Sept. 19, 1944. G. E. BRENHOLTZ 2,358,378

METHOD FOR FORMING METAL BALLS

Filed July 14, 1941 2 Sheets-Sheet 1

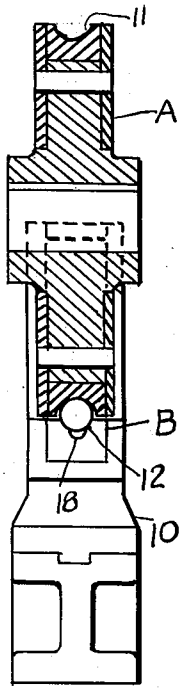


FIG. 2.

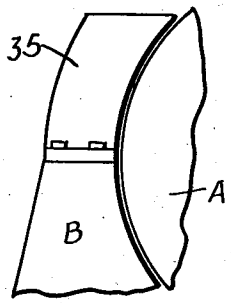


FIG. 14.

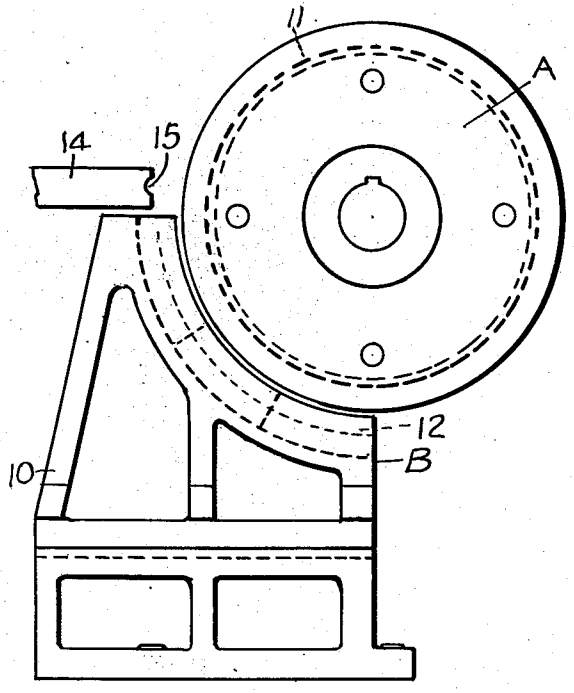


FIG. 1.

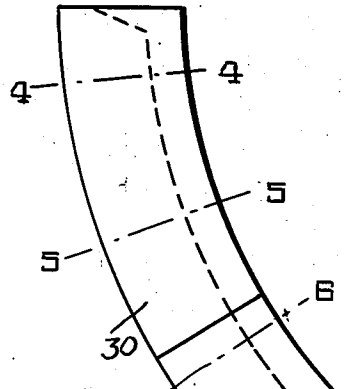


FIG. 3.

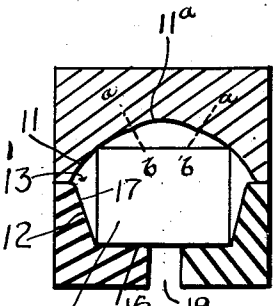


FIG. 12.

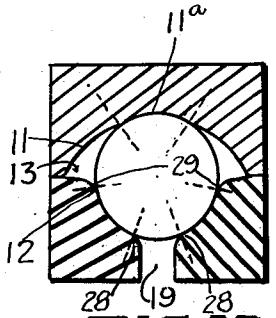


FIG. 13.

INVENTOR
G.E.BRENHOLTZ
BY
Eugene E. Stevens
ATTORNEY

Sept. 19, 1944. G. E. BRENHOLTZ 2,358,378

METHOD FOR FORMING METAL BALLS

Filed July 14, 1941 2 Sheets-Sheet 2

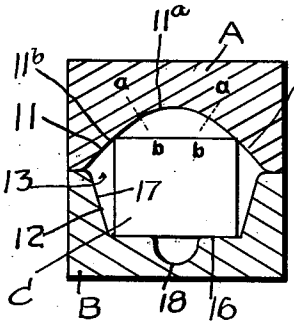


FIG. 4.

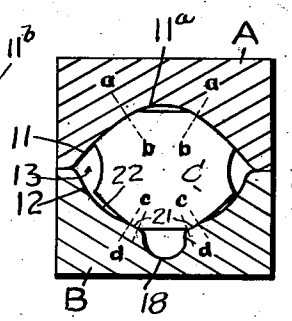


FIG. 5.

