July 24, 1956 R. F. MOORE 2,755,544

METAL TREATMENT

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FIG. 1.

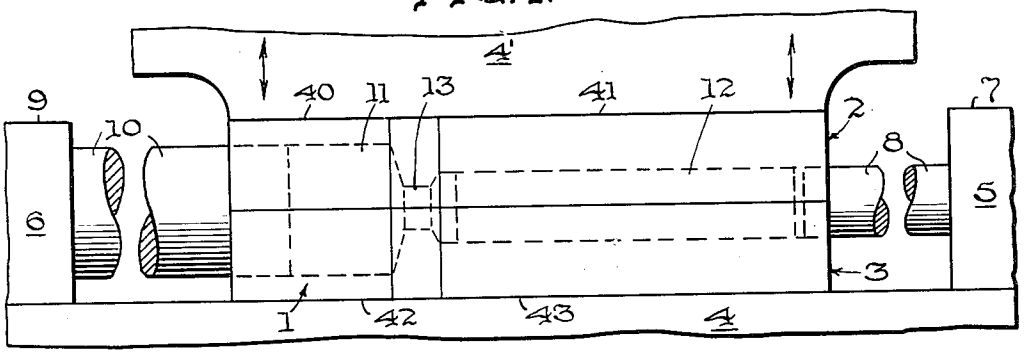


FIG. 2.

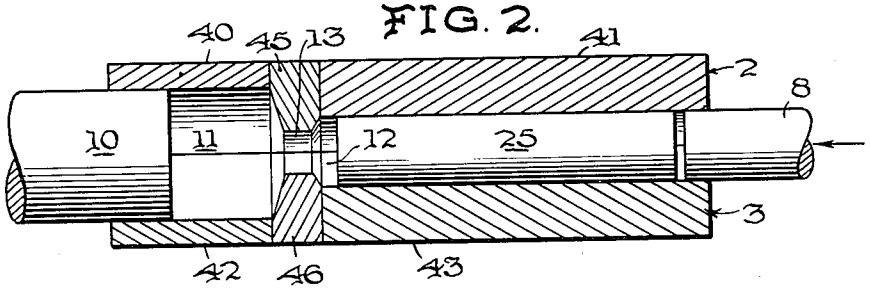


FIG. 3.

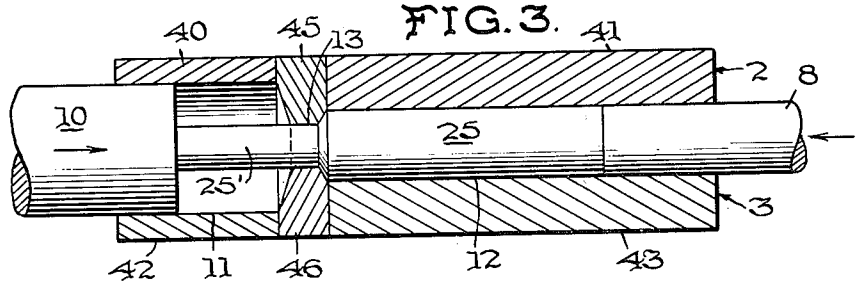
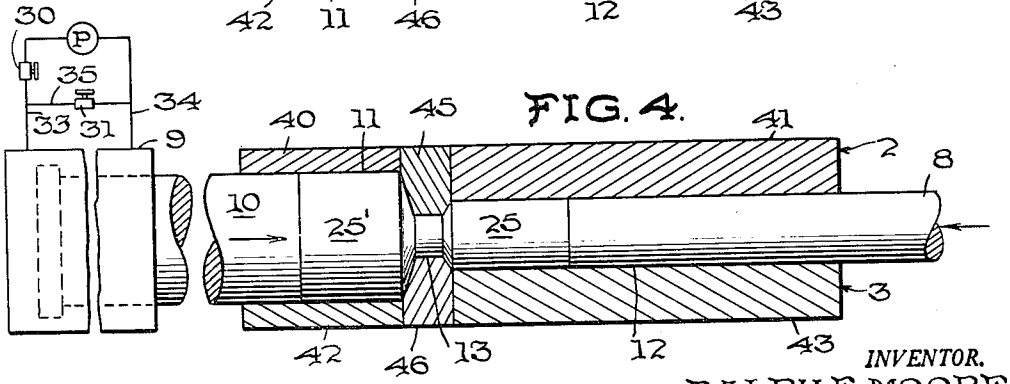


FIG. 4.



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FIG. 5.

