Dec. 17, 1935. A. A. HANDLER 2,024,285

METHOD OF MAKING PISTONS

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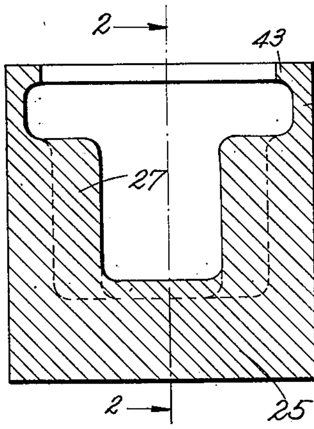

Fig. 1

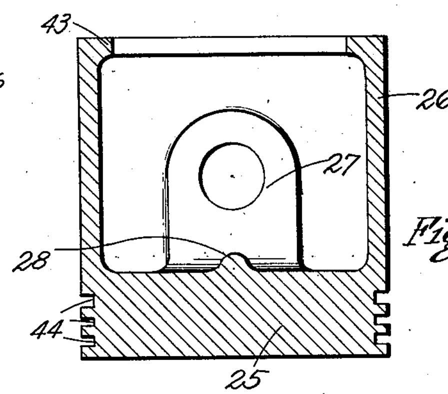

Fig. 2

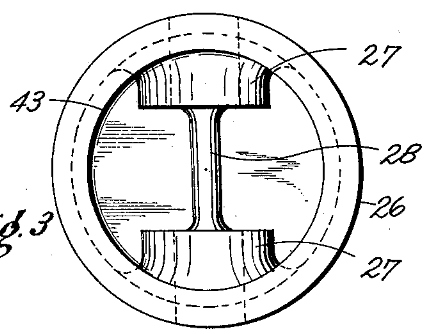

Fig. 3

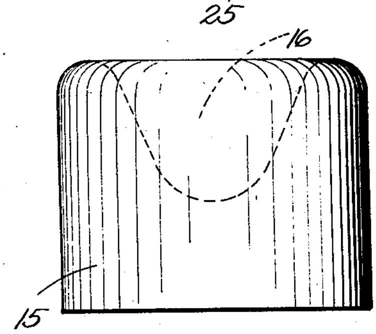

Fig. 4

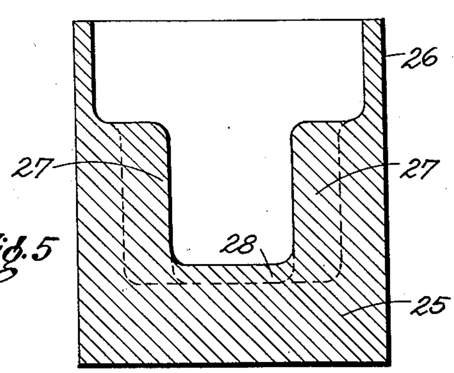