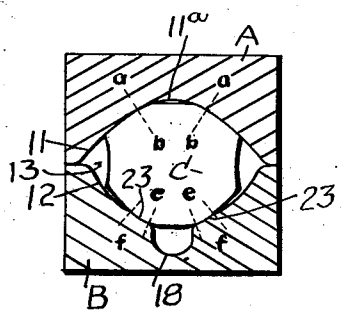


FIG. 6.

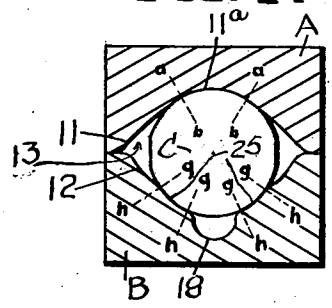


FIG. 7.

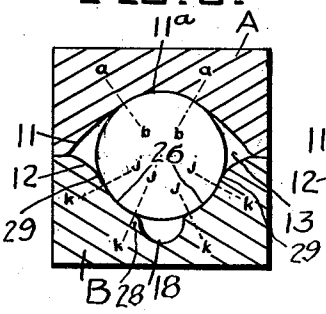


FIG. 8.

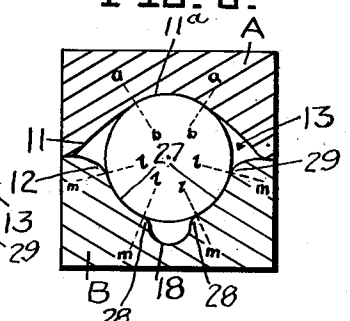


FIG. 9.

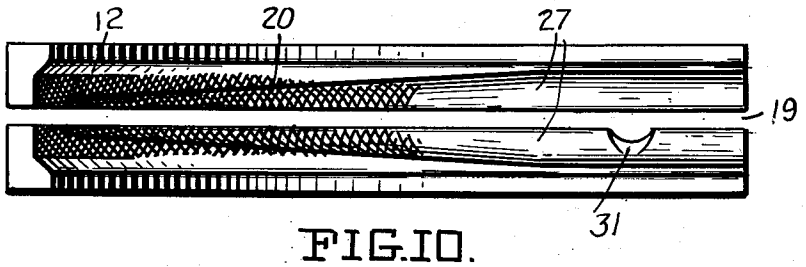


FIG. 10.

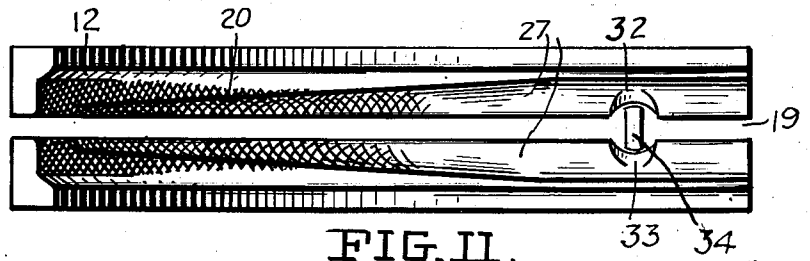


FIG. 11.

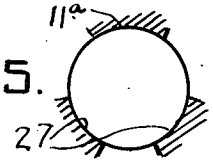


FIG. 15.

INVENTOR
G.E. BRENHOLTZ

BY Eugene E. Stevens
ATTORNEY

Patented Sept. 19, 1944

2,358,378

UNITED STATES PATENT OFFICE

2,358,378

METHOD FOR FORMING METAL BALLS

George E. Brenholtz, Hamilton, Ontario, Canada

Application July 14, 1941, Serial No. 402,408

8 Claims. (Cl. 29—148.4)

This invention relates to a method for forming metal balls.

The general method of making metal balls in use at the present time is carried out by a machine of the open die type wherein two identical hemispherical die cavities are reciprocated toward each other with a metal slug disposed between them so as to compress the slug into the form of a sphere when the dies meet. One particular disadvantage of this machine is that since the die cavities must be completely filled, excess metal must be permitted in the slug which has the result that an equator ring is formed on the ball. Moreover, in order to discharge the ball from the die cavities as they are moving away from each other, a sliding plunger is used to contact the ball which has the result of flattening the ball at its pole.

In some instances where a perfect sphere is required such as in the case of ball bearings, it is necessary to subject the balls to further finishing operations, trimming for the equator ring and grinding the sphere, thus requiring two or more operations.