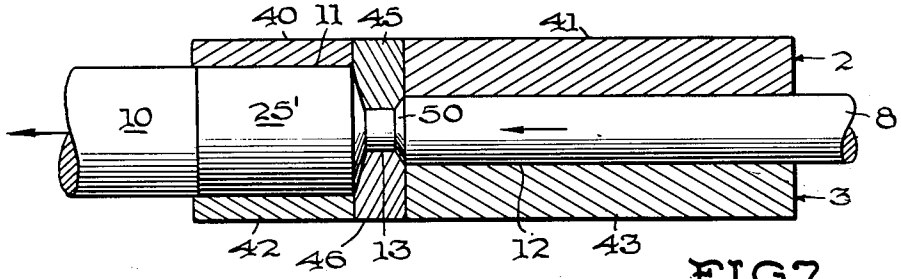


FIG. 6.

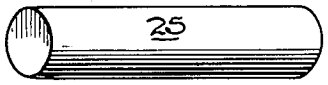


FIG. 7.

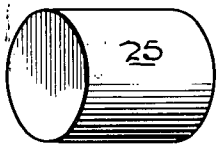
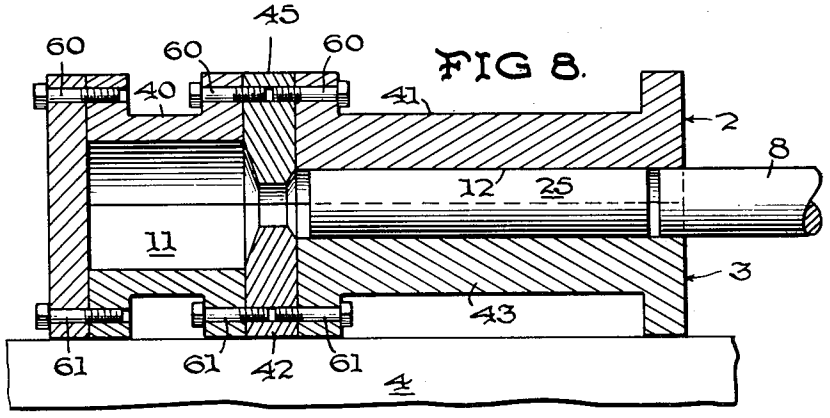


FIG. 8.



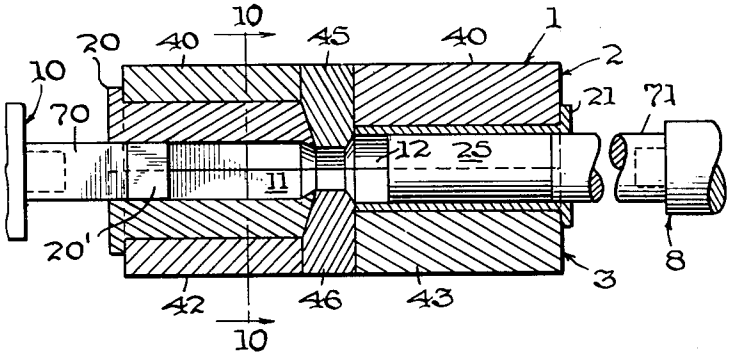


FIG. 9.

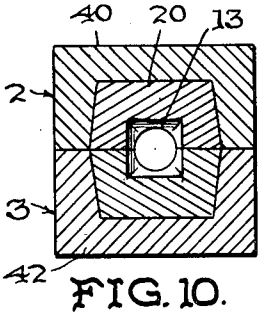


FIG. 10.

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METAL TREATMENT

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Application July 10, 1952, Serial No. 298,135

3 Claims. (Cl. 29—553)

This invention relates to metal working. More particularly, it is concerned with providing a novel method and apparatus for preparing wrought metal stock prior to the hot or cold forging thereof.

At the present time, it is customary in the metal working industry to cross-work or knead a blank of material by means of a press or drop hammer, i. e., the billet, bloom or ingot is compressed and then upset several times, until the physical properties thereof are properly altered or raised to meet the specifications or requirements set for the various further steps of hot or cold forging the blank.

Another method for working metal stock prior to forging is to employ an extrusion process for compressing the metal blank instead of a drop hammer or press, after which the blank is extricated from the extrusion chamber and then upset. However, in this prior method of extruding the blank and then upsetting the same during the kneading or cross-working thereof, a multiplicity of intricate operating steps or cycles is involved. In addition, several different machines are ordinarily required.

