

March 29, 1949.

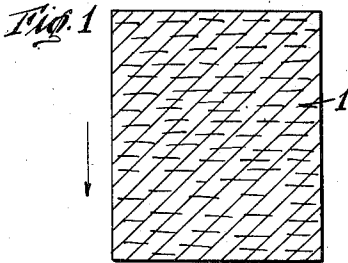
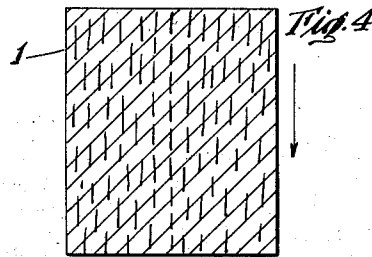
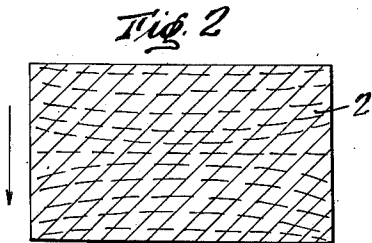
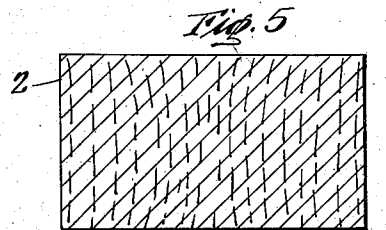
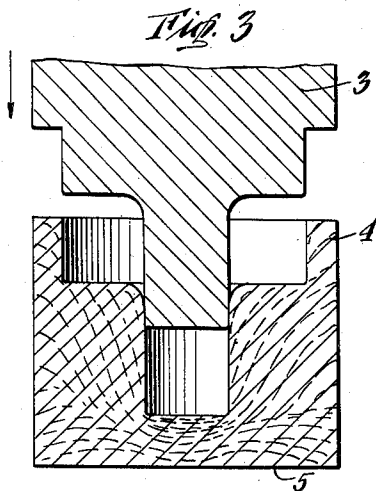
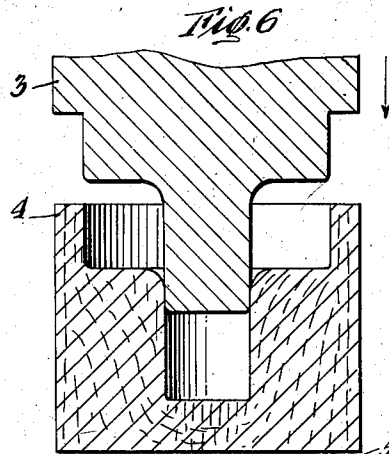
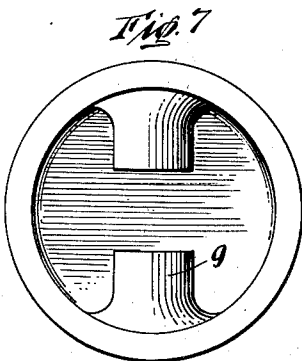
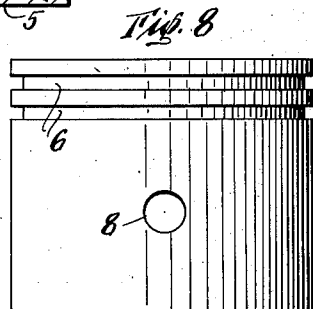
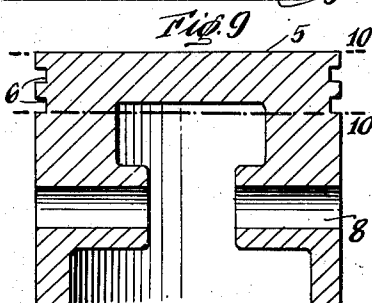
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PISTON

Filed July 28, 1944

2 Sheets-Sheet 1



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PISTON

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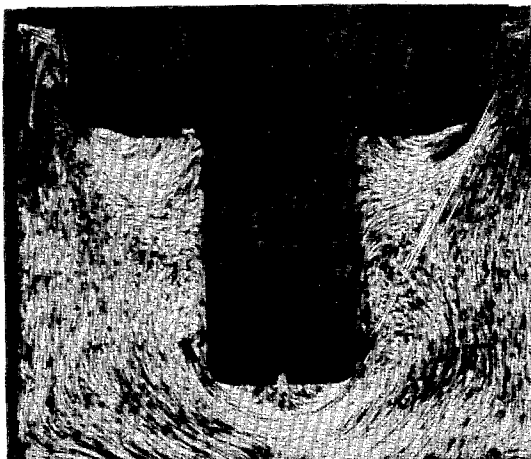


Fig. 10

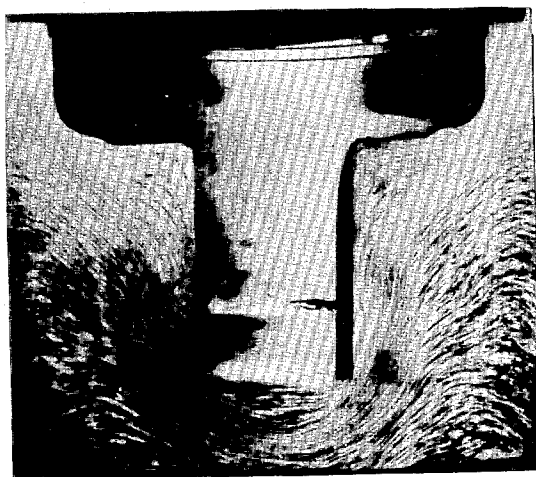


Fig. 11

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PISTON

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1 Claim. (Cl. 309-4)

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This invention relates to improved methods of manufacturing metal pistons such as are used in internal combustion engines and to a metal piston of improved quality.