A further method which is employed in forming balls makes use of spiral passageways formed in cooperating rolls which operate on the principle of a worm and draw in to the passageways bar stock from which lengths are cut to form slugs and such slugs subjected to a progressive forming operation as they pass along the spiral throughout the length of the rolls. A particular disadvantage of this method is that the collars between sections of the spiral passage in the rolls have a tendency to pull the end edges of the slugs downwardly and upwardly so as in effect to fold some of the metal over, giving the ball a cabbage-leaf effect with the result that such leaves subsequently flake off and are objected to since they clog the screens of the ball mills and the like.

A further disadvantage of both methods above referred to and in most ball forming methods is that perfect synchronization of the moving parts of the mechanism and the fitting of the slugs from which the balls are formed is required and this necessarily requires the use of timing mechanism.

It is an object of the present invention to avoid the disadvantage of these prior types of machines by providing a method through which the balls can be formed into a perfect sphere in one continuous operation which when formed will not be subject to the objections of equator ring, flat pole or cabbage-leaf effect.

A further object of the invention which naturally follows is the production of metal balls economically.

A still further object of the invention is to provide a method of this character through which such balls may be produced in volume in a comparatively short space of time.

A still further object of the invention is to provide a method through which the mechanism employed for producing the balls may be quickly adapted to produce balls of different sizes as may be required.

With these and other objects in view the method generally comprises forging metal balls from slugs by causing each slug to travel along an extended path, preliminarily subjecting the slug to the pressure engagement of deforming dies at four points of its surface to deform the slug initially, and finally subjecting the deformed slug to the pressure engagement of arc-shaped dies at three points only, on its surface throughout the remaining portion of its travel, the polar zones of the gradually forming sphere being formed by two die surfaces and the intervening circumferential zones being formed by the other or remaining die. The method preferably provides for the formation of metal spheres or balls in one continuous operation and includes a rotary forging operation wherein the axis of the rotation of the ball being formed remains parallel substantially throughout its travel through the forming dies and preferably the axis of rotation is finally swung so as to assume a position substantially at right angles to its normal position during a final finishing step over a minor portion of its travel through the dies.

The various features of the method will be clearly understood by reference to the following detailed specification taken in conjunction with the accompanying drawings.

In the drawings:

Fig. 1 is a schematic side elevation of rotary and stationary dies and their preferred positioning for forming metal balls.

Fig. 2 is a vertical section taken through the centre of the rotary die in advance of the stationary die.

Fig. 3 is a side elevation of die sections making up the stationary die.

Figs. 4 to 9 are sections taken along the lines 4—4, 5—5, 6—6, 7—7, 8—8 and 9—9 of Fig. 3.

Fig. 10 is a plan view of stationary die which is shown formed in two separated sections and illustrating an enlargement in the groove of one section to permit the swinging of the balls being formed, from their normal axis of rotation.

Fig. 11 is a view similar to Fig. 10, but showing an enlargement in both sides of the groove of the die and also illustrating mechanical means for causing the balls being formed to swing from their normal axis of rotation.

Fig. 12 is a transverse section taken through the cooperating rotary and stationary dies at a point adjacent to the entrance to the die passageway and showing a metal slug positioned as it begins travel between the dies.

Fig. 13 is a transverse section taken through the cooperating dies at a point just adjacent to the discharge and showing a ball practically finished by also illustrating the extent of contact between the surface of the ball and the forming surfaces of the dies.

Fig. 14 is a fragmentary detail of the apparatus illustrating an extension which may be applied to increase the length of the path of travel of the slugs when forming balls of large diameter, and

Fig. 15 is a schematic illustration of the three point contact between the ball being formed and the die faces in the final stages of processing.

Referring to the drawings, a preferred general type of apparatus is illustrated in Fig. 1 wherein A indicates a rotary forging die and B indicates a cooperating stationary forging die which may be mounted on any suitable stationary framework 10. The stationary die B is arcuate in elevation and is designed as shown to lie parallel to a corresponding arc of the rotary die. The rotary die is formed with a circumferential groove 11 of constant cross section while the stationary die is formed with a corresponding groove 12 of changing cross section along its length as will appear in detail hereinafter. The grooves of these open faced dies are, as clearly shown in Fig. 2 and Figs. 12 and 13, disposed in opposed relation to one another so as to form therebetween a channel 13 over an extended arcuate path through which metal slugs will pass progressively as they are formed from their initial shape into that of a ball or sphere.