For example, it has been conventional in the aluminum industry to take an 18 inch round billet and roll or extrude it down to a 10 inch square billet. In such a case, the reduction in area is approximately 3 to 1.

This step alone, however, did not raise the physical properties of the blank to the extent necessary for many good subsequent forgings. Consequently, a plurality of further cross-working or kneading operations was required prior to final forging, so as to raise the physical properties of the material to those set for a particular end product. This cross-working or kneading prior to forging may require as many as 10 to 14 pressure applications. Under conventional practice it may be possible, of course, to raise the properties of the metal stock or blank to the desired amount by a series of extrusion operations, but the disadvantage of such a process is that the blank with which one must work ordinarily takes the form of a long stick-like member, which is very difficult to work with satisfactorily during the forging operation and where the forging operation contemplates utilizing, for example, a cylindrical disc-shaped blank, the stick-like member would first have to be upset to form the disc-like blank. Furthermore, such operations are extremely time consuming and expensive.

Another disadvantage of prior art practices is that for the most part the cross sectional area of the original stock is reduced during the working operations, as by rolling or extruding and at the most, the stock when worked by the kneading operation, retains approximately the same cross sectional area. This disadvantage has led to a serious handicap in industry since the industry has not had available bodies of worked or wrought metal of sufficient mass and cross section for producing large or massive forgings.

With present day apparatus it is impossible to upset the extruded stick-like member above a 3 to 1 ratio, i. e., if the overall initially unoccupied length of a circular die cavity used for upsetting exceeds three times the diameter of the

stick-like extruded member, no upsetting will take place but instead the blank or stick-like member will merely bend or fold back on itself.

The present invention is concerned with providing a novel method and apparatus for combining the extrusion and upsetting steps in a single pressure applying operation and while utilizing but one machine or apparatus in place of the plurality of cross-working or kneading operations and/or machines in order to raise the physical properties of the metal blank the requisite amount prior to hot or cold forging of the same. The word "blank" is used herein to denote metal stock, which does not have the desired physical properties for forging stock as, for example, metal stock in the as cast or under-worked condition.

In an advantageous embodiment of the invention, the proposed apparatus contemplates the use of one die cavity of small cross-section, which is adapted to receive a heated metal blank initially. A relatively small extrusion bore connects this first die cavity with a second die cavity and a separate movable plunger is located in each die cavity. This second die cavity can be of any size depending upon the results desired. For example, the second die cavity could be either much larger or slightly larger than the first die cavity. In the first case, the first die cavity might be on the order of 15" in diameter, the extrusion bore 7" in diameter and the second cavity 30" in diameter. In the latter case, the first die cavity might be 15" in diameter, the extrusion bore 7" in diameter and the second die cavity 20" in diameter. On the other hand, the second die cavity could be of the exact same size, as the first when it is desirable to upset the extruded blank back again to the same size it had initially prior to being extruded.

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 extruded through the small extrusion bore into the second chamber or die cavity, where it is upset as the extruded portions of the blank are forced against the plunger in the second die as a result of the continuous application of pressure to the other end of the blank by the plunger in the first small die cavity.

It is a primary object of this invention, therefore, to provide a novel method for extruding one portion of a heated metal blank while simultaneously upsetting another portion of the metal blank by the same application of pressure prior to the final hot or cold forging thereof.

A further object of this invention is to provide a novel method of transforming a cast ingot and/or metal blank into wrought stock suitable for hot or cold forging.

It is another object of this invention to provide a novel apparatus for both extruding and upsetting a heated metal blank prior to the hot or cold forging thereof.

It is a further object of this invention to provide a novel apparatus for both extruding and upsetting a heated metal blank prior to the hot or cold forging thereof comprised of a minimum amount of parts, which can be easily replaced and/or repaired.

It is a further object of this invention to provide a novel method of preparing a heated metal blank for hot or cold forging by combining in a single pressure applying operation the extrusion and upsetting of a cast ingot and/or blank of aluminum in place of a plurality of cross-working or kneading operations ordinarily required to raise the physical properties of the material the requisite amount prior to hot or cold forging.

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 heated 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, disclosing the position of the several members of the die 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, showing the second step of extruding the heated blank;

Figure 4 is a view similar to Figure 3 and showing the third step of extruding one portion of the blank, while simultaneously upsetting another portion thereof;

Figure 5 is a view of the die portion of the apparatus of Figure 1, showing the fourth and final step of extruding, while continuously upsetting the heated metal blank until the extruding and upsetting operation has been completed, after which the dies are opened and the worked blank removed;

Figure 6 is a view of a blank prior to its being extruded and upset;

Figure 7 is a view of the same blank after it has been extruded, upset and trimmed;

Figure 8 is an elevational sectional view of a modified type of die apparatus which may be advantageously used in carrying out the instant invention;

Figure 9 is a sectional view of the die portion of the apparatus and showing inserts located in each die cavity; and,

Figure 10 is a view taken along lines **10**—**10** of Figure 9.