Fig. 5

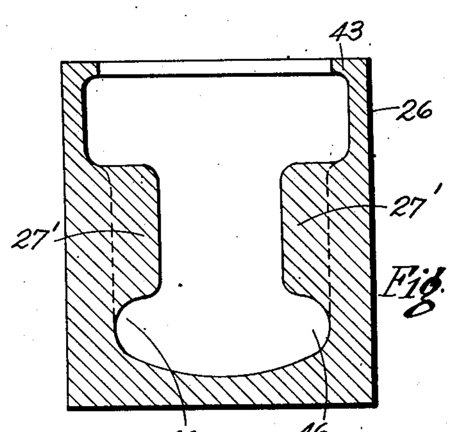

Fig. 6

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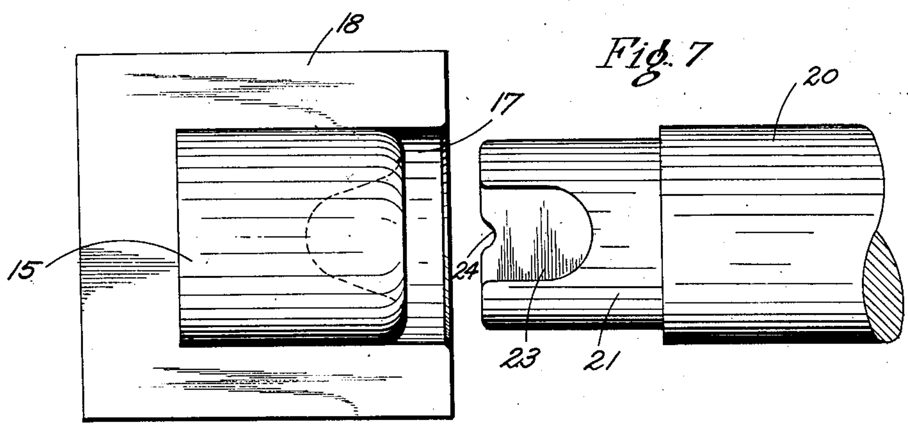

Fig. 7

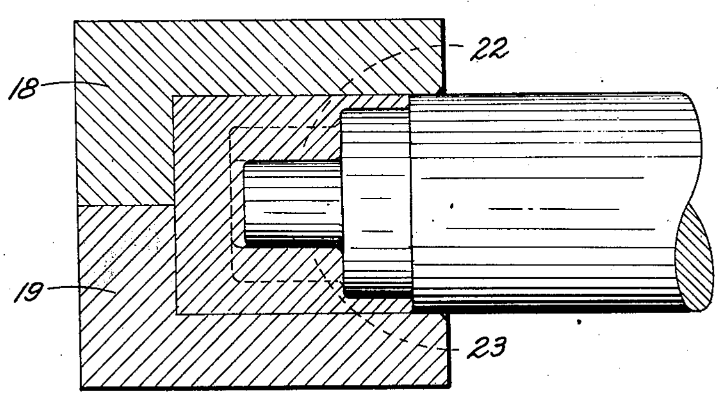

Fig. 8

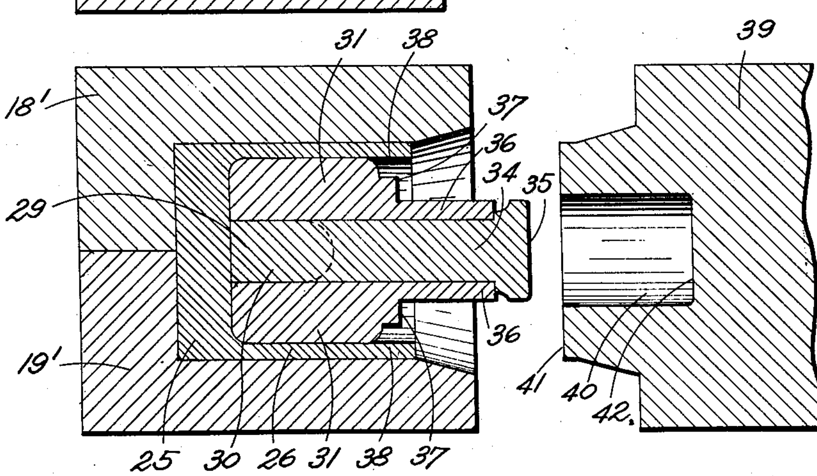

Fig. 9

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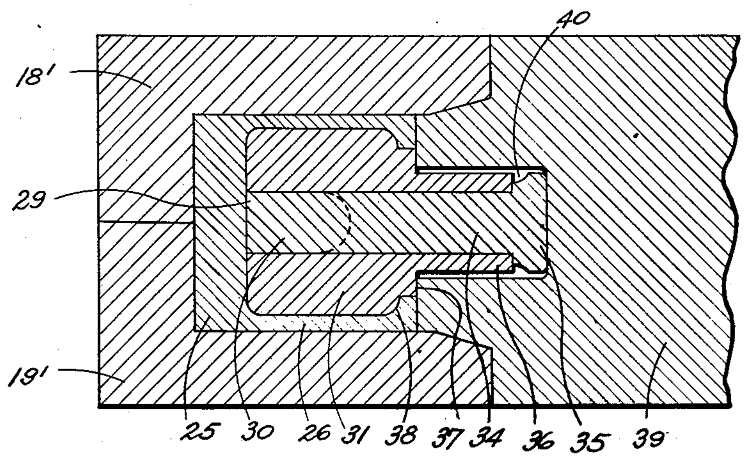