The slugs C are shown in Fig. 12 are preferably cut from bar stock of a diameter and length such that they will provide sufficient metal as to form a perfect sphere of given size after passing through between the dies A and B. These slugs may be sheared to length by suitably reciprocating shearing knife 14 reciprocated by suitable mechanism (not shown) and preferably has an arcuate cutting edge 15 designed to contact with the bar stock which is preferably fed horizontally through the mechanism in the path of the knife 14.

The slugs as they are cut may pass along a suitable table which may be in the form of a guideway, cut slugs being disposed contiguous to one another on the table and pushed one by the other through suitable mechanism reciprocating in conjunction with the knife 14 until the foremost slug passes through the point of entry of the channel 13 between the dies A and B, a slug being fed into the machine each time one is cut from the bar stock.

The length of the guideway or channel 13 will depend upon the size of the balls being formed and the amount of processing required and provision may be made to increase the length of the channel by employing additional parts as will be referred to hereinafter. However, I prefer that the discharge end of the channel 13 will, where possible, coincide with the centre of the rotary die and at the bottom of the rotary die as clearly shown in Fig. 1.

A salient feature of the invention resides in the contour and arrangement of the rotary and stationary dies A and B. The stationary die may be formed in one piece as clearly shown in Figs. 4 and 9 or may be formed in two parts as shown in Figs. 12 and 13. In either case, however, the contours of the groove 12 which is formed by both sides of the die will be the same.

The stationary die at the inlet end is formed with a flat base 16 and preferably of a width slightly wider than the length of the slug so as to accommodate the rough edges that may be present on the slug. The side walls 17 of the groove at this point are preferably flat and sloped inwardly to the base 16 so that the slug when received will be accurately disposed with its side wall lying on the flat base so that it may be caused to roll along the flat base 16. The groove generally retains this cross sectional shape for a short distance, to start the rolling motion of the slug during which period, the surface of the groove 11 of the rotary die A commences a preliminary deforming operation which will be referred to hereafter.

The groove requires two working surfaces so that as a means of eliminating any possible extra friction it is centrally divided either by a trough or channel 18 or may be formed in two separate sections with a dividing channel 19 such as shown in Figs. 12 and 13. On the other hand it may have both a trough 18 over a portion of its extent and be divided over another. At the end of the flat base 16 the contour of the groove gradually changes into a gradually increasing arcuate deforming surface which is part of the true arc of the sphere finally to be formed.

The deforming surface starts on each side of the groove from the edge of the trough 18 or the channel 19 as the case may be, gradually increasing until in the final stages of processing, the arcuate deforming surfaces of the groove 12 each approximate one-sixth of the complete circle corresponding to the diameter of the ball being formed.

The gradual forming of the slug into a sphere by means of this gradual change in the contour of the groove 12 of die B in conjunction with the constant shaped groove 11 in the rotary die will be appreciated by reference at this point to the shape of the groove of the rotary die. In this connection reference is made to Fig. 12 wherein it will be seen that the centre part of groove 11 is formed as an arc to the extent of one-sixth of the true arc of the sphere being formed and in some cases slightly more than one-sixth of this distance, such arc being indicated at 11*a* extending between the broken lines *a*—*b*. The remaining portion of the groove on each side of the arc portion 11*a* is gradually flared out as at 11*b* to meet the width of the opening of groove 12 in the stationary die and in fact the shape of the marginal portions of groove 11 substantially corresponds to the cross sectional shape of groove 12 at the point shown by section of Fig. 5.

The base 16 of the stationary die and part of the curved walls of the groove are ragged or scored so as to provide a rough surface which will prevent slippage as indicated at 20, Figs. 10 and 11. Correspondingly the flared portion 11*b* of the groove 11 is ragged or scored throughout the whole circumference of the die. These ragged

surfaces as well assist in causing the slug to rotate about its axis so that as the slug passes between the dies it is subjected to a rolling forging operation.

As the rotary die A rotates the slug which has just entered the passageway 13 as shown in Fig. 12 will be caused to rotate and its corners will be subjected to the pressure engagement of the flared portion of the groove 11 clearly shown in Fig. 12 where pressure contact is just beginning to commence. This pressure contact is caused by the contour of the groove 12 in the lower stationary die. As the slug moves along the passageway 13 and reaches a point in the passageway corresponding to that where the cross section of Fig. 5 occurs on lower die B, the corners of the slug have been deformed substantially to the extent shown in Fig. 5 and at this point the inner portions of the die groove surfaces have been formed with a small portion 21 of the true arc of the sphere being formed, (shown between broken lines *c—d*) while the outwardly and upwardly flared surfaces 22 on each side of the arc portion 21 are such as to lessen the depth of groove 12 at this point. As a result, therefore, it will be seen that the metal of the slug is being caused to flow gradually upwardly and downwardly, a portion of the true arc of the sphere being formed by the arcs 21 while at the same time a further portion of the arc of the true sphere is being formed on the slug by the arcuate portion 11*a* of rotary die A as the metal flows upwardly and downwardly.