Two general methods are used in the art for the manufacture of the familiar hollow or cup shaped piston blank which constitutes the body of the piston and from which the final piston is shaped by machining and similar operations. One of these is the casting method in which molten metal is cast into a mold and solidified in the form of the desired piston blank. In recent years the other method, a working method, has had wide use, particularly in the manufacture of pistons to be used in motors for aircraft. In this working method a piece or block of metal of suitable size is subjected to the application of compressive forces to form a piston blank. The block of metal to be so shaped is cut from a rolled bar or slab. The application of compressive forces to this block is usually called forging, and this term will suffice to describe this general working method or operation by which the block is shaped into a piston blank. The invention, its objects and advantages are most conveniently described with reference to the attached drawings, in which:

Figs. 1, 2 and 3 show, diagrammatically, the working of a piston blank in accordance with this invention; Fig. 1 shows, in cross section, the block of metal oriented for presentation to the working forces; Fig. 2 illustrates, in cross section, the block after the first stage of working; Fig. 3 shows, in cross section, the piston blank resulting from the forging;

Figs. 4, 5 and 6 show, in cross section, the steps illustrated in Figs. 1 to 3, inclusive, as those steps were practiced prior to this invention;

Fig. 7 is a plan view looking downwardly into the cup shaped article illustrated in either Fig. 3 or Fig. 6;

Fig. 8 represents a conventional piston shape machined or otherwise shaped from the blanks shown in Fig. 3 and Fig. 6;

Fig. 9 is a cross sectional elevation of the piston shown in Fig. 8, said section being taken through the wrist pin bosses 8;

Fig. 10 is a cross sectional elevation through a piston blank forged in accordance with previous practice and shows the lines of grain flow in said blank;

Fig. 11 is a similar cross sectional view taken through a piston blank made in accordance with the present invention and illustrating a typical grain flow line structure such as results from the practice of the new methods herein described.

As is well known, when metal is worked, by rolling, extrusion or by similar methods, from a cast ingot into the form of bar, slab or the like, the grains of the metal are established along

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lines of flow which are oriented in the direction of working. Where the metal also contains inclusions or is an alloy having more than one solid phase (and particularly an alloy having an undissolved solid phase in minor amount) the inclusions and the undissolved solid phases also tend to elongate in the direction of the elongation or working of the metal. In any event, all metal worked to slab or bar by such fabrication operations exhibits these flow lines or fibres, which lines are sometimes sufficiently marked to be visible to the eye and sometimes must be made visible by etching and by the use of the microscope.

In the previous practice of forging piston blanks from pieces or blocks of metal cut from rolled slab or bar, it has been customary to orient the block of metal to be forged with respect to the compressing action of the deforming or forging force so that the lines of grain flow in the block lie initially in the general direction of, i. e. are substantially parallel to, the direction of the compression action of the deforming force.

The prior practice is illustrated in Figures 4, 5 and 6. Referring to those figures, the metal block 1 shown in Fig. 4 has been cut from a previously worked bar or slab and has been so oriented that the flow lines, represented by the broken lines shown on the block, run up and down. The first step in treating this block is to subject it to an upsetting operation in which forces are applied in the direction of the arrow (shown alongside of Fig. 4) to compress and widen the block to a shape such as shown in Fig. 5. After this compression operation the flow lines as illustrated in the compressed shape 2 shown in Fig. 5 are still substantially uni-directional in the direction of the application of the compressive forces, as illustrated by the arrow. The compressed block 2 is then further subjected to the action of the forging die 3, the compressive force of said die being again delivered in the general direction of the flow lines indicated on block 2 in Fig. 5.

Fig. 6 schematically illustrates the forging die 3 and a cross section through a piston blank 4 at the moment that the forging operation is completed and the die is being withdrawn. While the number of forging operations which may be necessary to compress the upset block 2, as shown in Fig. 5, to the final piston blank form shown in Fig. 6 may be more than one, these steps are all similar in the sense that the compressive force is applied by the forging die in the direction of the arrow shown in Fig. 6 and, thus, in the direction of the flow lines in block 1 as that block was initially subjected to the forging operations. While the piston blank resulting from these operations shows flow lines which are no longer uni-

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directional, as said lines originally appeared in the block 1 which was submitted to the operation, the flow lines in the piston blank still have the general directional property of the flow lines in the original metal block, as shown by the broken lines in Fig. 6 with the result that many of the flow lines terminate in the head surface 5 of the piston blank.

