons is limited by the strength of the material, these suggestions have been mainly along the line of materials which could be used in place of cast iron. Aluminum alloys, magnesium alloys, steel and combinations of aluminum alloys and magnesium alloys with steel and cast iron have been suggested. And some of these suggested substitutes, notably aluminum alloys, have been used commercially but each of them has been found to have undesirable features, in the matter of mechanical properties, or cost, or both.

The need for a relatively light and inexpensive piston led to the work which resulted in this invention. At the outset, the thought of utilizing aluminum alloys or magnesium alloys was put aside, principally because of the cost of these materials. Combinations of aluminum alloys and magnesium alloys with steel and cast iron were not given much consideration because of the cost of the aluminum and magnesium alloys and mechanical defects in all known designs. There remained, for consideration, steel which is from many standpoints the ideal piston material.

A number of methods of fabricating steel pistons had been suggested but none which were known to us were entirely satisfactory as regards both mechanical properties and cost of the product. We, therefore, set out to devise a cheaper and better method of making pistons from steel. The result of this work has been to produce what we believe is a novel method of making pistons and an entirely satisfactory steel piston with some novel features.

This piston and the method of making it form the subject matter of this application and are described in the following specification and illustrated in the accompanying drawings.

In the accompanying drawings:

Figures 1, 2, 3, 4, 6 and 7 illustrate successive operations employed in making a piston in accordance with our invention and more or less diagrammatically the apparatus employed therein.

Figure 5 is a perspective view of the embryo piston after the completion of the operation illustrated in Figure 4.

Figure 8 is a section taken on the line 8—8 of Figure 7.

Figure 9 is a longitudinal section, taken as indicated by the line 9—9 of Figure 10, through an embryo piston in accordance with our invention after the operation which follows that illustrated in Figures 7 and 8 has been completed.

Figure 10 is a view, partly in elevation and partly in longitudinal section on the line 10—10 of Figure 9, through a finished piston in accordance with our invention.

Figure 11 is a fragmentary section taken on the line 9—9 of Figure 10.

Figure 12 is a fragmentary section taken on the line 12—12 of Figure 10.

Figure 13 is a fragmentary section, taken similarly to Figure 9, through an embryo piston of modified form.

Figure 14 is a fragmentary section, taken similarly to Figure 10, through a piston of the form shown in Figure 13 after it is finished.

In making a piston in accordance with our invention, there is employed as stock a slug *a* of any steel which is suitable from the standpoint of workability, machinability and strength. A steel of the following analysis has been found satisfactory:

	Percent
Carbon	0.30–0.40
Manganese	1.60–1.90
Phosphorus	0.40
Sulphur	0.50
Silicon	0.15–0.30

The slug *a* is preferably flat and square because square, flat slugs can be economically cut or sheared from flat plates, but it may be of any shape and formed in any suitable manner. The slug should, of course, contain enough metal to form a cup-shaped body somewhat deeper and with somewhat heavier walls than the piston which is to be produced.

The first operation in the fabrication of a piston in accordance with our invention consists of deforming the slug *a* into a cup-shaped body, such as that designated by the reference character *b* in Figure 1, whose side wall is considerably heavier at its closed end than elsewhere and whose walls are generally somewhat heavier than those of the piston which is to be produced. This operation may be performed by means of apparatus such as that more or less diagrammatically illustrated in Figure 1. This apparatus consists of male and female die elements 10 and 11 secured, respectively, to the movable and stationary jaws of a power press and a plate 12 in which there is formed an opening slightly larger in diameter than and through which the male die element projects. The female die element 11 has in it

a generally cup-shaped recess somewhat larger in diameter than the piston which is to be produced and slightly flared (about 1°) to facilitate removal from it of the cup-shaped body which is to be formed. The male die element is a generally cylindrical element which is tapered slightly (about 1°) to facilitate its withdrawal from the cup-shaped body. It is smaller in diameter than the female die element at corresponding points in its length by twice the thickness of the side wall of the cup-shaped body which is to be formed and is reduced in diameter at its outer end so that the side wall of the cup-shaped body will be heavier at its closed end than elsewhere.