As the slug progresses through channel 13 and reaches a point where the cross section of Fig. 6 is taken, the arc 21 as shown in Fig. 5 now becomes arc 23, (shown between broken lines *e—f*) which is substantially twice as long whereas the flared portions 22 of groove 12 are such that the cross sectional area of the groove on each side of arc 23 has been lessened. In view of this, the metal is caused to flow to a greater extent upwardly and downwardly and while a greater portion of the true arc of the final sphere is formed by the arcs 23 of the die B, a greater portion of the arc of the true sphere is being formed on the slug by the arcuate portion 11*a* of the rotary die A.

The cross sections of the die B as shown in Figs. 7, 8 and 9, disclose progressively increased arcuate surfaces 25, 26 and 27 (occurring between the broken lines *g—h*, *j—k*, *l—m* respectively) until at 27 about four-fifths of the true arcuate surface of the lower die sections is attained, the final arcs (Fig. 13) corresponding as previously stated to substantially one-sixth in each case of the circumference of the sphere being formed. The gradual formation of the slug can be seen from Figs. 5 to 9 and the finished sphere between the dies A and B, is shown in Fig. 13. In this instance it will be noted that the full arcuate surfaces of the stationary die B in effect overlap the full arcuate surface 11*a* of the rotary die A so that the three points of contact which have been gradually enlarged in the case of die B, substantially to correspond with the constant full size of arc 11*a* in die A, assure that a perfect sphere is formed by the time that the slug is discharged.

As noted by referring to the die cross sections, the edges of the die sections of die B are gradually rounded at their inner edges as at 28 (see Figs. 8, 9, 13) while the outer edges are also gradually rounded as at 29 so as to avoid sharp edges which might have a tendency to crease the slug being formed and by reason of this and the fact that at least upper die arc 11*a* is greater than one-sixth of the circumference of the sphere, the sphere is kept from being marked by the dies.

The lower die B may be formed in a series of segments 30 as shown in Fig. 3, so that individual segments may be adjusted laterally to accommodate wear, and also in the case of the first part of the die so as to increase the size of the die passageway, if necessary, in order to make certain that slugs which have become crooked or distorted through hot shearing may be accurately centered to lie on the die base 16. The lower die, in this instance, would therefore preferably be split in two sections and as many segments as desired may be employed and varying in length if necessary.

As the slug is gradually formed into a sphere as above described through the rolling forging operation, the slug rotates about its axis substantially parallel with the path of travel of the slug. In order to avoid the possibility of small cone peaks at the end of the axis of rotation it is desirable to change the position of the slug towards the end of its passage between the dies so that it may be caused to rotate substantially at right angles to its normal axis of rotation. To this end a part of the groove of the lower die section may be enlarged as indicated at 31 (see Fig. 10) which would have the effect of relieving the pressure of the die on the slug at one side and through the friction set up by the contact of the ball being formed with the rotary die and with the other side of the lower die, the tendency is to spin the ball causing it to change its positions so that the ends of normal axis of rotation or, in other words, the polar zones of the sphere would be positioned so that they would be engaged by the arcuate portion 11*a* of die A, thus to eliminate any possibility of peaks. Alternatively, the die sections of stationary die B may be enlarged as at 32 and 33 and a mechanically operated friction wheel 34 may be positioned below the die sections between the enlargements 32 and 33 so as to contact the sphere being formed. The friction wheel 34 is disposed to rotate in a direction at right angles to the normal axis of rotation of the sphere being formed so that it would cause the sphere being formed to rotate at right angles to its normal axis of rotation, thus assuring that during the remaining part of its passage between the dies it would be caused to rotate substantially at right angles to its normal axis of rotation during its previous passage between the dies.

As previously indicated the length of the stationary die and consequently the extent of the path of travel of the slug through the dies will depend upon the size of the sphere to be formed. This might be extended by adding to the structure in Fig. 1 an extension 35 to the stationary die and feeding slugs between the dies at a point higher than normal. Alternatively, the sphere might be formed in two operations, the first consisting in shaping the slug up to a point shown by the lower die shape in Fig. 7, and completing the final shaping as shown in Figs. 8, 9 and 13 in a second operation. In other words, two similar machines would be employed.