Fig. 10

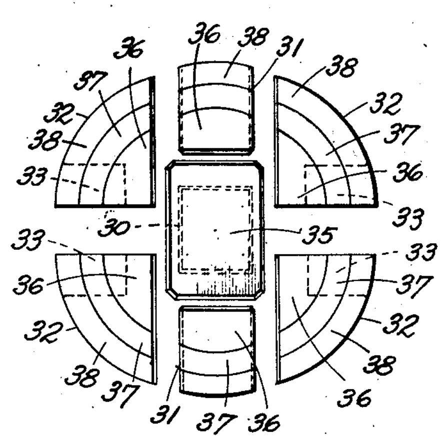

Fig. 11

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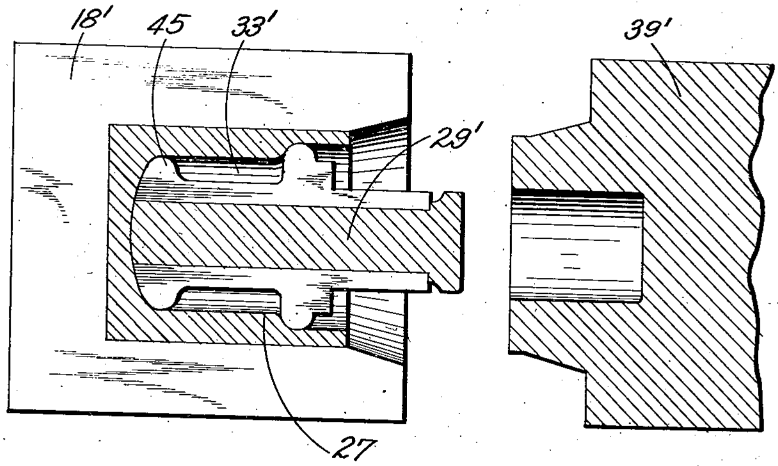

Fig. 12

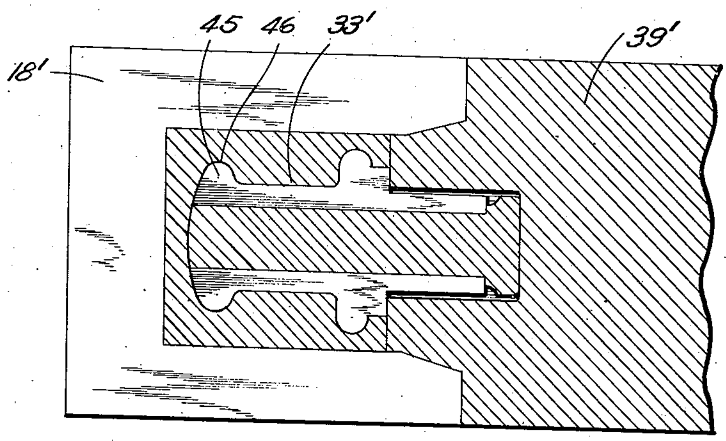

Fig. 13

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UNITED STATES PATENT OFFICE

2,024,285

METHOD OF MAKING PISTONS

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Application March 18, 1931, Serial No. 523,602

8 Claims. (Cl. 29—156.5)

This invention relates to metal-working, and particularly to the manufacture of cup shaped articles such as pistons for internal combustion engines.

In the manufacture of internal combustion engine pistons and the like from aluminum and its alloys or similar light metals, it has been customary to cast the articles in permanent molds. The present invention has for its principal object the provision of a process of manufacturing cup shaped articles by working such metals to obtain a new and improved metallic structure and characteristics including tensile strength and elongation.

