March 16, 1943. U. JELINEK 2,313,876

METHOD OF MAKING BALLS

Filed June 18, 1940

Fig. 1.

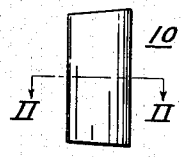


Fig. 2.

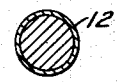


Fig. 3.

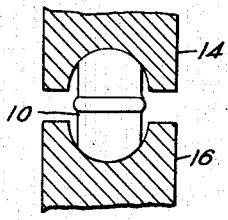


Fig. 4.

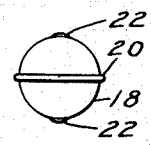


Fig. 5.

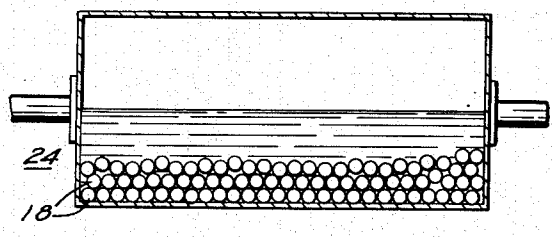


Fig. 6.



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METHOD OF MAKING BALLS

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9 Claims. (Cl. 29—148.4)

This invention relates to balls of stainless steel suitable for use in ball bearings and to the method for making them.

In the electrical industry watthour meters have been constructed which utilize a ball rotating between sapphire cups as the lower bearing of the meter. Heretofore the balls have been formed of high carbon steel but they are not always satisfactory since they are subject to the formation of rust under certain atmospheric conditions. Other materials have been suggested as the composition of the ball, but they have one or more of the disadvantages of rust formation, lack of sufficient hardness and toughness to give a long life, or the cost of the ball is commercially prohibitive.

An object of this invention is to provide a method of producing balls of stainless steel.

A more specific object of this invention is to provide a method of producing a ball by cold-working high carbon stainless steel to the desired shape and giving it a surface finish free from imperfections at a magnification of at least 54 diameters.

Other objects of this invention will be apparent from the following description when taken in conjunction with the accompanying drawing, in which:

Figure 1 is a view in elevation of a slug utilized in this invention;

Fig. 2 is a view in section of the slug of Fig. 1 taken along the line II—II thereof;

Fig. 3 is a view in elevation and partly in section of upsetting dies and a slug as utilized in this invention;

Fig. 4 is a view in elevation and greatly exaggerated of the slug after it has been formed to the approximate shape and size of the desired ball in accordance with the teachings of this invention;

Fig. 5 is a view in elevation and partly in section of a rotating tumbling barrel employed in practicing the method of this invention; and

Fig. 6 is a view in elevation of a steel ball produced in accordance with this invention.

In practicing this invention, it is preferred to employ a hard stainless steel having a composition of between .9% and 1.1% of carbon, from 17% to 19% of chromium and the balance substantially all iron. In addition to the essential elements of carbon, chromium and iron, impurities such as not more than .65% of manganese, not more than .5% of silicon and not more than .035% of each of phosphorus and sulphur may be present without detrimentally affecting the characteristics of the steel. This preferred stainless steel is quite tough and in the hardened condition has a Rockwell C hardness of 63 as compared with the Rockwell C hardness of from 64 to 66 for tool steel.

In order to deform the stainless steel as supplied by the manufacture into the balls of this invention, it has been found desirable to form the steel into wire of predetermined size depending upon the size of the balls which are to be manufactured therefrom. However, since the steel is quite hard, in order to conserve and prolong the life of the dies utilized in forming the steel into wire of predetermined size, the stainless steel is coated with a die lubricating metal such as copper or cadmium. The coating of die lubricating metal need not be excessive, it being found that a coating having a thickness of .0001 inch is satisfactory as the lubricant. Copper is preferred as the die lubricating metal since it can be readily applied to the steel in a number of known commercial ways. Further copper is comparatively inexpensive.

