March 20, 1962 R. S. HAERR 3,025,905

METHOD FOR PRECISION FORMING

Filed Feb. 7, 1957

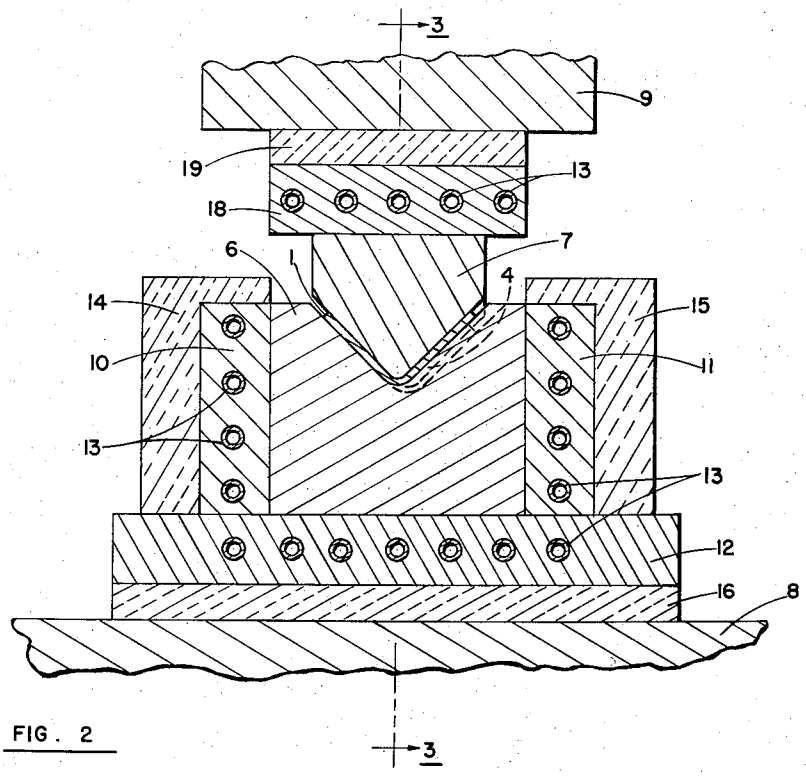


FIG. 2

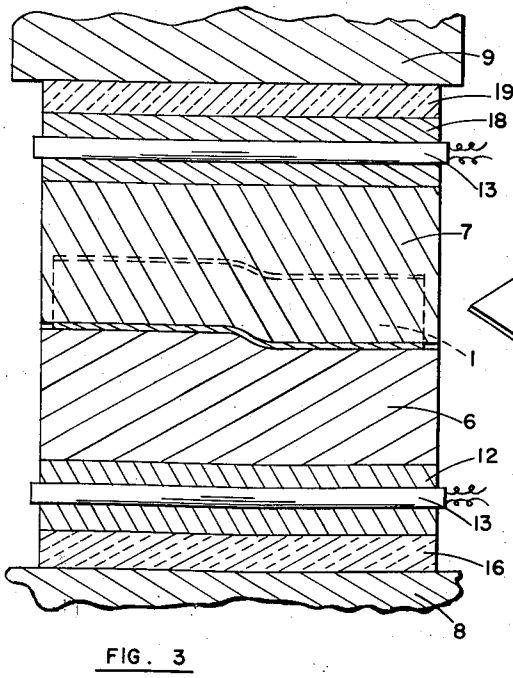


FIG. 3

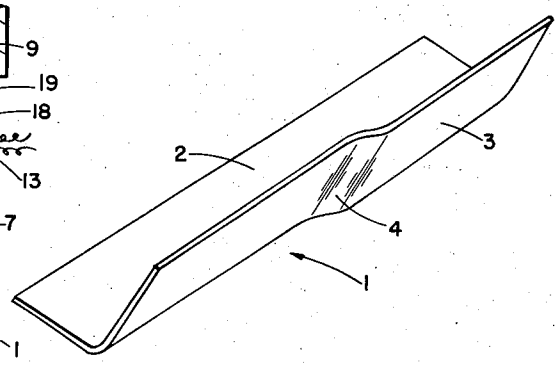


FIG. 1

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3,025,905

Patented Mar. 20, 1962

3,025,905

METHOD FOR PRECISION FORMING

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Filed Feb. 7, 1957, Ser. No. 638,801
3 Claims. (Cl. 153—32)

This invention pertains to metal forming and more particularly to forming accomplished by the application of heat and relatively low forming forces.