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'** on the press. 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** and extrusion bore members **45** and **46**. These die members are so formed that when they are brought together they form a die provided with a 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 by means of an extrusion orifice or open throat portion **13** located between the properly shaped extrusion sections **45** and **46**. These die cavities preferably conform to the particular configuration necessary to produce the proper ratio of extrusion and upset for the specific size of metal blank required. It is also contemplated, as indicated in Figure 10, 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 10, insert **20** may be of such a size as to make die cavity **11** of the same cross sectional size as the die cavity **12** or the initial unworked blank.

As indicated in Figure 2, the first step of the combined extrusion and upsetting operation during a single application of pressure contemplates that a suitably 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 extrude through the orifice or open throat **13** until the extruded portion **25'** comes into contact with piston or plunger **10**, as indicated in Figure 3.

It has also been found that irrespective of the size of the extrusion orifice **13**, if the initial open or unfilled portion of die cavity **11**, into which the extruded metal 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 extruded stock, 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 extruded rod-like stock to bend or fold upon itself and result in improper grain flow. Accordingly, during the initial extrusion 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 orifice **13** than a distance equal to three times the cross-sectional length of the extruded stock. Thus, where the blank is round, this distance would then be equal to three times the diameter of the extruded portion of the blank, and in the case of where a circular heated blank **25** is on the order of 15 inches in diameter and the orifice **13** of the extrusion member on the order of 7 inches in diameter, the end of piston **10** initially should not be positioned over 21 inches or 3 diameters of the extruded stock in length away from the extrusion orifice. The die cavity **11** in this case may be on the order of 30 inches in diameter.

By the proposed process, the extruded metal is immediately upset as it leaves the extrusion orifice 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 stock extruded 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 extruded stock, which is so upset in the die cavity that the disadvantages mentioned above will not result.

Step 3 of the combined extrusion and upsetting operation is indicated in Figure 4, during which continuous pressure is still being exerted on piston **8** thereby causing the 15-inch blank to be extruded through the 7-inch orifice, after which it is 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.

At this time, 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 4, 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 extruded 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 additionally extruded material

until the cast ingot or heated metal blank is substantially completely utilized in the next step or step 4. This is accomplished, for example, by the use of a pressure relief 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 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 cavity 11 for additional stock in a continuous cycle and with a back pressure being exerted by piston 10 sufficient to make upsetting of the remainder of the blank occur to the prescribed diameters or cross-section.

If there is any tendency for excessive heat to develop in the area of the extrusion bore due to too great a reduction in cross-section of the metal blank, suitable cooling means could be used to prevent any adverse effect of the heat on the working imparted to the stock. Also, by proper control of the relationship between the size and shape of the heated blank and the size and shape of the extrusion bore 13 and the second die cavity 11, any desired amount of working to produce a wrought blank having the appropriate physical properties may be had. Thus, in this process, by the simple expedient of extruding a blank through an extrusion bore 13 and simultaneously upsetting the extruded portion 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 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 triangular. 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. The extrusion orifice 13 may also be of any suitable shape or design consistent with proper extrusion practice.

In an advantageous embodiment of the invention, the die cavity 11 may have a fixed volumetric capacity, i. e., the die cavity will be utilized without the reciprocating piston 10 as indicated in Figure 8 and a fixed backing plate 69 is then rigidly affixed to the die sections 40 and 42.

In addition, since the 3 to 1 rule mentioned above still applies, to prevent folding or bending of the extruded stack in the upsetting cavity, the length of the die cavity 11 now of necessity can be only 3 times the diameter of the extrusion bore 13.

In a further modification of the invention as indicated in Figure 10, 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, 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 sections. In this event the shape of the piston heads will of course conform with that of the hollow portions of the various inserts. In addition, the projection or knob 50, which is formed on the end of the blank at the end of the upsetting operation, may be cut off by a suitable shearing or cutting device in a manner well known in the art.