Even with the coating of die lubricating metal applied to the steel, it is found that the steel is too hard for commercially reducing it to any predetermined size of wire or rod. It is, therefore, necessary to anneal the coated wire to a tensile strength of from 90,000 to 110,000 pounds per square inch. This change in the tensile strength in the steel can be obtained by any suitable annealing technique, an example of which is to heat the steel to approximately 1350° F. for a period of time from four to six hours, after which the steel is permitted to cool very slowly in the furnace.

With the steel suitably annealed as described and coated with the die lubricating metal, copper, the steel is passed through suitable dies to effect a substantial reduction in area of the wire. In reducing the steel to a wire of any given predetermined size, it is found that a reduction of from 10 to 20% in area so increases the hardness of the stainless steel that an intermediate annealing operation must be performed before subjecting the steel to further reduction in area. The re-anneal may be a heat treatment similar to that described hereinbefore for reducing the tensile strength of the steel. If swaging dies are employed, it is possible to effect a reduction in area of the steel ranging up to as much as 60% in one pass. Alternate annealing of the wire and passing it through the die to effect further reductions in area are practiced until the desired size of wire is obtained.

With the stainless steel in the form of a wire having a predetermined size, the wire is cut into slugs 10 as illustrated in Fig. 1 of the drawing, the slugs having a predetermined length for producing a given size ball. These slugs also carry a coating 12 of the die lubricating metal as is illustrated in Fig. 2 of the drawing. The coating 12 is essential as will be explained more fully hereinafter and if it is found that the coating initially formed on the stainless steel has been removed from the steel during the annealing and swaging operations an additional coating of the die lubricating metal is applied to the wire before it is cut into the slugs of predetermined length. Thus the peripheral surface of the slug is entirely coated with the die lubricating metal. Although not necessary, where desired each individual slug may be subjected to any suitable plating process for applying a coating of the die lubricating metal over the cut ends of the slug to provide the entire slug with a coating of the die lubricating metal.

After the wire has been formed into the slugs as described hereinbefore, the slugs may again be annealed to impart a tensile strength of between 90,000 and 110,000 pounds per square inch to facilitate the forming of slugs into balls. In practice the annealed slug is placed between the opposing members 14 and 16 of an upsetting die as illustrated in Fig. 3 of the drawing and is subjected in the cold state to sufficient pressure to upset the slug 10 to form the ball 18 illustrated in Fig. 4 of the drawing, this ball being somewhat larger than the desired size of the finished ball. In the step of cold upsetting the slug to form the ball, it is found that the coating of die lubricating metal present on the peripheral surface of the slug prevents cracking of the slug and so lubricates the die members as to give them an exceedingly long life. Without the coating 12 of the die lubricating metal it is found that the slugs of high carbon stainless steel crack and the die members are destroyed in a very short time when the slug is subjected to the cold upsetting operation.

As illustrated in Fig. 4, the ball formed during the cold upsetting operation carries an equatorial band 20 and poles 22 of the stainless steel. In order to remove these projections and also to remove the remains of the coating of the die lubricating metal, and to present a substantially spherical surface having a uniform roughness, the balls 18 are subjected to a grinding procedure, preferably in a Hoffmann grinder, not shown, or some similar machine which rotates the ball between serrated filing plates. After the projections are removed, the balls are then subjected to a further suitable rough grinding operation such as is well known in the art. A grinding procedure which has been found to be satisfactory is to introduce the balls into a ball race, not shown, which consists of beveled rings and an abrasive wheel located off center just below the ring so that the balls travel around at a uniform rate in contact with the abrasive wheel until the required amount of the material has been removed from the surface of the high carbon stainless steel balls. The eccentricity between the abrasive wheel and the row of balls prolongs the life of the grinder since it prevents the formation of grooves in the wheel as the balls are ground.