It is a basic precept in metal forming that permanent deformatio may be introduced in a workpiece by imposing a force above the yield strength of the material. This induces a permanent strain which causes the part to retain the contour which is given to it. However, in forming titanium many difficulties have been encountered and the results have not been satisfactory. Partially this is due to the nature of this metal, and additionally from the nonuniformity of the material as produced. Titanium alloy has a typical yield strength of around 120,000 p.s.i. which is not far from its typical ultimate strength of 130,000 p.s.i. This means that there is only a relatively narrow range in which this material is formable by conventional means. Beyond this stress range the material will rupture, and below the yield point will not be reached. The nonuniformity of the production material, resulting in varying values for the yield and ultimate strengths, complicates the forming problem. Perhaps even more important is the fact that when forces are imposed upon titanium it acts somewhat differently from more conventional materials and will not readily retain the contour imparted to it even when stressed beyond the elastic limit. Extreme difficulty from springback has been encountered so that it is impossible to impart a precision contour to a titanium workpiece in an ordinary press. Many hours of laborious hand straightening are required which is not only expensive but results in inferior finished parts. In one example where a large number of titanium parts were being produced, fifty hours of hand finishing were required for each hour of press time.

For other metals hand straightening problems are not as severe as with titanium, but hand work is a factor to be contended with wherever precision work is required. The large volume of aluminum parts used in an aircraft, for example, requires many persons engaged in hand straightening to provide the parts with the desired precision shapes. The same is true of other metals used in making finished parts.

According to the provisions of this invention a part may be given an exact precision contour without necessity for hand finishing. This is accomplished by heating the workpiece and simultaneously applying a relatively low forming force which is maintained for a predetermined period of time. After this the part is released and will permanently retain the contour without loss of properties or necessity for hand finishing, although the forming force may have been far below the value required for conventinoal forming.

Therefore it is an object of this invention to provide a means for obtaining precision metal parts. An additional object of this invention is to form parts by imposing relatively low forming forces thereon. A further object of this invention is to form parts to a precision contour so that hand finishing is eliminated and no loss in properties is encountered. Yet another object of this invention is to form parts by a simplified arrangement economical to construct, operate and maintain. These and other objects will become apparent from the following detailed description taken in connection with the accompanying drawing in which

FIG. 1 is a perspective view of a part which may be formed according to the provisions of this invention;

FIG. 2 is a sectional view illustrating a workpiece being formed in a press having heated dies; and

FIG. 3 is a sectional view taken along line 3—3 of FIG. 2.

Part 1 illustrated in FIG. 1 is typical of those which may be formed in accordance with the teaching of this invention. The part is of titanium sheet metal to be given a precision contour. As illustrated it is substantially V-shaped having two sections 2 and 3, the latter including a joggle 4. Forming such a part in a conventional press will result in difficulties from springback and warpage and will not result in a finished article. Particular difficulty is encountered in accurately setting joggle 4. According to the provisions of this invention the part usually is given its approximate shape by conventional forming methods. With this procedure the complete forming takes place in two stages, with the second stage giving the exact precision shape to the workpiece. It is possible, however, to accomplish all of the forming in one operation.

The device of FIGS. 2 and 3 provides a means for following the method of this invention. This may be an adaptation of a conventional punch press which is provided with matching dies 6 and 7 carried on stationary bed 8 and movable ram 9, respectively. These dies should be made to net size defining exactly the contour of the part to be produced. No allowance need be made for springback or other distortion.

Die 6 is maintained at an elevated temperature at all times which may be accomplished by any suitable means such as by heated platens 10, 11 and 12. These platens are located at the sides and the bottom of die 6 and are raised to temperature by means of resistance heating elements 13. This raises the temperature of the entire die assembly to the required value. To assist in reaching and maintaining this temperature insulation sections 14, 15, and 16 are provided around the outside of the platens.

In the embodiment illustrated top die 7 is also heated, this being accomplished by platen 18 insulated at 19. It has been found that heating of the upper die is not necessary in all instances. Sufficient heat may flow to the workpiece from the lower die to maintain the same at the required elevated temperature, as made more clear hereinafter.

In achieving the precision forming of this invention workpiece 1 first is heated throughout to a temperature of around 1000° F. This may be accomplished in any convenient manner with an oven being utilized normally for this purpose. The dies are also raised to a temperature of substantially 1000° F. With the workpiece and dies at this temperature, the workpiece is removed from the oven and quickly transferred to the dies which are closed on the part and forced against same. The forces imposed by the dies in this way will not be such that the workpiece would assume the exact contour of the dies at the instant of engagement. If the workpiece were to be released in the conventional manner it would exhibit springback, warpage or other distortion. However, rather than opening the dies, the workpiece is held under pressure for a period of time prior to release. The time for the pressure dwell may range from only a few seconds to several minutes, but it is generally of from one to three minutes in duration. After this the dies are released and the part is removed. It will be found to have the exact contour of the dies, requiring no further finishing or handwork of any sort.