In performing the first operation, a slug *a* of steel (which contains somewhat more metal than is necessary to fill the space between the male and female die elements when the former is in its lowermost position and whose diagonal dimension if the slug is square should be only slightly less than the diameter of the recess in the female die element), heated to a suitable temperature, say about 2000° F., is placed in the recess in the female die element. Then the male die element **10** is forcibly lowered into the recess in the female die element until its lower end is spaced from the bottom of the recess in the latter a distance somewhat greater than the thickness of the head of the piston which is to be produced. The pressure thus exerted on the slug *a* causes the metal of which it is made to assume the shape of and completely fill the space between the female and male die elements and the excess of metal beyond that required to do this when the male die element is in its lowermost position to be extruded through the annular space between the female die element and the body of the male die element. Thus there is formed the slightly flared cup-shaped body *b* whose side wall is heavier at its closed end than elsewhere shown in Figure 1.

After the slug *a* has been reduced to the cup-shaped form illustrated in Figure 1, the male die element **10** is retracted. The embryo piston *b* is raised with the male die element until the open end of the former engages the plate **12** and is thus freed from the recess in the female die element **11**. Engagement of the embryo piston with the plate **12**, of course, frees the former from the male die element. It will, of course, be understood that after the embryo piston has been freed from the male die element, the plate **12** is raised and the male die element raised farther to facilitate removal of the embryo piston from between the male and female die elements.

Immediately after the operation illustrated in Figure 1 is completed, the embryo piston *b* is transferred to the recess in the female die element **13** of the apparatus shown in Figure 2 and the male die element **14** of this apparatus is forcibly lowered into the embryo piston to a point slightly nearer the bottom of the recess in the female die element **13** than the male die element approached the bottom of the recess in the female die element in the operation illustrated in Figure 1.

The apparatus shown in Figure 2 does not differ materially from that shown in Figure 1 except in that the depth of the recess in the female die element **13** is about equal to the length of the embryo piston, the clearance between the male and female die elements **14** and **13** is slightly less and the male and female die elements have "squarer" contours. The operation illustrated in Figure 2 is simply a "restrike" or "shaping" operation and serves merely to "shape" or "square up" the embryo piston and, incidentally, to reduce the thickness of its walls.

The next operation consists in drawing the embryo piston *b* to eliminate the flare in its side wall and to "size" it. This operation and the apparatus for performing it are illustrated in Figure 3. The apparatus consists of drawing dies **19** secured to the fixed and a ram **20** secured to the movable jaw of a power press to force the embryo piston through the drawing dies. The spring-pressed bolt **21** permits the embryo piston to pass it on the down stroke of the ram **20** but prevents the embryo piston accompanying the ram on its return stroke and thus serves to free the embryo piston from the ram after the drawing operation has been completed.

After the drawing operation is completed but before the embryo piston is machined, it is trimmed to remove the "raw" edges from its open end. The trimming operation may be preformed by any suitable apparatus such as that shown in Figure 4. This apparatus consists of a fixed element **15** in which there is formed a recess and a vertically and horizontally shiftable element **16** which carries a stud **17** which consists of two parts which may move horizontally with respect to each other. In trimming an embryo piston by means of the apparatus shown in Figure 4, the embryo piston is disposed within the recess in the element **15** with its "raw" edge projecting out of the recess and the element **16** is lowered to dispose the lower part of the stud **17** within the embryo piston and hold it firmly in the recess. Then the element **16** is moved horizontally in different directions or in a circular path to shift the upper part of the stud **17** with respect to the lower and thus shear off the raw edge of the open end of the embryo piston. To facilitate removal of the embryo piston from the recess in the fixed element **15** of the apparatus after it has been trimmed, there may be provided a vertically movable element **18** on which the embryo piston rests while in the recess in the fixed element **15**.

After the embryo piston has been trimmed but before it is machined, it is equipped with wrist pin bosses. Because wrist pin bosses sufficiently long to afford the requisite bearing area and sufficiently heavy to afford the necessary strength cannot be drawn or otherwise economically formed from the side wall of the embryo piston, this operation is performed in three steps. The first consists of punching slugs from the side wall of the embryo piston to provide openings at the points at which the wrist pin bosses are to be located. The second consists of drawing inwardly projecting flanges or "stub" wrist pin bosses from the material which encircles the openings thus formed. The third step consists in securing extensions in the stub wrist pin bosses.