Another object of this invention is to provide a process of metal working which will permit the successful manufacture of internal combustion engine pistons from aluminum alloys which possess desirable characteristics, but which are difficult to cast in the desired form. Other objects of this invention are to work pistons from aluminum alloys and the like in such a manner as to provide special physical characteristics in the different parts of a piston better adapted to meet the special requirements of such parts; to simplify the manufacture of pistons and reduce the loss from scrap and imperfections; and to provide an upsetting process for making pistons or the like with projecting elements overhanging the interior surface thereof. Other objects will appear from the following detailed description.

In the accompanying drawings:

Fig. 1 is a vertical section through a piston manufactured in accordance with this invention.

Fig. 2 is a similar section at right angles to Fig. 1 after completion of the machining process.

Fig. 3 is an end view of the piston shown in Fig. 2.

Fig. 4 is an elevation of a slug of metal used to make a piston by the present process.

Fig. 5 is a view similar to Fig. 1 of a slightly modified form.

Fig. 6 is a similar view of a further modified form of piston.

Fig. 7 is a view partly in section and partly in elevation of an apparatus for carrying out the present process.

Fig. 8 is a view of the parts shown in Fig. 7 in a different position.

Figs. 9 and 10 are sectional views of apparatus for forming a flange on the piston.

Fig. 11 is an exploded view of the core shown in Figs. 9 and 10.

Figs. 12 and 13 are sectional views of apparatus for forming the piston, shown in Fig. 6.

The improved process consists broadly in flowing metal into the desired form by means of a plunger or the like while the metal is confined externally by a die of any suitable type. The metal may be intially cast into the form of a slug or blank 15 as illustrated in Fig. 4. The outside diameter of the slug 15 is preferably only slightly less than the diameter of the confining die in which the upsetting operation takes place, and a depression or recess 16 may be formed in one end of the slug. If desired, however, the piston may be formed from wrought or forged stock of any suitable shape. The slug may be formed with but a slight depression, or may approximate to any desired degree the final shape of the piston.

If initially cast, the slug 15 is chill cast in a permanent mold from a light metal alloy having ingredients proportioned to form a relatively small quantity of eutectic. The most desirable results are obtained when the slug is cast in accordance with the method claimed in United States Letters Patent to Joseph H. Bamber, No. 1,296,589, March 4, 1919, to produce a structure in which the eutectic forms a network substantially surrounding the excess substance of the alloy, as claimed in said patent and in United States Patent to Bamberg No. 1,296,591, March 4, 1919.

In carrying out the process, the slug 15 or an equivalent piece is placed in the recess 17 formed at the intersection of the two halves 18 and 19 of a divided die. A plunger 20, having a cylindrical tongue 21 formed in accordance with the desired internal contour of the piston, that is of for the piston of Figs. 1, 2 and 4 with oppositely disposed recesses 22 and 23 and a groove 24 in the end face thereof, is then forced into the metal as shown in Fig. 8, causing the metal to flow into the form of the piston 25 as shown in Fig. 5. The cylindrical tongue 21 forms a cylindrical shell or skirt 26 on the piston, and the recesses 22 and 23 form piston pin bosses 27 which extend from the head in substantially uniform section. The groove 24 in the end face of the plunger forms a rib 28 on the inner side of the head of the piston.

If desired, the piston 25 in the form shown in Fig. 5 may be machined and used in an engine. In this case the quantity of metal in the slug 15 and the length of the stroke of the plunger 20 will be selected to produce the desired dimensions of the finished piston, with allowances for the final machining operations. Preferably, however, a flange is formed on the open end of the skirt, and when this is to be done, the skirt 26 is made sufficiently longer than the desired finished legnth to provide the necessary metal for the flange.

