Jan. 17, 1950 A. C. DUNN 2,494,935

METHOD OF FORGING

Original Filed April 21, 1941

Fig. 1

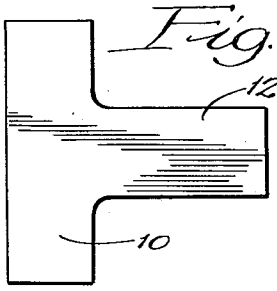


Fig. 2

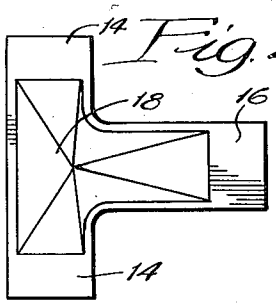


Fig. 3

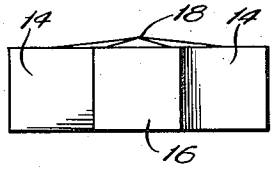


Fig. 4

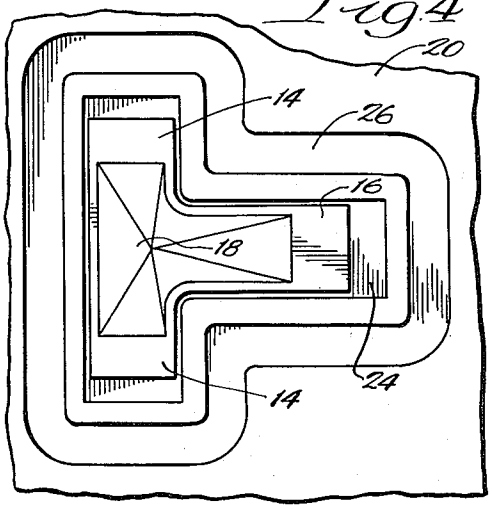


Fig. 5

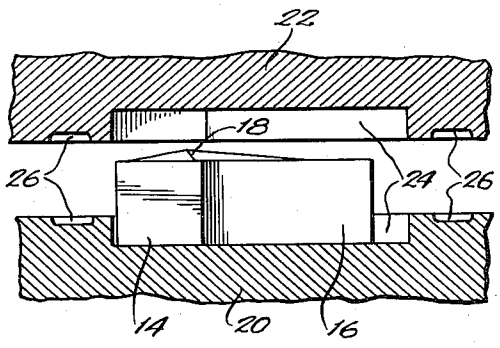
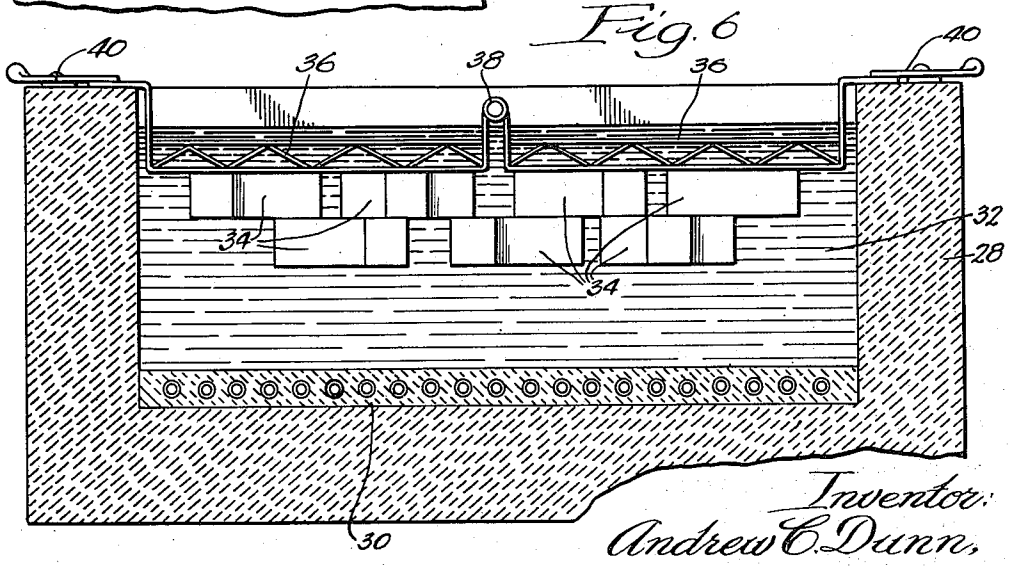


Fig. 6



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UNITED STATES PATENT OFFICE

2,494,935

METHOD OF FORGING

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Continuation of application Serial No. 389,540, April 21, 1941. This application March 4, 1947, Serial No. 732,223

6 Claims. (Cl. 78—81)

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This invention relates to forging and more particularly to the forging of high strength pieces from alloys of metals.