After the piston blank has been completed, it is then subjected to the usual operations to produce the final form of piston shown in Figs. 8 and 9, that is to say, by machining operations the ring grooves or lands 6 are formed in the piston. The piston is likewise given its exact dimensional shape circumferentially, and holes 8 to receive the wrist pin are formed in the thickened portions 9 of the piston blank. See Fig. 7.

The operation just described is a familiar one well known in the art.

The object of the present invention is to improve upon this process of working to the end that a piston of greater strength and sounder physical characteristics may be produced. A further object of the invention is the provision of a piston having a piston head which is stronger and better adapted to receive the forces imparted to it during its operation in an internal combustion engine.

By the head of the piston I mean to designate that portion of the piston which is generally included between the parallel planes indicated at 10 by dotted lines in Fig. 9. This head portion includes, therefore, the surface which is presented to the action of the explosive forces in the cylinder of an internal combustion engine and also the ring grooves 6 which hold the piston ring, and by the use of the word "head" I mean to distinguish from the remainder, or skirt, of the piston.

In the practice of the present invention the same steps are followed as are above described as general practice in the art, with the improvement that the metal block 1 presented to the operation is so cut from the previously worked metal stock, be it rod, bar or slab, that the lines of grain flow in the block are presented transversely of the direction in which the compressive force of the deformation operation is to be applied, this direction being indicated in Figs. 1, 2 and 3 by arrows. I will now refer to Figs. 1, 2 and 3, which schematically illustrate the practice of the methods of this invention. It will be noted on comparison of Figs. 1 and 2, in which the broken lines represent the lines of grain flow, that in the block 2 (Fig. 2) those lines after the first working step are still transverse to the direction of working. In the step or steps which follow in which the block is finally worked by the forging die 3 into the shape generally indicated at 4 in Fig. 3 (and this shape may be developed by one or by a multiplicity of applications of the forging die without variance in the general result), the grain flow lines become distorted but in the final shape they still reflect their original transverse direction in the following manner:

The lines of grain flow remain generally transverse to the vertical axis of the piston shape 4 in the sense that they pass across the vertical axis;

Most of the lines of grain flow terminate, or start, at points on the circumference of the piston shape and only a portion of them terminate in the head surface 5 of the piston shape; and

The structure has a minority of grain flow lines

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disposed in a direction generally parallel to the piston axis.

It will, of course, be recognized that the original transverse lines of grain flow are bent by the compressive action of the forging die. Many of the lines, and particularly those which originally lay entirely in that portion of blocks 1 and 2 that now forms the skirt and wrist pin bosses of the piston blank, run somewhat in the direction of the vertical axis of the piston through a part of their travel. However, in the head portion of the piston blank the lines, while many are somewhat distorted, still travel generally transverse of the piston's vertical axis. The structure resulting from my improved method is, however, as compared with the structure resulting from methods previously employed, characteristic, as will be seen by a comparison of the flow lines as indicated in Figs. 3 and 6.

The method of this invention, which comprises subjecting a piece or block of previously worked metal having unidirectional lines of grain flow to the compressive action of a deforming force in such a manner that the grain flow lines are initially perpendicular to the compressive action, results, therefore, in a piston blank from which may be formed, by machining and other operations, a final piston having a head portion characterized by grain flow lines which terminate at points on the circumference of the piston and are disposed in a direction generally transverse to the piston's vertical axis. It is further characteristic of this piston that its head portion is devoid of flow lines disposed in a direction generally parallel to said axis.

The advantages of such a piston lie in improved performance in an internal combustion engine under the conditions of stress to which the piston is there subjected. My improved piston is not as prone to mechanical failure as were prior worked pistons although such tests as have been made do not indicate any great improvement in the actual tensile strength or hardness of the metal therein, the advantages appearing to stem from the relation of the lines of grain flow to the forces exerted upon the piston when it reciprocates in the motor cylinder. The head of the piston is subject to plastic deformation during its performance in a motor and pistons embodying this invention have increased ability to undergo such deformation without damage.

What has been schematically shown in Figs. 1 to 6 inclusive, by way of illustration of the piston of this invention and its novel characteristics, as compared to other forged pistons, is likewise illustrated by a comparison of Figs. 10 and 11 which are views of cross sections made through actual piston blanks, the surface of each section having been etched to bring out the detail of the flow lines. Fig. 10 is a section of a piston blank made by the prior forging processes (illustrated in Figs. 4 to 6 inclusive). Fig. 11 is a cross section of a piston blank made in accordance with the principles of this invention. It will be noted that the characteristics above discussed are clearly evident in the piston blank of Fig. 11 while in Fig. 10 the lines of grain flow do not terminate or rise at the circumference of the piston blank and are generally parallel to the vertical axis of said blank.

I claim:

A forged metal, hollow piston having a head portion and a skirt portion, the head portion including a surface arranged to be presented to the action of explosive forces operating within an

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engine, said head portion being composed of metal in which the majority of the lines of grain flow are generally transverse to the vertical axis of the piston and terminate at points on the circumference of the piston.

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