In order that the finished balls may have the hardness desired, the balls are subjected to a suitable heat treatment after the rough grinding operation to secure the maximum hardness characteristics of the metal composition of the balls. These characteristics may be obtained by heating the balls at a temperature of 1350° F. for a period of time of three to six hours and then quenching the steel balls in any suitable medium such as oil or the like. After the balls have been hardened in this manner, they may be subjected to a final grinding operation to insure the presentation of a surface having a uniform roughness. This final grinding can be applied by any suitable grinder, it being preferred, however, that the grinding be done with a wheel having a predetermined abrasive size such as a 350 grit wheel or finer for obtaining the desired surface.

In order to polish the steel balls, it is necessary to employ a polishing agent or compound which is harder than the hardest constituent of the steel which is to be polished. A particular polishing compound which has been found to be satisfactory for the polishing of the high carbon stainless steel employed in this invention is an aqueous solution which carries aluminum oxide. In order to obtain the best polishing action at least 65% of the aluminum oxide crystals in the aqueous solution is of a size between 200 and 250 grit with the balance being a finer size. In particular, the preferred polishing compound comprises aluminum oxide in an aqueous solution of sodium carbonate, the aluminum oxide being present in the solution in the proportion of 12 grams to 250 c. c. of solution, the solution containing about 13.4 grams of sodium carbonate. This solution is very efficient in polishing the high carbon stainless steel balls, it being found that during the polishing operation as described hereinafter that the aluminum oxide crystals gradually become rounded, thereby efficiently polishing the balls.

In order to efficiently utilize the polishing compound, a quantity of the balls 18, having a uniform roughness, are placed in a tumbling barrel 24 as illustrated in Fig. 5 and which has a suitable opening (not shown) for this purpose, a sufficient amount of the polishing compound or solution being added to the mass of balls in the barrel to fill the barrel to its axis of rotation when it is in a horizontal position. The barrel is then rotated until the desired smoothness and polish is obtained on the balls.

As a specific example of the polishing operation, 2½ pounds of the rough ground balls were placed in a 7" diameter 2¼" deep steel barrel with a sufficient amount of the polishing compound to fill the barrel to its axis of rotation. The barrel was then rotated for approximately four days at a speed of 48 to 52 R. P. M. after which time it was found that the high carbon steel balls had a surface finish which was free from imperfections at a magnification of 175 diameters. Consistent results comparable to those obtained in the specific example may be obtained by following the teachings of this invention. In all cases a surface finish free from imperfections at a magnification of 150 diameters is obtained by following the method utilizing the polishing compound described hereinbefore.

After the desired polish has been give the balls as described hereinbefore, the balls are removed from the polishing barrel and freed from the polishing compound by rinsing them in clean running water, and then removing the excessive water from the balls. The balls are then agitated in acetone for a period of time of

five minutes, after which the excess acetone is removed therefrom and, if desirable, a further treatment in the acetone may be applied to the balls to ensure removal of all water and polishing compound therefrom. The acetone is then evaporated from the balls by any suitable means such as by heating the balls in an oven for fifteen minutes at a temperature of about 100° C.

As a general rule, the balls 18 removed from the polishing compound and treated as hereinbefore described have a very highly polished surface as illustrated in Fig. 6 of the drawing. However, if there appears to be any film present on the polish surface of the ball, the film may be removed by rotating the balls in a mixture of pulverized corn cob and shreads of chamois in another tumbling barrel which has been lined with a good grade of cloth such as velveteen. The rotation of the balls in the presence of the mixture of corn cob and chamois ensures cleanliness and luster to the surface of the high carbon stainless steel balls.

By practicing the teachings of this invention it has been found possible to cold upset slugs of high carbon stainless steel to form the steel into the approximate size of desired balls without damage to the balls or to the upsetting dies. Further by this method a very highly polished stainless steel ball is obtained, which, because of its composition, is very hard and tough, the combination of the polish and the characteristics of the steel giving an extremely long life to the resulting balls. In all cases the balls will have a surface finish free from imperfections at a magnification of at least 54 diameters and a hardness of from 58 to 64 Rockwell C. Although in the specific example referred to hereinbefore, a surface finish free from imperfections at a magnification of 175 diameters was obtained, balls have been produced by continued polishing which have such a high polish that their surfaces are free from imperfections at a magnification of 600 diameters. The stainless steel balls produced in accordance with this invention are, therefore, far superior to the high carbon steel balls or balls of other compositions utilized in the bearings of watthour meters prior to this invention.

