July 24, 1956 R. F. MOORE 2,755,546

METAL TREATMENT

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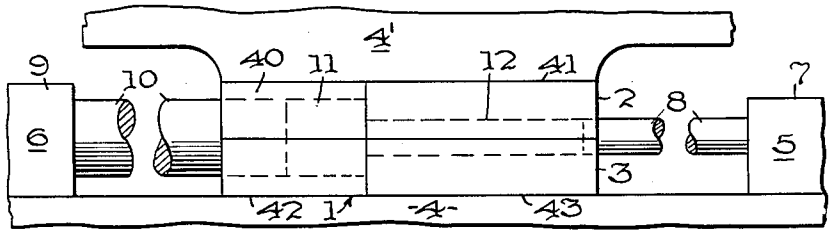


FIG. 1.

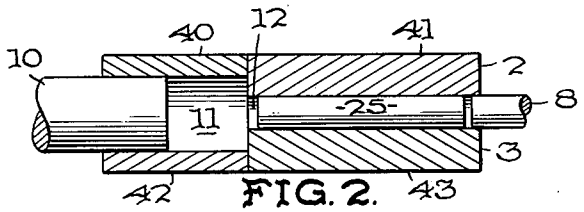


FIG. 2.

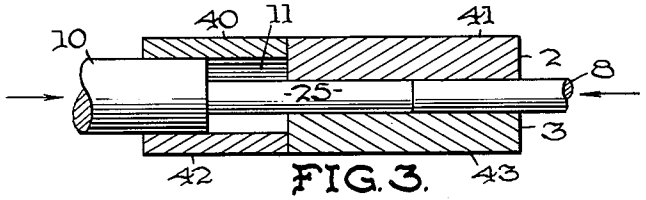


FIG. 3.

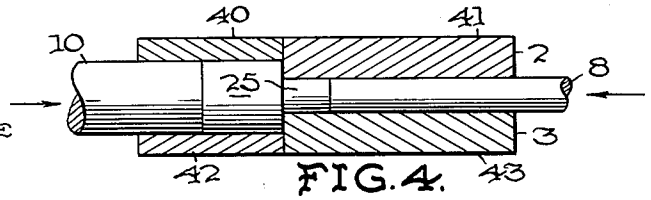


FIG. 4.

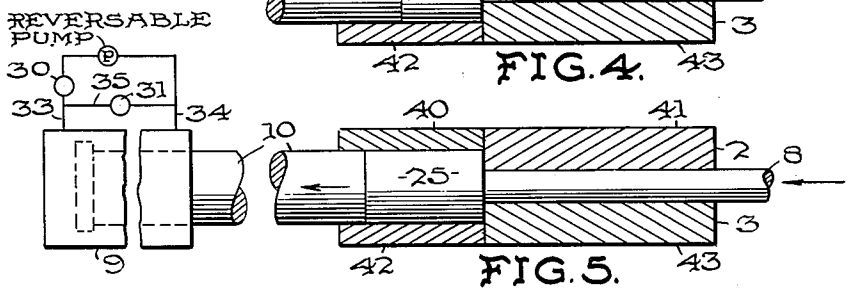


FIG. 5.

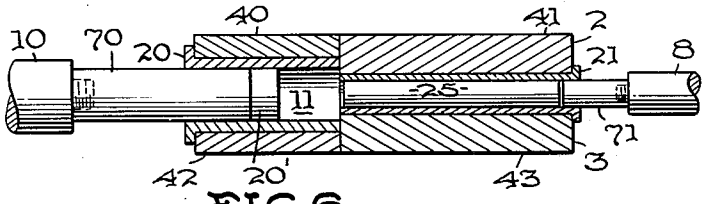


FIG. 6.

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METAL TREATMENT

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2 Claims. (Cl. 29—553)

This invention relates to the working of metal. More particularly the invention relates to a novel method and apparatus for preparing wrought metal stock possessing physical properties of a high order such as are required for forging stock and the like.