In making the flange, the piston 25 is retained in the confining dies 18' and 19' and a multi-part core 29 is assembled therein. The dies 18' and 19' as illustrated, differ slightly from the dies 18 and 19, but it is to be understood that a single set of dies may be used for both operations if desired. The core 29, shown in detail in Fig. 11 may be divided in any desired manner but preferably consists of a central member 30, two side members 31, and four corner members 32, all of which fit together to provide an exterior surface conforming to the desired interior surface of the piston. Each of the corner members 32 is formed with a recess 33 to receive the piston pin bosses 27. The central member 30 is provided with a stem 34 terminating in an enlarged head 35, and each of the members 31 and 32 is formed with a shank 36 all of which fit together about the stem 34 and the outer ends of which abut the inner surface of the enlarged head 35 to position the various members 31 and 32 with respect to the central member 30.

Each of the members 31 and 32 is also formed with a shoulder 37 and a groove 38 which, when the core is assembled, combine to form an annular shoulder and an annular groove.

The central member 30 is preferably tapered so that the sides thereof converge toward the end remote from the head 35 to permit loosening of the core members upon the initial withdrawal movement of the central member 30. Each of the side and corner members 31 and 32 is arranged to contact with the interior surface of the piston or with the piston pin bosses only on convergent surfaces, so that the initial lateral movement of each side and corner member will free the same from all contacting surfaces of the piston.

After the core is in place, a plunger 39 is forced against the end of the piston skirt 26 to upset the same into the annular groove 38 on the core 29. The plunger 39 is formed with a cylindrical recess 40, arranged to receive the head 35 and the combined shanks 36 of the core 29, and with a projecting annulus 41 adapted to enter the recess of the confining die and engage the end of the skirt 26 of the piston and the annular shoulder 37 of the core. In the inward movement of the plunger 39, the annulus 41 engages the end of the skirt 26 and thickens and upsets the metal into the groove 38 as shown in Fig. 10 to form an inwardly extending annular flange 43. The annulus 41 then engages the shoulder 37, and simultaneously the bottom wall 42 of the recess 40 engages the head 35.

The plunger 39 is then withdrawn and the completed piston is freed from the core and die. To accomplish this, the locking device holding the die sections 18' and 19' together may be first eased off so as to relieve a part of the pressure existing between the core and die. The central core member 30 is then preferably withdrawn longitudinally or axially from the piston, this operation being facilitated by the tapered construction thereof whereby the initial movement of the member 30 relieves the remaining pressure between the core and die and frees the core members from each other. Each of the side members 31 is then moved laterally radially of the piston into the central cleared space formed by the removal of the member 30 until the recess 38 clears the flange 43 which has been formed on the piston, and is then withdrawn longitudinally or axially from the piston. Each of the corner members 32 is then moved away from the piston walls and from the piston pin bosses by a combined pivoting and sliding movement so that all the surfaces thereof simultaneously move out of contact with the piston walls, and is then withdrawn from the piston. The lateral movement of each of the side and corner members is facilitated by the arrangement of the surfaces thereof which contact with the piston walls, the divergent relation of such surfaces permitting freeing of the core members upon the initial movement thereof. For this purpose the inner surfaces of the piston head and of the flange 43 diverge inwardly, as shown in the drawings.

After the core members have been removed the die sections 18' and 19' are separated and the piston is removed therefrom. The piston then has the form shown in Figs. 1, 2 and 3 with an inwardly directed flange 43 at the open end of the skirt. While this flange is illustrated as being circumferentially complete and located at the extreme end of the skirt, it is to be understood that it may, if desired, be divided or made in any suitable length and may be located any convenient distance from the extreme end of the skirt. The piston is then ready for the final machining operations, during which the ring grooves 44 are cut in the head.

During separation of the core members and die sections from the piston any freezing or sticking due to cooling and contraction of the piston when the flanging operation is performed on a heated article or due to the pressure applied by the plunger may be readily relieved with little or no danger of breaking or injuring the piston, since the worked piston structure possesses a considerably higher tensile strength than a casting. This permits the application of greater force to the core members to separate them from the piston and reduces the skill and care required in manufacture, in addition to reducing to a minimum the loss from broken or damaged articles. Furthermore, when the piston is heated before flanging, less pressure is developed against the core by shrinkage of the pistons than is the case in casting, since the initial temperature of the metal is below the freezing or solidification point and the fall in temperature during the upsetting operations may be maintained at a minimum.