The first step and the apparatus employed in performing it are illustrated in Figure 6. The apparatus consists essentially of a fixed mandrel **22** over which the embryo piston *b* may be sleeved and a vertically reciprocable head **23** which is disposed above the mandrel and carries a perforating punch **24**. The head also carries a vertically reciprocable element **25** urged to its lowermost position by springs (not shown) to hold the piston firmly in position on the mandrel during the perforating operation. Below the mandrel, there is disposed a retractible element

26 from whose upper surface there projects a pin 27 which is alined axially with the punch 24.

The apparatus shown in Figure 6 is employed in the following manner: An embryo piston *b* is sleeved over the mandrel 22 and then the head 23 is moved forcibly downwardly. Downward movement of the head 23 first brings the element 25 into contact with the embryo piston and holds it firmly against the mandrel and then forces the punch 24 to pass through and shear a slug from the side wall of the embryo piston between its open end and the thickened zone at its head end. After the first opening is formed in the side wall of the embryo piston, the head 23 is retracted and the element 26 raised from the inoperative position in which it was disposed during the operation just described to the operative position in which it is shown in the drawings and the embryo piston rotated about the mandrel until the pin 27 enters the opening formed by punching out the first slug. Then the head 23 is lowered again and another opening formed in the side wall of the embryo piston by punching out of it a slug at a point directly opposite that from which the first slug was punched.

The step of drawing inwardly projecting flanges or stub wrist pin bosses around the openings formed during the step illustrated in Figure 6 and the apparatus employed in performing it are illustrated in Figures 7 and 8. The apparatus does not differ materially from that shown in Figure 6 except in that a suitably shaped drawing punch 28 is substituted for the perforating punch 24 and a suitably shaped die cavity 29 is provided in the mandrel 30 in place of the bore 38 and insert 39.

After the operation illustrated in Figure 6 is completed, the embryo piston *b* is sleeved over the mandrel 30 and located so that one of the openings punched in it during this operation is disposed on the upper side of the mandrel and alined axially with the punch 28. Then the head 31 is moved downwardly to bring the element 32 into contact with and hold the embryo piston firmly against the mandrel and then to force the punch 28 through the opening in the embryo piston which is disposed on the upper side of the mandrel. This operation draws the metal which encircles the opening into an inwardly projecting flange or stub wrist pin boss *c*. Then the head 31 is retracted and the element 33 raised from the inoperative position in which it was disposed during the operation just described to the operative position in which it is shown in the drawing and the embryo piston rotated about the mandrel until the pin 34 enters the opening just flanged. After this, the head 31 is lowered again and a flange *c* disposed diametrically opposite to and axially alined with that first formed drawn from the material which encircles the other opening in the side wall of the embryo piston.

The final step in the operation of equipping the embryo piston *b* with wrist pin bosses is preferably performed by pressing into each of the stub wrist pin bosses *c* a copper-coated tubular wrist pin boss extension *d* of sufficient length to afford the requisite wrist pin bearing area and heating the assembly in a so-called hydrogen brazing furnace to fuse the copper coating and metallically bond the wrist pin boss extensions to the stub wrist pin bosses. The wrist pin boss extensions *d* are preferably made of such diameter that they will make what is known as a press fit with the stub wrist pin bosses and coated with copper to a depth of not more than 0.003" so that the bond between them and the stub wrist pin bosses will partake of the nature of an autogenous weld rather than a braze. The embryo piston *b* at the completion of this step is shown in Figure 9.

After the embryo piston is equipped with wrist pin bosses, packing ring grooves *e* are turned in the thickened zone of its side wall near its head end and it is finished in the usual manner by machining it all over its external surface and grinding the outer surface of its skirt. After this, or after the skirt but before the other parts have been finished, the piston is preferably coated with tin to a depth of 0.00045" to 0.00075" as set forth in the Summers Patent No. 1,856,272 (Reissue No. 18,814).