Various processes have been proposed for preparing wrought forging stock but none of these processes have been found completely satisfactory from the cost and production standpoint. One conventional practice is to knead or cross-work the metal stock by means of a press or drop hammer, i. e., to exert forging pressure along one axis of the stock, then work the stock back to substantially its original shape and continue repeating this procedure until the physical properties have been raised to the desired extent. Not only is such a process costly from the standpoint of time and man-power consumed, but the end result is a piece of stock material which is substantially the same size as the original stock. In other words, the size or cross-sectional area of the wrought stock is limited by the size of the original stock. In many instances, however, the size of stock generally used (as-cast or hot-rolled) does not have sufficient mass and cross-section for the production of massive forgings as, for example, the aluminum spar caps for aircraft.

It is also conventional practice, in the working of metal, to subject the stock to a relatively small reduction in an extrusion machine, remove the stock from the extrusion chamber and place it in an upsetting chamber where it is upset to approximately the size of the original stock, and repeating this cycle of operations to develop the necessary physical properties in the stock. Such a procedure is time-consuming and normally requires the use of several different machines. The restrictions or limits of end stock size, as discussed above, are also imposed on this process of working stock.

To accomplish the necessary working of metal stock it has also been proposed to merely subject the stock to a plurality of extrusion operations but the primary disadvantage of such a process is that the extruded stock takes the form of an elongated stick-like member which is difficult to work with satisfactorily during the forging operation. Where, for example, the forging blank was disc-shaped, the extruded rod would necessarily have to be upset. With present day apparatus it is impossible to satisfactorily axially upset such a stick-like member where the length is over three times the diameter of the member. If this ratio is exceeded the member will bend and fold back on itself, giving rise to unsatisfactory metal stock due to the tendency for these folds or laps not to be eliminated during subsequent working operations.

The present invention is concerned with providing a novel method and apparatus for working metal stock into the desired wrought condition in one pressure application in place of the plurality of crossworking or kneading or extrusion operations and/or machines conventionally used to provide stock material having physical properties suitable for use as forging stock and the like. Moreover, the invention is concerned with the production of wrought stock of relatively large cross section, suitable for use in the production of massive forgings. The proposed apparatus contemplates the use of one die cavity which is adapted to receive a heated metal blank. One end of this first die cavity is connected with a second die cavity and a separate movable plunger is located in each die cavity. This second die cavity is larger or of greater cross-sectional area, than the first die cavity. For example, the first die cavity might be on the order of 10 inches in diameter while the second die cavity could have a diameter on the order of 30 inches.

In the proposed method the heated metal blank is placed in the first die cavity. Pressure is applied to one end of the blank by a plunger moving in the first die cavity so as to cause the opposite end thereof to be progressively forced into the second chamber or die cavity, where it is upset as the stock is forced against the plunger in the second die cavity as a result of the continuous application of pressure to the other end of the blank by the plunger in the first chamber or die cavity.

It is a primary object of this invention, therefore, to provide a novel method for preparing metal stock for fabricating into articles which overcomes many disadvantages attendant in processes heretofore known.

Another object of this invention is to provide a novel method for transforming elongated metal blanks of varying length into blanks of varying length and cross-sectional area and possessing a wrought structure by means of a single pressure application.

A further object of this invention is to provide a novel method for transforming a conventional as-cast ingot into a wrought ingot characterized by possessing high physical properties and having a cross-section greater than that which can be satisfactorily produced by normal casting practice.

A more specific object of this invention is to provide a novel method for transforming an as-cast or slightly worked blank into wrought condition suitable as forging stock and the like where high physical properties are necessary.

It is another object of this invention to provide a novel apparatus for preparing metal stock for subsequent fabricating operations where high physical properties in the stock are necessary.

A further object of this invention is to provide a novel die apparatus which can be used for preparing various types, shapes and sizes of metal blanks for forging.