It has been the practice heretofore in forging to utilize rolled or extruded bar or rod stock, which is forged into the final shape either directly from the rod or bar, or from pieces cut from a rod or bar. Such stock is expensive and it is necessary, generally, to subject it to several forging operations in order to flow the metal sufficiently to produce the desired shape. A large number of forging operations not only requires more expensive dies but also causes a greater upkeep.

In the present practice of forging from bars or rods, when the bars or rods are rolled or extruded there is a work hardening or work strain that takes place throughout the stock that is not relieved in bringing the material up to a forging temperature. There is also an age hardening which occurs when the rods or bars are stored. This age hardening causes the disintegration or separation of some of the alloys, causing an imperfect bar or rod, and therefore an imperfect forging.

One of the objects of this invention is to provide metal for forging which is free from work hardening or age strains, producing a stronger, harder, and more durable forging.

It is another object of the present invention to provide a forging method in which high strength forgings can be produced by a single forging operation, thus saving wear on the dies and materially increasing the productivity of the forging or pressing equipment.

Another object of the invention is to provide a forging method wherein stock can be used which has not been previously rolled or extruded, thereby saving the cost of said rolling or extruding.

Another object of the invention is to provide a forging method in which a predetermined grain structure of the metal can be obtained in the finished piece, so as to provide maximum strength where needed.

Still another object of the invention is to provide a forging method in which the metal can be flowed more readily to fill the die and to reduce the probability of causing cracks.

Yet another object of the invention is to provide a forging method in which the metal will forge easier at forging temperatures and permit the forging at lower temperatures than is possible under the known methods, to attain more satisfactory results. Reduction of the temperature

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tends to increase the density of the metal, thereby providing a harder, tougher, and smoother forging.

According to one method embodying the invention, alloyed metal to be forged is first cast or otherwise formed roughly to a predetermined shape containing a mass of metal slightly in excess of that in the finished forging. According to one important feature of the invention, the casting or rough shape is so shaped as to cause the metal to flow during the forging operation in such a direction as to establish in the finished piece a grain structure following the lines of maximum stress so as to provide predetermined localized maximum strength. This is accomplished in general in the forging shown by making the rough casting or rough shape shorter and thicker than the finished forging, thereby causing the metal to flow in such a way as to set up a longitudinal grain structure. It will be understood that the exact form of the casting or rough shape will depend upon the finished shape of the forging and the loads to be imposed thereon; the grain structure in general being caused to follow the lines of maximum stress.

In other shaped forgings it may be desirous to have added tensile strength crosswise or radial in certain parts. This is accomplished by forming the casting or rough shape so as to flow the metal in the directions of the predetermined tensile requirements.

The castings may be made by any known method, but preferably in permanent molds. When the metal is poured it is allowed to cool to a temperature at which it will set. Such a temperature is below the melting point of the metal, but is above the normal forging temperature of that particular metal, and in the case of alloy, is so selected as to lie above the solubility temperature of the alloy. For example, in the case of aluminum alloys, the casting is cooled to a temperature of about 1000° to 1100° F.

When the temperature of the alloyed metal is above the solubility temperature, all the constituents are in solution, and if the metal is then cooled down only to the forging temperature, a very slight, if any, change takes place by age hardening or precipitation, thereby leaving the metal much easier to deform at normal forging or below normal forging temperatures, as the metal is in a soft, plastic condition.

After the casting is cooled to this temperature it is placed in a liquid bath, as for example, a lead bath, maintained at the desired forging temperature. In cases of metals to which the cool-

ing solution employed in the bath might adhere, particularly as when a metal bath is used, the castings are preferably first either oxidized or smoked to prevent adherence of the bath solution thereto. This can be accomplished by exposing the castings to a smoking oil flame or the like for a short period.

The castings may be maintained in the bath until such time as they are ready to be forged, and may then be forged in the usual manner in a single cavity die instead of in a multiple step die. As before pointed out, the forging is carried on in such a way as to cause the metal to flow in the general direction of maximum stress. Due to the heat treating operation by which the castings are maintained at an elevated temperature until the time of forging, and are not allowed to cool to room temperature prior to forging, I have found that the forging may be carried out at a temperature lower than that normally employed.

