

[54] **METHOD OF FORGING ELONGATED METAL SHAPES FROM INGOTS AND RESULTING PRODUCT**

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[51] Int. Cl. B21j 1/04

[58] Field of Search..... 72/356, 373, 374, 375, 376, 72/377, 700; 29/187

[56] **References Cited**

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[57] **ABSTRACT**

A method of forging an elongated metal shape from an ingot. First the ingot is pressed in the direction of its central axis. Next the partially forged shape is pressed in a direction perpendicular to its central axis to elongate it in a direction at right angles both to the new direction of pressing and to the original axis. The piece then is pressed repeatedly in at least two directions both at right angles to its direction of elongation to produce a shape, the lengthwise axis of which is perpendicular to the original central axis of the ingot.

5 Claims, 7 Drawing Figures

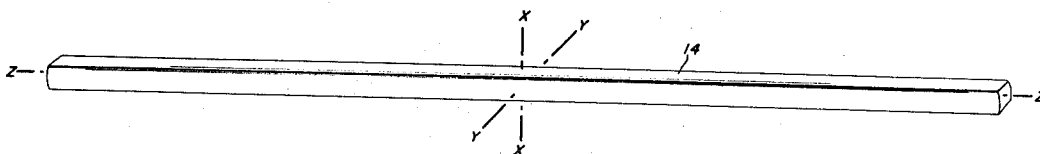


FIG. 1

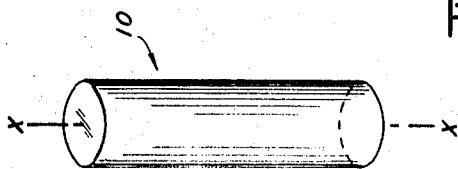


FIG. 2

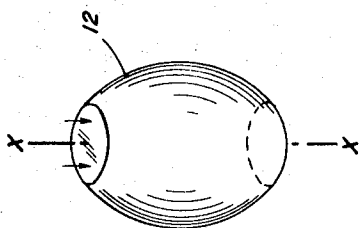


FIG. 3

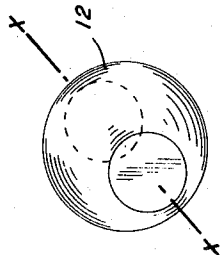


FIG. 4

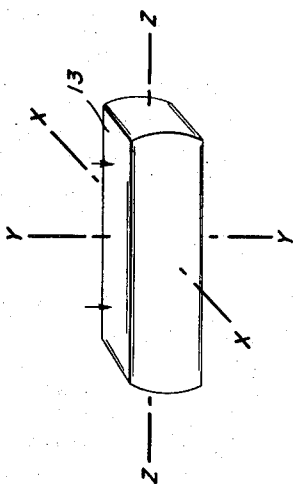


FIG. 5

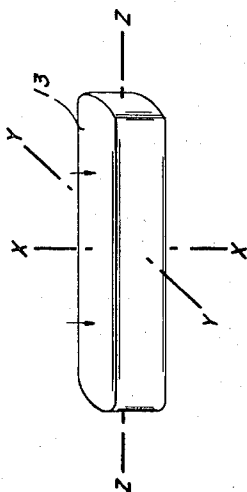


FIG. 6

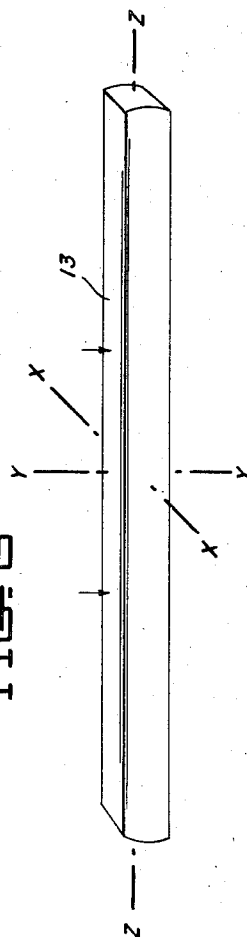
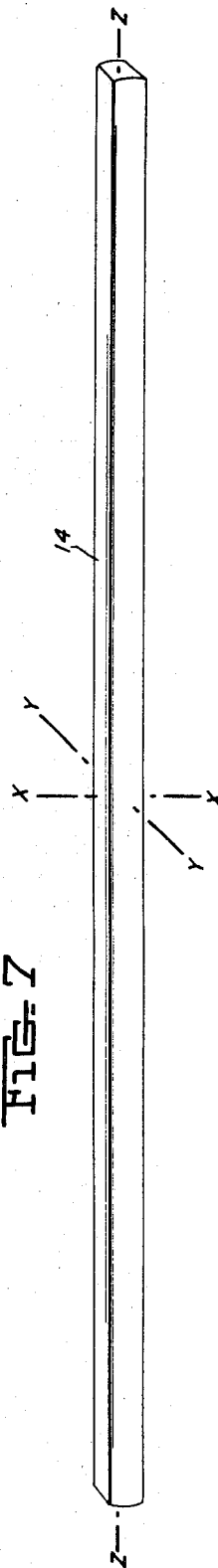


FIG. 7



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METHOD OF FORGING ELONGATED METAL SHAPES FROM INGOTS AND RESULTING PRODUCT

This invention relates to an improved method of forging elongated metal shapes from ingots and to the resulting product.