Further objects and advantages of this invention will be more readily observed by a reference to the following detailed description when taken in conjunction with the appended drawings, wherein:

Figure 1 is a side elevational view partly broken of one type of apparatus which may be employed in performing the method of the instant invention;

Figure 2 is an elevational sectional view of the die portion of the apparatus of Figure 1, illustrating the position of the die members during the first step of loading the heated blank into the die and thereafter closing the die members.

Figure 3 is an elevational sectional view of the die portion of the apparatus of Figure 1, illustrating the second step of positioning the blank just prior to the commencement of the upsetting operation.

Figure 4 is a view similar to Figure 3 and illustrating the progressive upsetting of the blank.

Figure 5 is a view similar to Figure 4 and illustrating the completion of the upsetting of the blank.

Figure 6 is a sectional view of the die portion of the apparatus and illustrating inserts located in each die cavity.

The apparatus which forms the preferred embodiment

of the invention is generally comprised of a suitable die **1**, formed from a pair of cooperating upper and lower die members **2** and **3**. The lower die member **3** is attached to a press bed **4**, while the upper die member **2** is affixed to a movable platen **4'** of a press capable of exerting sufficient pressure for carrying out the method of the instant invention. Two oppositely disposed hydraulic cylinders **5** and **6** are also located on the bed of the press. Hydraulic cylinder **5** is comprised of a cylinder barrel **7** within which a piston **8** reciprocates. Hydraulic cylinder **6** is comprised of a cylinder barrel **9** within which a piston **10** is adapted to reciprocate. The upper and lower die members **2** and **3** may each be advantageously made of a plurality of elements or sections, namely, die cavity members **40**, **41**, **42**, and **43**. These die members are so formed, that when they are brought together they form a die provided with hollow chamber or die cavity **11** located between die sections **40** and **42** and within which piston **10** is adapted to move and an oppositely disposed chamber or die cavity **12** located between die sections **41** and **43** and within which piston **8** is adapted to reciprocate.

These hollow cylinders or die cavities **11** and **12** in turn are connected together so as to be in open communication with one another. These die cavities preferably conform to the particular configuration necessary to produce the proper ratio of upset for the specific size of metal blank required. It is also contemplated, as indicated in Figure 6, that inserts **20** and **21** and slugs **20'** may be placed in the various die cavities so as to enable the same die to be used for the various sizes or dimensions that might be required in the working of a particular size or dimension of cast blank or ingot, thereby eliminating costly die blocks for each size range required.

As indicated in Figure 2, the first step of the upsetting operation contemplates that the heated cast ingot or blank **25** be placed in its initial position in the hollow die cavity **12**. This is accomplished by raising the movable or upper platen **4'** on the press proper, thereby removing the upper die member **2** as a unit from the lower die member **3**. The ingot or blank **25** is then placed in position in the cavity **12** and the die is closed. Pressure is then applied to the movable platen of the press to keep the die members **2** and **3** securely together. Pressure is next exerted on piston or plunger **8**, which then acts to apply pressure to one end of the blank **25**, thereby causing the other end of the blank to pass into hollow die cavity **11** until it comes into contact with piston or plunger **10**, as indicated in Figure 3.

It has also been found that irrespective of the side of the die cavity **12**, if the initial open or unfilled portion of die cavity **11**, into which the inner end of blank **25** is forced, so that it can then be upset, is of such a size that in length it was over three times the cross-sectional length of the blank, there would be a tendency of bending or folding of the stock rather than upsetting. In other words, although the die cavity would be filled in such a case, there is a tendency for the rod-like stock or blank to bend or fold upon itself and result in an improper flow of metal in the folded portions and also improper grain flow. Accordingly, during the initial upsetting of the blank the piston **10** should be located in die cavity **11** in such a way that the end thereof which contacts the blank is no further from the inner end of die cavity **12** than a distance equal to three times the cross-sectional length of the blank. Thus where the blank is round this distance would then be equal to three times the diameter of the blank, and in the case where a circular heated blank **25** is on the order of 10 inches in diameter, the end of piston **10** initially should not be positioned over 30 inches or 3 diameters of the blank in length away from the inner end of die cavity **12**. The die cavity **11** in this case may be on the order of 30 inches in diameter.