If desired, the piston pin bosses may be partially separated from the head in order to reduce the weight of the piston slightly. In this case, the initial upsetting operation illustrated in Figs. 7 and 8, is carried out with a slightly smaller quantity of metal, and the bosses 27 are made relatively short, as shown in Fig. 12. The piston is then placed in the confining die 18' and 19' and a core 29' assembled therein. This core 29' differs from the core 29 previously described in that the recesses 33' to receive the bosses are formed with outwardly extending projections 45 at the bottom to form spaces 46 in the piston between the bosses and the head. The plunger 39 is then forced into the die, and the metal is caused to flow into the boss cavities 33', as illustrated in Fig. 13. The resulting piston, illustrated in Fig. 6, differs from that previously described and shown in Figs. 1, 2, and 3 in that the bosses 27' are partially separated from the head by the spaces 46. It will be evident that the bosses may be formed in this manner either with or without upsetting the flange 43 on the open end of the skirt.

The core 29' is preferably divided into seven parts, corresponding to the parts of the core 29 previously described, in order to form a flange 43. However, when this type of boss is formed without the flange it is unnecessary to divide the core into such a large number of parts, and any suitable arrangement which will permit removal of the core may be employed. Preferably the inner surface of the head of the piston, in this embodiment of the invention, is made slightly concave in order to provide greater divergence between the inner surfaces of the head and the flange and permit the removal of the core members directly away from the bosses.

All of the foregoing upsetting operations may be carried out with the metal heated to a temperature of from about 800 degrees F. to about 960 degrees F. with most aluminum alloys, or any temperature between the ordinary forging temperature and the melting point of the most fusible eutectic in the alloys comprehended by this disclosure. The ordinary forging temperature is usually the highest temperature which can be safely used without danger of breaking up the object being forged. Since the upsetting operations disclosed herein take place in a confining die, there is little danger of breaking up the metal, and higher temperatures may be used. The wide range of permissible temperatures obviates the necessity of close control of the preliminary heating of the metal. Preferably, however, the flanging operation is performed while the piston is cold, avoiding the expense and loss of time involved in maintaining a high temperature, and also avoiding the shrinkage against the core resulting from any temperature drop during the operation. Under certain conditions, the initial upsetting step may also be carried out with a cold slug, avoiding shrinkage from cooling of the metal and producing a finer grained structure due to the cold working of the metal.

The foregoing operations upset or extrude a piston skirt from a cast or wrought slug, the head portion of the completed piston in the former event being worked or upset but slightly, or not at all. If made from a cast slug the head portion therefore retains the characteristics of a casting including a fine, granular structure free from porosity and a network of eutectic substantially surrounded by the excess substance of the alloy. The skirt portion, however, assumes the characteristics of a worked structure, the grains of metal being deformed and compressed into closer proximity to each other and the network of eutectic being almost entirely broken up by reason of the flowing of the metal. The skirt portion therefore consists of a finer, closer grained structure than the head portion and possesses much greater tensile strength and less susceptibility to fatigue and fracture than a cast structure.

After the pistons have been completed, but preferably before the final machining, they may be subjected to heat treatment in the usual manner to improve the physical qualities of the metal. Preferably the heat treatment consists of heating the articles to about 960 degrees F. for at least two hours followed by quenching and reheating at about 340 degrees F. for eight to twelve hours. During the high temperature treatment many constituents which may cause brittleness of the alloy are substantially dissolved in the body thereof, allowing the metal to attain its maximum hardness, tensile strength, and elongation.