A further example of the proposed process would be the conversion of an 18-inch square aluminum billet blank as cast into a disc-shape blank having a 10-inch diameter. By the conventional practice, the 18-inch square aluminum billet would be rolled or extruded down to a 10-inch square billet to give a reduction in area of approximately 3 to 1. Such a reduction in area will not enable one to obtain the desired high physical properties in many types of forged articles. This disadvantage, therefore, requires cross-working or kneading operations prior to the forging step. Under one form of the proposed method the extrusion bore of the die would be on the order of four inches in diameter. When the billet blank is extruded, the reduction in area would be approximately 24 to 1 based on an 18-inch square billet in a 4-inch diameter extrusion bore. Thus, when the extruded portion is then upset to a 10-inch diameter blank, this would give approximately a 6 to 1 ratio of change in area between the extrusion step and the step of upsetting. Therefore, the total ratio of change in area or reduction in area would be approximately 30 to 1.

As stated previously, under conventional practices used today, the hot forging or cold forging of the usual hot rolled or extruded stock will not raise the properties sufficiently for the forged articles and it is believed that 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 a desired physical properties after forging. Furthermore, present day aluminum casting is limited to approximately 18-inch diameter billets and this proposed process will allow the production of larger size wrought blanks of desired properties from such billets and in many instances such large size blanks are highly desirable, particularly for forging various aircraft parts.

By the process and apparatus of the instant invention, it is possible to take a small size ingot or blank of the conventional size and extrude and upset it to produce a wrought blank of relatively large cross-sectional area and having the required or desired physical properties for later hot or cold forging.

In employing the proposed process for producing a desired blank for forging, it would be necessary, of course, to first determine on an experimental trial-and-error basis the necessary billet blank size, the size of the extrusion bore and the size or shape of the second bore or cavity and the pressure to be exerted by the press members used in carrying out the process. This would necessarily have to be done in order to give the proper ratio of reduction in area and upsetting to result in the desired properties in the blank.

It is also to be observed that while the proposed process has been disclosed with respect to its use on aluminum blanks or ingots, it is not necessarily limited thereto, since the same problem of working the blank to attain the desired properties therein prior to forging is likewise true of ferrous metals and other non-ferrous metals, such as brass.

In addition, whereas the processes and apparatus of the prior art were limited to the extrusion and upsetting of relatively small billets, the present apparatus and method can be used for extruding and upsetting billets of much larger sizes and the advantages thereof are apparent.

The proposed process has no limitations on extruded versus upsetting ratio except during the initial part of the extruding operation. Accordingly, by means of the present invention there is provided a method and apparatus whereby a cast ingot or heated metal blank of any length and any diameter can be worked to any ratio desired to achieve optimum physical properties and then can be reshaped to any diameter and to any length desired.

An advantageous embodiment of this invention has been herein shown and described. It is obvious that various changes may be made therein without departing from the spirit and scope thereof as defined by the appended claims.

What is claimed is:

1. A method of preparing wrought aluminum metal stock and the like prior to the final forging thereof including the steps of placing a heated aluminum metal blank in a confined zone, thereafter applying external pressure to one end of said blank so as to cause successive longitudinal portions of said blank to pass into and through

a second confined zone contiguous to said first zone and reducing the cross-section of said successive longitudinal portions of the blank during the passage thereof through said second zone, and immediately thereafter by the continued application of the same external pressure causing the said reduced in cross-sectional portions of said blank to pass from said second zone into a third confined zone contiguous to said second zone and into contact with an initially stationary pressure applying surface located in said third zone, said pressure applying surface being initially spaced from the end of said third zone which is adjacent said second zone at a maximum distance of three times the cross-sectional length of said reduced in cross-sectional portions of the blank, whereby upon contact with said pressure applying surface in said third zone, the upsetting of said blank in said third zone is initiated, and thereafter completing the upsetting of the said reduced in cross-sectional portions of the blank within said third zone by applying pressure to opposing ends of said blank and while moving said pressure applying surface in said third zone away from said second zone at a rate commensurate with the volumetric rate at which the remaining reduced in cross-sectional portions of the blank are forced into said third zone by said first mentioned application of external pressure until substantially all portions of the blank have been first progressively reduced in cross-section and then immediately thereafter progressively increased in cross-section by a single application of external pressure.

2. The method as claimed in claim 1, wherein during said upsetting step the successive reduced in cross-section portions of the blank are upset and increased in cross-section to an amount substantially greater than that of the initial unworked blank.

3. The method as claimed in claim 1, wherein during said upsetting step the successive reduced in cross-section portions of the blank are upset and increased in cross-section to an amount approximating that of the initial unworked blank.

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