Although my invention is not thus limited, my method is particularly useful for forging billets from titanium ingots. As used herein, the term "titanium" includes the various titanium-base alloys as well as the pure metal. A conventional titanium ingot is cylindrical and usually about 75 to 105 inches high and 18 to 36 inches in diameter. Billets forged from each ingot may have total lengths of about 120 to 2,800 inches and cross-sectional areas of about 36 to 900 square inches. Conventional practice is to turn the ingot on its side and press it always perpendicular to its central axis in two directions at right angles to each other until it is reduced to the desired dimensions. The partially forged piece is reheated between forging steps as necessary to maintain plasticity. It is known to upset an ingot in the axial direction before turning it on its side, but the original central axis of the ingot then becomes the lengthwise axis of the shape as it is subsequently forged, and remains such in the finished product. With this practice the shape can be worked mechanically only to a limited extent in the forging operation. More extensive mechanical working is desirable, both to achieve fine grain structures and to seal pipes which form as ingots are cast.

An object of my invention is to provide an improved forging method in which I work a metal shape mechanically to a much greater extent in reducing it from ingot form to billet form than is possible with the foregoing practice.

A more specific object is to provide an improved forging method wherein I press or upset an ingot first in its axial direction and subsequently press the partially forged piece alternately in at least two directions, one of which is perpendicular to the original central axis of the ingot and the other parallel therewith, whereby the lengthwise axis of the forged product always lies at right angles to the original central axis.

A further object is to provide, as an article of manufacture, a forged product which results from the practice of my method.

In the drawing:

FIG. 1 is a perspective view of a cylindrical ingot as cast;

FIG. 2 is a perspective view of the ingot after the first forging step in which I upset or press it in the axial direction;

FIG. 3 is a perspective view of the upset ingot shown in FIG. 2, but turned on its side; titanium,

FIG. 4 is a perspective view of the piece shown in FIG. 3 after the second forging step in which I press it in a direction perpendicular to its central axis;

FIG. 5 is a perspective view of the piece shown in FIG. 4 turned over for another forging step in which I press it in a direction parallel with the original central axis;

FIG. 6 is a perspective view of the piece shown in FIG. 5 turned on its side and after further forging steps; and

FIG. 7 is a perspective view of a completely forged billet of my invention.

Before I start to forge an ingot, I heat it to an appropriate temperature, commonly about 1,800° to 2,400° F. for titanium. The optimum starting temperature of course varies with the composition of the ingot. As forging proceeds, the temperature of the piece drops. When the piece cools to a temperature at which it cannot readily be forged, I reheat it, as known in the art. In the example of titanium, I reheat the piece whenever it cools below about 1,600° F. I use conventional equipment both for heating and forging; hence I have not

shown this equipment.

FIG. 1 shows a conventional cylindrical ingot 10, the central axis $x-x$ of which is vertical initially. First I upset or press the heated ingot in the direction of axis $x-x$ to a bulbous configuration 12, as shown in FIG. 2. In this step I reduce the ingot height by about 30 to 60 percent. Next I turn the bulbous piece 12 on its side, as shown in FIG. 3, and press it in a direction $y-y$ perpendicular to the original central axis $x-x$ to a flattened configuration 13, as shown in FIG. 4. In this step I reduce the now vertical transverse dimension by about 20 to 50 percent and start to elongate the piece in the direction of an axis $z-z$ at right angles to both axes $x-x$ and $y-y$.

As distinguished from known practice, I next turn the flattened piece 13 so that its original central axis $x-x$ again is vertical, as shown in FIG. 5. I press the piece again in a direction parallel with axis $x-x$ and thus further elongate it in the direction of axis $z-z$. In succeeding forging steps I repeatedly press the piece, alternating between at least two directions, both at right angles to axis $z-z$. One direction $y-y$ is perpendicular to axis $x-x$ as shown in FIG. 6, and the other parallel with axis $x-x$ as shown in FIG. 5. In each forging step after the first two I reduce the vertical dimension of the piece by about 5 to 15 percent before I turn the piece to press it in the other direction. FIG. 7 shows a completely forged billet 14, the lengthwise axis $z-z$ of which lies at right angles to the original central axis $x-x$ of the ingot.

The gain in mechanical working which my method achieves can best be demonstrated by a specific example. A typical titanium ingot may be 96 inches high and 30 inches in diameter. A billet almost 40 feet long and 1 foot square in cross section may be forged from this ingot. If the conventional practice is followed, the 30-inch dimension is worked down to 12 inches, a linear reduction ratio of 2.5 to 1. If my method is followed the 96-inch dimension is worked down to 12 inches, a linear reduction ratio of 8 to 1. Hence my method is much more effective than other forging methods in achieving a fine grain structure and in sealing any pipe in the ingot.

My forging method also minimizes the effect of any freezing segregation which may take place in the top portion of an ingot. My method relocates any segregated metal in a more desirable place near the surface of the billet rather than in the center. Any segregated metal is reduced in thickness in the same ratio as the ingot and hence becomes much thinner and is easily eliminated by thermal diffusion treatments.

I claim:

1. A method of forging an elongated metal shape from an ingot comprising pressing the ingot first in the direction of its central axis, pressing the partially forged shape next in a direction perpendicular to said axis whereby the piece is elongated in a direction at right angles to said axis, and repeatedly pressing the partially forged shape in at least two directions at right angles to its direction of elongation to produce an elongated piece, the lengthwise axis of which lies at right angles to the original central axis of the ingot.

2. A method as defined in claim 1 in which the ingot is titanium and is cylindrical originally.

3. A method as defined in claim 1 in which the directions of pressing are at right angles to each other, one such direction being parallel with the original central axis of the ingot and the other perpendicular to said central axis.

4. A method as defined in claim 1 in which the first pressing produces a bulbous-shaped piece, the height of which is reduced 30 to 60 percent from the height of the original ingot.

5. As an article of manufacture, an elongated metal piece produced by the method of claim 1.

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