During the heat treatment grain growth tends to occur where any substantial contrast in the sizes of adjacent grains exists. In the present process however, the initial upsetting step refines the grain of the metal substantially uniformly throughout the worked portion, any variation being in the nature of a uniform progressive decrease in grain size from the head toward the open end of the skirt. Accordingly, no material grain size contrast exists in the completed articles, avoiding excessive grain growth during heat treatment.

A distinct advantage of the present process is its adaptability for use with aluminum, magnesium and other light metals and alloys which are difficult to cast successfully in contiguous thick and thin sections without the formation of surface cracks or porosity from internal shrinkage and the like. This is particularly true of high silicon light metal alloys or similar compositions having a relatively high percentage of hardening or expansion-reducing constituents which may be cast in substantially uniform sections, such as the slugs or billets from which pistons are formed by the present process, without difficulty and without the formation of porosity or surface cracks, but which are difficult to cast successfully in contiguous thick and thin sections such as are necessarily present when pistons and the like are cast to final form in a mold. When worked according to the present process, pistons having extremely desirable physical characteristics may be conveniently manufactured from such alloys without material scrap loss and with but negligible loss from imperfections.

The pistons produced by the present process are disclosed and claimed in my co-pending application, Serial No. 525,277 filed March 25, 1931; and the apparatus disclosed herein is claimed in my co-pending application, Serial No. 523,604 filed March 18, 1931.

Although the foregoing description of illustrative embodiments of my invention is necessarily of a detailed character in order that the invention may be fully disclosed it is to be understood that the specific terminology employed is not to be construed as restrictive or limiting, and it is to be further understood that various modifications may be resorted to without departing from the spirit and scope of the invention as defined in the following claims.

I claim:

1. The process of making cup shaped articles consisting of upsetting metal into the form of a piston having a head and a skirt, and further upsetting a portion thereof to form a projecting element overhanging the interior surface of the article.

2. The process of making pistons comprising upsetting a billet of metal into the form of a piston having a head, skirt and piston pin bosses by means of a plunger while the metal is confined externally and further upsetting a portion of the piston to form a projecting element overhanging the interior surface thereof.

3. The process of making cup shaped articles comprising pressing metal into a cup shape, assembling sectional means therewithin, upsetting the open end of the cup inwardly against the sec-

tional means while the cup is confined externally and removing the sectional means from the cup.

4. The process of making a piston including confining a cup shaped piece externally, assembling sectional means therewithin, and exerting pressure simultaneously on the open end of the piece and on the sectional means to upset the metal inwardly against the means and thereafter removing the sectional means in sections from the piece.

5. The process of making a piston which includes the steps of forming a cup shaped piston from a blank by pressure shaping between internal and external shaping means, removing the internal shaping means from the piston cup, substituting a second internal shaping means in the piston cup and upsetting the end of the piston cup against the second internal shaping means while holding the second internal shaping means in the proper position and thereafter removing the second internal shaping means from the piston cup and the cup from the external shaping means.

6. The process of making a piston which includes the steps of forming a cup shaped piston from a blank by pressure shaping between internal and external shaping means, removing the internal shaping means from the piston cup, substituting a second internal shaping means in the piston cup and upsetting the end of the piston cup against the second internal shaping means and thereafter removing the second internal shaping means from the piston cup and the cup from the external shaping means.

7. The process of making a piston which includes the steps of casting a metal blank, forming a cup shaped piston from the blank by pressure shaping between internal and external shaping means, removing the internal shaping means from the piston cup, substituting a second internal shaping means in the piston cup and upsetting the end of the piston cup against the second internal shaping means while holding the second internal shaping means in the proper position and thereafter removing the second internal shaping means from the piston cup and the cup from the external shaping means.

8. The process of making a piston which includes the steps of casting a metal blank, forming a cup shaped piston from the blank by pressure shaping between internal and external shaping means, removing the internal shaping means from the piston cup, substituting a second internal shaping means in the piston cup and upsetting the end of the piston cup against the second internal shaping means and thereafter removing the second internal shaping means from the piston cup and the cup from the external shaping means.

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