From the foregoing it will be appreciated that the method described will attain the objects I have set out. The elimination of the necessity for synchronous feed and synchronization of the dies permits feeding of slugs to the machine as

fast as the shearing knives can shear them. Furthermore, while the method and apparatus tends to avoid slippage it will be noted that if slippage were to occur in the case of any slugs passing through the dies, nothing disadvantageous would result as the slug would merely receive a little more processing whereas in the synchronized machine the machine would jam or the slug would be spoiled.

A salient feature of the invention, as will be realized from the foregoing, lies in the fact that the dies are so shaped and arranged that friction is reduced to a minimum. In this instance, it will be appreciated that throughout the passage of the slug between the rotary and stationary dies, there are very few points of contact between the slug and the stationary die and the rotary die which are similar, and in the final stages of processing the ball being formed is contacted by the dies at three points only, the point of contact with the rotary die being positioned between the points of contact with the stationary die so that the speed of rotation of the ball in terms of its contact with the rotary die is not impeded as would be the case were it contacted by continuous semi-circular grooves.

It should be appreciated that the changing in cross sectional shape of the die faces of the stationary die is gradual throughout and that the illustration of the change in shape of the slug illustrated in Figs. 4 to 9 and 13 are approximations of the shape as the slug reaches that point in the die, with other changes in shape occurring at intermediate points.

The apparatus involved for carrying out the method is of the simplest type and, of course, may be varied in general construction to provide special feeding means, shearing means, or the like.

What I claim as my invention is:

1. In the method of forging metal balls in one continuous operation the steps of causing metal slugs to travel successively through an extended single arcuate path and subjecting each slug to the pressure engagement of dies at three points only during a substantial portion of their travel while gradually forging the slug into a sphere.

2. The method of forging metal balls in one continuous operation which comprises causing metal slugs to travel successively through an extended single arcuate path preliminarily subjecting each slug to a pressure engagement at four points during the first portion of its travel to deform each slug and then subjecting the slug to the pressure engagement of dies at three points only during the remaining portion of their travel while gradually deforming each slug into a sphere.

3. The method as claimed in claim 2 in which the three points of contact between each slug and the dies during a remaining portion of the travel of the slugs are gradually increased.

4. The method of forging metal balls in one continuous operation from elongated metal slugs which comprises causing each slug to travel successively through an extended single arcuate path parallel to its longitudinal axis, preliminarily subjecting each slug to the pressure engagement of deforming dies at four points to deform them while causing them to rotate about its axis and then subjecting each slug to the pressure engagement of dies at three points only during the remaining or final portion of their travel while gradually forging each deformed slug into a sphere.

5. The method as claimed in claim 4 in which the position of each slug in the path of travel is changed towards the end of the remaining or final portion of their travel to change the axis of rotation, of each slug.

6. The method of forging metal balls in one continuous operation which comprises initially shearing cylindrical bar stock to form a metal slug having the planes of its ends substantially at right angles to its axis passing the metal slug through between three circumferentially spaced apart arcuate die surfaces of frictional character and jointly arranged in one single arcuate path and gradually increasing the arc of two of the surfaces to overlap the third surface while gradually forming the slug into a sphere.

7. The method of forging metal balls in one continuous operation which comprises initially shearing cylindrical bar stock to form a metal slug having the planes of its ends substantially at right angles to its axis passing the slug between three circumferentially spaced apart arcuate surfaces of frictional character and jointly arranged in one single arcuate path and in pressure contact therewith, forming the polar zones of the sphere from two of said surfaces and the equatorial zones of the sphere from the remaining arcuate surface.

8. The method of forging metal balls in one continuous operation which comprises initially shearing cylindrical bar stock to form a metal slug having the planes of its ends substantially at right angles to its axis passing the slug between three circumferentially spaced apart arcuate surfaces of frictional character and jointly arranged in one single arcuate path, causing said slug to rotate in pressure contact therewith, about an axis forming the polar zones of the sphere from two of said surfaces and the equatorial zones of the sphere from the remaining arcuate surfaces and changing the position of the slug during the final stage of contact with said surfaces to cause it to rotate at substantially right angles to said axis whereby polar zones of the sphere are brought into pressure contact with the remaining arcuate surface.

GEORGE E. BRENHOLTZ.