By the proposed process the blank is immediately upset as it leaves die cavity **12** and flows in cavity **11** as indicated by the previously described step. At this time also use is made of the movable piston **10**, which then opens up cavity **11** at a rate of volume change constant with the volumetric rate of blank stock passing per unit time into cavity **11**, which is also formed by the two opposing die members. Thus, the die cavity can then be enlarged to any desired size without the possibility of forming elongated stock, which is so upset in the die cavity that the disadvantages mentioned above will result.

Step 3 of the upsetting operation is indicated in Figure 4, during which continuous pressure is still being exerted on piston **8** thereby causing the 10 inch blank to be upset to 30 inches in diameter against piston **10** in die cavity **11**. Piston **10** has remained stationary in all of the steps up to and including this step after its initial predetermined setting to keep it in the 3 to 1 ratio as set forth above.

Prior to the start of the upsetting operation piston **10** is actuated such as, for example, by the low pressure hydraulic cylinder **6** to advance it to the required position. To cause it to remain stationary up to and including step 3, the inlet valve **30** connected to cylinder **6** by line **33** as indicated in Figure 5, is closed, thereby trapping the fluid in the cylinder. All during step 3 continuous pressure is exerted on piston **8** so as to cause the remainder of the blank to be upset into the 30-inch diameter cavity **11**. However, at the end of step 3 as the initial opening in the cavity becomes filled as determined by the 3 to 1 rule, space must be provided for the additional or remainder of the metal in the blank to be upset. This is accomplished, for example, by the use of a pressure release valve **31** connected to cylinder **6**, by fluid lines **33**, **34**, and **35**, this valve being set or adjusted for each individual size of round ingot or blank to the pressure required to upset the stock to the outside walls of the die cavity **11**. Only when this is accomplished and the pressure is exceeded, will the valve **31** open, allowing fluid to be evacuated from the head end of the cylinder through lines **33**, **35** and into the line **34** leading to the rod end of the cylinder **6** so as to cause the piston **10** to recede, thereby providing room within die cavity **11** for additional stock in a continuous cycle and with a sufficient back pressure being exerted by piston **10** to make upsetting of the remainder of the blank occur to the prescribed diameters or cross-section.

It will be readily seen that by proper selection or control of the relationship between the size and shape of the heated blank and the second die cavity **11**, any desired amount of working to produce wrought stock possessing the appropriate physical properties may be had. Thus, in this process, by the simple expedient of upsetting the blank as it enters the die cavity **11** of a predetermined size and cross-section, the same properties may be given the blank that heretofore required a plurality of cross-working or kneading or extrusion operations.

Although the die cavities **11** and **12** are preferably cylindrical, it is obvious that they can also be of other cross-sectional designs depending upon the results desired. For example, they can be square, rectangular, or of other polygonal cross-section. The shape of the pistons used in the die cavities of course will then be made to conform to the cross-sectional shape of the die cavities.

In a further modification of the invention, as indicated in Figure 6, when depending on the results desired, various types of inserts **20** and/or **21** are used with the apparatus and are placed in the several die cavities **11** and **12**, and piston **10** and/or piston **8** may be advantageously made in sections, which are locked together, so that heads **70** and **71** of the pistons will fit snugly within the inserts **20** and **21**, which may or may not be also made in sec-

tions. In this event the shape of the piston heads will, of course, conform with that of the hollow portions of the various inserts. It is also to be noted that it may be desirable in certain instances to use a head 70 of relatively small cross-section for various sizes of die cavities 11. In such case, suitable punches or pressure plugs 20' can be inserted within the end of the die cavity in front of the head 70 for each operation.