Where it is not practical to maintain the castings heated until they are ready to be forged, as for example, where the casting is done in one building and the forging in another at some distance thereto, the castings may be allowed to cool to room temperature. In the case of certain alloys, and particularly various brass and aluminum alloys, age hardening occurs when the temperature is allowed to fall. Such alloys, after remaining relatively cool for even a short period of time, increase considerably in hardness and are difficult to deform.

According to the present invention, in such cases the castings are reheated to a temperature lying in the range above the solubility curve of the alloy, so as to bring all constituents of the alloy back into solid solution and to soften the casting. In the case of aluminum alloys, I have found that a temperature in the range between 1000° and 1100° F. is satisfactory.

The heated castings are then placed in the cooling bath as described above, to bring their temperature down to the desired forging temperature, and may then be forged. According to this method the castings will forge as readily as in the case where they are forged directly after casting without being allowed to cool below forging temperature.

The reheating may be performed, if desired, in a liquid bath which is raised to the relatively high temperature and then allowed to cool slowly.

Reheating of the castings may also be preferred in some cases where it would be possible to maintain the castings heated to improve the grain structure. Most aluminum alloys and brasses may be given a finer grain structure by quenching, and with materials of this type it may be preferred to quench the castings and to reheat them prior to forging, as described.

Instead of using castings formed in the usual manner by pouring molten metal into molds, I have found that highly satisfactory results can be obtained by utilizing powdered metals. Mixtures of metal powders, when heat treated as explained above, are found to alloy and to produce highly satisfactory forgings.

In carrying out the invention with powdered metals, powders of different metals are mixed in the necessary proportions to form any desired alloy and are compressed to the form of the rough casting as described. The metal powders may be mixed hot or may be heated after molding, but in any event, are raised to a temperature above the solubility temperature of the

final alloy and are maintained at this temperature a length of time sufficient to allow the metals to go into solid solution, the time required varying with the particular metals and proportions employed. Thereafter, the metal is cooled to the desired forging temperature and is forged. It will be understood that by the term "rough casting" as employed herein, it is intended to mean a casting formed by pouring molten metal into a mold or by compressing mixtures of powdered metals.

The accompanying drawings illustrate the formation of one type of piece according to the invention.

In the drawings:

Figure 1 is a plan view of a finished forging;

Fig. 2 is a plan view of a casting from which the forging of Fig. 1 is made;

Fig. 3 is an end elevation of the casting of Fig. 2;

Fig. 4 is a plan view of a forging die with the casting placed therein;

Fig. 5 is a vertical section through the die of Fig. 4 with the casting shown in elevation; and

Fig. 6 is a diagrammatic section of a cooling bath.

The piece selected for illustration in Fig. 1 comprises a generally key shaped member of rectangular section having a cross bar 10 and a projecting arm 12. Such a piece might be used in a number of environments, but the loading thereon, as for example when used as a cantilever or a ball crank lever, will cause the maximum stress lines to follow in general the outline of the piece.

It will be understood that the key shaped member of Fig. 1 is constituted by a body portion which is formed at the juncture of the parts 10 and 12. Such body portion is provided with end portions at opposite ends of the part 10 and 1 is also provided with an end portion 12, all of these forming a plurality of projections. It will be understood of course that the body portion may be smaller, equal in size to, or larger than any or all of the projections.

The piece of Fig. 1 is forged from a casting, as shown in Fig. 2, which is of the same general outline, including a cross bar 14 and an arm 16 projecting therefrom. It will be noted by comparing the two figures that the width of the arm and cross bar of the casting are only slightly less than the corresponding dimensions of the finished forging, but that the lengths are substantially less in the casting than in the forging. Thus, during the forging operation, the metal is caused to flow lengthwise of both the cross bar and the arm, so as to establish a grain structure following, in general, the outlines of the forging.

In order to insure that the metal will flow as desired, the casting may be formed on one or both surfaces with a raised portion 18. As will be seen by reference to Figures 2, 3, and 5, this raised portion is of pyramidal shape and extends partially along the cross bar and the arm. Thus, during the forging operation metal will flow from the high part of the raised portion, both along the cross bar and along the arm, so as to establish the desired lines of grain structure.

The casting is forged in much the usual manner, in a single die having a lower part 20 and an upper part 22. Both parts are formed with a cavity 24 corresponding in outline to the shape of the finished forging, and each of a depth substantially one-half the desired thickness of the forging. Surrounding the cavity in each of the

die members, and spaced therefrom a relatively short distance, as for example from one-fourth to three-fourths of an inch, is an open channel or groove 26.