Although 1000° F. is the temperature usually selected, the range of 700° F. to 1050° F. is operative for forming the parts both for the preheat and the temperature

at which the dies are maintained. For forming titanium it is preferred to use the higher portion of the temperature range, generally at least above 800° F. Actually forming may be successfully accomplished above the 1050° F. limit, but current titanium specifications prohibit heating titanium parts beyond this figure. Forming has been achieved in presses of 50 to 100 tons capacity, given pressures on the workpiece ranging from around 3,000 to 65,000 pounds per square inch, depending upon the size and shape of the part. When the dies and the workpiece are given a higher temperature less time under pressure in the press will be necessary. Similarly, the higher the pressure the lower the time and temperature required. These factors may be weighed to obtain the optimum forming conditions for a particular job. The gauge of the part and the severity of forming to be accomplished will also influence the values selected. Heavier parts which are given relatively sharp bends require longer forming times or higher pressures than thinner parts with little contour. The use of a preheated part assures that forming time in the press is held to a minimum.

It has been found that the procedure just described is applicable also for forming stainless steels. The temperature range for 17–7 stainless steel, for example, is substantially the same as for titanium parts. Again, 1000° F. is regarded as optimum.

It should be borne in mind that the force imparted to the workpiece when it is inserted in the dies would not accomplish the precision forming which results from this invention, without both the elevated temperature and the dwell time at pressure. In other words, the force applied to the part by the press will be insufficient to give it a permanent contour at the time it is closed. It is only a prolonged application of the force at the temperature which results in the complete forming operation.

The exact reason for this phenomenon is not known, but it is believed to involve creep which occurs at a rapid rate at the temperature ranges specified for titanium metal. Creep forming in this manner allows the workpiece to gradually assume the shape of the dies upon continued application of pressure, regardless of the fact that force imparted to the workpiece may be insufficient to exceed the elastic limit thereof at least for the entire portion of the workpiece. Thus as the workpiece is subjected to heat and the forming forces, for a period of time, its internal resisting stresses relax. This permits the forces to give the workpiece a new contour even though these forces may not have exceeded the yield strength of the material at the time of initial engagement. The principle of this invention, therefore, is applicable generally to metal forming and permits forming of high strength materials with a minimum of investment in equipment.

The foregoing detailed description is to be understood as given by way of illustration and example only, the spirit and scope of this invention being limited only by the appended claims.

I claim:

1. The method of precision finish forming without springback to a desired final configuration a substantially preformed part comprising the steps of heating a workpiece to an elevated temperature sufficient to lower the creep resistance thereof; imposing forces on said workpiece such as to urge said workpiece to the desired final configuration, said forces being below the yield strength of the workpiece material at said elevated temperature and being insufficient to cause the workpiece to permanently assume the desired final configuration at the time said forces are imposed; maintaining the workpiece subjected to said forces at said elevated temperature for a period of time sufficient to allow relaxation of internal resisting stresses and cause said workpiece to assume the desired final configuration of a complete part; and then releasing said workpiece whereby the same retains the final configuration imparted thereto.

2. The method of precision finish forming without springback to a desired final configuration a substantially preformed stainless steel part comprising the steps of heating the stainless steel workpiece to the range of from 700° F. to 1050° F.; heating matching dies substantially to the range of from 700° F. to 1050° F.; urging said dies against said workpiece with a force below the yield strength of the stainless steel workpiece at the elevated temperature and which force when initially imposed is insufficient to cause said workpiece permanently to assume the desired final configuration of said dies; and maintaining said workpiece so engaged by said dies while at an elevated temperature for a period of time sufficient to cause relaxation of internal resisting forces in said workpiece so that said workpiece assumes and retains the desired final configuration of said dies.

3. The method of precision finish forming without springback to a desired final configuration a substantially preformed titanium part comprising the steps of heating a titanium workpiece to the range of from 700° F. to 1050° F.; heating matching die means to the range of from 700° F. to 1050° F.; engaging said workpiece by said die means and urging the same against said workpiece with a force below the yield strength of the titanium workpiece at the elevated temperature and with a force insufficient to cause said workpiece to permanently assume the desired final configuration of said die means at the time of such engagement; maintaining said workpiece so engaged by said heated die means for a period of time sufficient to lower the internal resistance thereof so that said die means cause said workpiece to permanently assume the desired final configuration defined thereby; and subsequently releasing and removing said workpiece from said die means.

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