The finished piston *f* with a coating *g* of tin on its outer surface is shown in Figures 10, 11 and 12. By making the piston in the manner described and illustrated in the drawings, we have overcome what has been a serious obstacle to the manufacture of pistons by methods other than casting and have eliminated what has been a serious defect in pistons produced by methods other than casting. The obstacle was the difficulty of providing sufficient stock in the packing ring zone to permit removal of enough to form packing ring grooves without undesirably weakening the piston in this zone. Obviously this difficulty is not encountered in the manufacture of a piston by our method. The defect referred to was inadequate wrist pin boss support. The method of manufacture we have disclosed entirely eliminates this defect and yet provides adequate wrist pin bearing area. By making the side wall of the embryo piston originally considerably heavier than it is to be in the finished piston (e. g., so that the skirt will be about $\frac{3}{32}$" thick at the completion of the drawing operation if it is to be finished to a thickness of about $\frac{1}{32}$") and forming only stub wrist pin bosses from the side wall of the embryo piston and these before the excess stock is removed, we are able to make sections of the stub wrist pin bosses considerably heavier than the skirt of the finished piston and the stub wrist pin bosses generally sufficiently heavy and strong to support the loads imposed on them while the piston is in use. Adequate wrist pin bearing area is insured by the provision of the wrist pin boss extensions *d*.

The strength of the wrist pin bosses is further increased by two expedients to which attention has not previously been directed. One of these resides in shaping the sections which connect the cylindrical portions of the stub wrist pin bosses and the skirt so that they gradually increase in thickness as they approach the skirt and making the portions *h* and *i* thereof above and below the cylindrical portions of the stub wrist pin bosses relatively long and gently inclined. To do this it is, of course, necessary only to give the proper form to the punch and die cavity employed in the operation illustrated in Figures 7 and 8. The other of the expedients under consideration resides in providing ribs *j* and *k* which extend from the skirt of the piston above and below the wrist pin bosses to the inner extremities of the stub wrist pin bosses. These ribs are formed as a pair of continuous diametrically oppositely disposed ridges *l* during the formation of the piston by providing in the male die element 10 of the apparatus shown in Figure 1 grooves 35 which extend from the lower to the upper end

of its body. Corresponding grooves for the accommodation of the ridges *l* are, of course, provided in the apparatuses shown in Figures 2, 3 and 4. The division of the ridges *l* into the ribs *j* and *k* occurs, of course, during the operation illustrated in Figure 6. For the accommodation of the ridges *l* and to insure that each of the openings formed in the skirt during the operation illustrated in Figure 6 will be located so that its axis intersects the longitudinal axis of one of the ridges *l* a groove **37** is formed in the upper surface of the mandrel **22**. To accommodate the ribs *j* and *k* during the operation illustrated in Figures 7 and 8 a corresponding groove is, of course, provided in the upper surface of the mandrel **30**.

The piston *f* is preferably cam ground so that it is slightly smaller in diameter in the line of the wrist pin bosses than at a right angle thereto. So that the side wall of the piston will be of uniform thickness after it is ground to this shape, the embryo piston *b* is preferably formed so that it is slightly smaller in diameter in the plane of the ridges *l* than at a right angle thereto. Therefore, the die elements of the apparatuses shown in Figures 1, 2 and 3 are made slightly smaller in diameter in the planes of the grooves **35** and the corresponding grooves in the male elements of the apparatuses shown in Figures 2 and 3 than at a right angle thereto. The mentioned grooves and the ridges *l* in the embryo piston, of course, insure proper orientation of the latter in the apparatuses shown in Figures 2 and 3.

To rigidify and stiffen the skirt of the embryo piston *b* in order to reduce the likelihood of distortion during the machining and grinding operations, an inturned flange *m* may be formed on its open end before these operations are performed. The embryo piston *b* equipped with such a flange is shown fragmentarily in Figure 13. The flange *m* need not be removed before the piston is put into use but may as Figure 14 indicates be carried into the finished piston to stiffen and rigidify its skirt while the piston is in use.

We claim:

In the manufacture of a piston, the operations of subjecting a slug of metal to pressure between a female die element with a closed end and a male die element of smaller diameter than the female die element and thus molding the slug to form the head of the piston and extruding metal between the male and female die elements to produce the skirt of the piston, the female die element being so shallow that metal is extruded well beyond its open end, and, subsequently, subjecting the embryo piston to pressure between another female die element with a closed end and a male die element of smaller diameter than the female die element to shape it, the depth of the last mentioned female die element being substantially equal to the lengh of the embryo piston.

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