In forging, the heated casting or rough shape is placed in the lower die and the upper die is dropped or pressed against it to flow the metal outwardly, as described above, to fill the cavity in the die. The casting or shape provides a slight excess of metal, which is forced out between the two dies in the form of flash. The channels 26 provide a space to receive excess metal, so that regardless of slight variations in the mass of metal in the castings or shapes, the width of flash resisting closing of the die will always be the same. By this construction, and due to the fact that a relatively narrow flash pressure is formed, the die may close more completely, and greater uniformity may be obtained between different pieces with the same applied pressure.

It will be readily understood from the above that during the forging operation, the metal of the casting or rough shape is first caused to flow and to fill the cavity in the die. Thereafter, because of the excess thickness of the shape, the excess metal forms the flash between the two dies which acts as a check valve on the metal in the dies. Thus, further application of the forging pressure causes the metal to fill all of the intricacies of the dies and imparts to the finished forging, exceedingly close dimensions with the same smooth surfaces as those of the dies.

A liquid bath for treating the castings prior to forging is illustrated diagrammatically in Fig. 6, and includes a tank 28 having a heating unit 30 mounted therein and adapted to contain a body of liquid, indicated at 32. The liquid employed may be lead or high gravity oil or the like, which will withstand a relatively high temperature, and which will be inert when exposed to the castings. A series of castings, as indicated at 34, may be placed in the bath and may be held submerged therein by trays 36 pivoted at 38, and held below the surface of the bath by latches 40. When it is desired to remove a casting from the bath for forging, one of the trays may be released and the casting may be removed by suitable tongs.

According to the present invention, the amount of flow of the metal during the forging operation may be limited to any desired extent and to any desired direction. Thus the present invention makes possible and easy the formation of forgings which have heretofore been considered either impossible or extremely difficult.

While the method of the present invention has been described with considerable particularity, it will be understood that the same may be employed for forging finished articles from metal shapes irrespective of the manner in which such shapes may be made. For example the shapes may be cast, machined or cut off from rolled, or extruded parts, or otherwise formed in any manner well known in the art. It will be also understood that the scope of the invention is not limited in any manner other than by the terms of the appended claims.

This application is a continuation of my application Serial No. 389,540, filed April 21, 1941, for Forging method, and now abandoned.

What is claimed is:

1. A process of forging an article having a body portion provided with end portions constituting a plurality of projections, comprising providing a blank in which the body portion and projections

are of substantially final dimensions between opposite sides and of greater dimensions between opposite sides at right angles to said first sides, confining said blank at said first mentioned sides against substantial expansion, subjecting said second mentioned sides to forging pressure to bring them to final dimensions and to flow the excess metal of said body and projections along said projections to elongate the same to final dimensions without substantial flow of metal in the direction between said first mentioned sides.

2. A process according to claim 1 wherein the projections are arranged at an angle to each other.

3. A process of forging an article having a body portion provided with and portions constituting a plurality of projections to obtain a grain structure extending from the body and longitudinally of the projections, comprising providing a blank of substantially the final shape except thicker through one dimension and with shorter projections, substantially confining the blank on all sides except the sides defining the thicker dimension and except at the ends of said projections, and placing said sides defining the the thicker dimension under forging pressure to flow the excess thickness of said body and projections generally longitudinally of said projections to create said grain structure and to bring said body and projections to final shape.

4. A process according to claim 13 wherein the projections are arranged at an angle to each other.

5. A process of forging an article of irregular shape having a body portion provided with end portions constituting a plurality of projections, comprising providing a blank in which the body portion and projections are of substantially the same dimensions between opposite sides as the final dimensions, and are of greater dimensions between opposite sides at right angles to said first sides than the corresponding final dimensions, heating the blank to a forging temperature, placing the blank in a die cavity of a die, the said die cavity having the desired finished shape and final dimensions and with the said first mentioned sides substantially fitting the die cavity, and forging said blank in the die cavity into the desired finished shape and final dimensions with another die provided with a cavity having the desired finished shape and final dimensions to bring said second mentioned opposite sides to final dimensions and to flow the excess metal of said body and projections along said projections to elongate the same to first fill the die cavities and to then form a flash between the two dies to allow the blank to completely fill the intricacies of the die cavities.

6. A process according to claim 5 wherein the projections are arranged at an angle to each other.

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