It is also contemplated, within the scope of the invention, that a suitable lubricant such as, for example, graphite and a soluble oil may be used to coat the die cavities 11 and 12 to obviate any tendency toward sticking of the blank or stock within the die cavities and also such an expedient may be beneficial in reducing die wear. In certain instances it also may be desirable to provide die cavity 11 with several fine, spaced holes which would act to allow release of any entrapped air between the stock and the die walls as the blank is being upset outwardly. This will alleviate any tendency for the upset stock to have unfilled areas or cavities on the exterior surface thereof.

As stated previously, under conventional practices used today, the hot or cold forging of the usual as-cast, hot rolled, or extruded stock will not raise the properties sufficiently for the forged articles and it is believed that in the majority of cases it is necessary to have approximately 50% or over of the desired properties in the blank prior to forging in order to give 100% of the desired physical properties after forging. Moreover, limits are imposed on the sizes of ingots which can be satisfactorily cast by present day processes and this accordingly limits the size of wrought blank which can be produced. For example, under present day aluminum casting practice, it is extremely difficult in the case of many alloys to cast sound ingots on the order of 18 inches in diameter or over and even where relatively large ingots can be cast, it has been found extremely difficult to work them such that a wrought structure is developed throughout the ingot. The method and apparatus of the invention, however, will allow the production of wrought stock of relatively large mass and cross-section from metal which cannot be satisfactorily cast or worked in such large sizes. This method has particular application in the production of massive forging stock, suitable for making large aircraft parts.

It is to be noted, that while the proposed process has been disclosed with respect to its use on aluminum alloys, the process of the invention is eminently suited for developing a wrought structure and increasing the mass and cross-section of stock materials of other metals and alloys, either in the as-cast, rolled, extruded or other worked condition.

Accordingly, it will be apparent to those skilled in the art that various modifications may be made in the instant invention without departing from the spirit and scope thereof, and as such, the invention is not to be taken as limited except by the appended claims wherein:

What is claimed is:

1. A method of preparing elongated forging stock of relatively massive cross-section from an elongated as-cast metal blank, comprising the steps of heating the blank, confining said heated blank in an elongated chamber which closely surrounds and supports said blank, subjecting one end of said blank to axial pressure to cause the opposite end thereof to enter an adjoining second chamber of substantially larger cross-section than that of said blank and wherein said opposite end of said blank abuts against a surface of said second chamber, the portion of the blank projecting into said second chamber and being unsupported circumferentially not exceeding an axial length equal to 3 times the greatest transverse dimension of said blank, and continuing said axial pressure application to progressively upset the entire blank into close conformity with said second chamber, whereby said as-cast blank is transformed into sound, worked metal stock possessing high physical properties and wherein such worked stock possesses a cross-sectional size substantially greater than that of the original as-cast blank.

2. A method of preparing elongated forging stock of relatively massive cross-section from an elongated as-cast metal blank, comprising the steps of heating the blank, confining the heated blank in an elongated chamber which closely surrounds and supports said blank, subjecting one end of said blank to axial pressure to cause the opposite end of said blank to enter an adjoining second chamber of substantially larger cross-section than that of said blank and wherein said opposite end of said blank abuts against a surface of said second chamber, the portion of the blank projecting into said second chamber and being unsupported circumferentially not exceeding an axial length equal to 3 times the greatest transverse dimension of said blank, continuing said axial pressure application to progressively upset said blank into close conformity with said chamber and wherein when said chambers has been completely filled with said progressively upset metal the length of said second chamber is progressively extended at a rate commensurate with the volumetric rate at which the remainder of the blank is being upset, and continuing said pressure application until the entire blank has been progressively upset within said second chamber, whereby said as-cast blank is transformed into sound, worked metal stock possessing high physical properties and wherein such worked stock possesses a cross-sectional size substantially greater than that of the original as-cast blank.

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