Although this invention has been described with reference to a specific embodiment thereof, it is, of course, not to be limited thereto except insofar as is necessitated by the prior art and the scope of the appended claims.

I claim as my invention:

1. The method of producing stainless steel balls having a carbon content of from .9% to 1.1% comprising the steps of, coating the stainless steel with a die lubricating metal, annealing the coated steel to give it a tensile strength of between 90,000 and 110,000 pounds per square inch, forming the stainless steel into slugs of a predetermined size having a coating of lubricating metal on at least the peripheral portion thereof, cold pressing the coated slugs into balls of approximately the finished size, subjecting the cold pressed balls to a grinding operation to remove the lubricating metal therefrom and provide the balls with a surface having a uniform roughness, and polishing the balls with a polishing compound to give the balls a surface finish free from imperfections at a magnification of at least 54 diameters.

2. The method of producing stainless steel balls having a carbon content of from .9% to 1.1% comprising the steps of, coating the stainless steel with a die lubricating metal, annealing the coated steel to give it a tensile strength of between 90,000 and 110,000 pounds per square inch, forming the annealed steel into slugs of a predetermined size having a coating of lubricating metal on at least the peripheral portion thereof, annealing the formed slugs to impart a tensile strength of between 90,000 and 110,000 pounds per square inch to them, cold pressing the coated slugs into balls of approximately the finished size, subjecting the cold pressed balls to a grinding operation to remove the lubricating metal therefrom and provide the balls with a surface having a substantially uniform roughness, and polishing the balls with a polishing compound to give the balls a surface finish free from imperfections at a magnification of at least 54 diameters.

3. In the method of producing balls from high carbon stainless steel, in combination, coating the stainless steel with a die lubricating metal, annealing the steel to give it a tensile strength of between 90,000 and 110,000 pounds per square inch, forming the steel into slugs of predetermined size having a coating of die lubricating metal thereon, upsetting the slugs of steel having the coating thereon in the cold state to form the slug into the approximate shape of a ball, and grinding and polishing the ball formed by the cold upsetting to remove the coating of lubricating metal and give the ball a desired size and surface finish.

4. The method of producing stainless steel balls having a carbon content of from .9% to 1.1% comprising the steps of, coating the stainless steel with a die lubricating metal, annealing the coated steel to give it a tensile strength of between 90,000 and 110,000 pounds per square inch, forming the stainless steel into slugs of a predetermined size having a coating of lubricating metal on at least the peripheral portion thereof, cold pressing the coated slugs into balls of approximately the finished size, subjecting the cold pressed balls to a grinding operation to remove the lubricating metal therefrom and provide the balls with a surface having a uniform roughness, and polishing the balls with a polishing compound including aluminum oxide to give the balls a surface finish free from imperfections at a magnification of at least 54 diameters.

5. The method of producing stainless steel balls having a carbon content of from .9% to 1.1% comprising the steps of, coating the stainless steel with a die lubricating metal, annealing the coated steel to give it a tensile strength of between 90,000 and 110,000 pounds per square inch, forming the annealed steel into slugs of a predetermined size having a coating of lubricating metal on at least the peripheral portion thereof, annealing the formed slugs to impart a tensile strength of between 90,000 and 110,000 pounds per square inch to them, cold pressing the coated slugs into balls of approximately the finished size, subjecting the cold pressed balls to a grinding operation to remove the lubricating metal therefrom and provide the balls with a surface having a substantially uniform roughness, and polishing the balls with a polishing compound including aluminum oxide to give the balls a surface finish free from imperfections at a magnification of at least 54 diameters.

6. The method of producing stainless steel balls having a carbon content of from .9% to 1.1% comprising the steps of, coating the stain-

less steel with a die lubricating metal, annealing the coated steel to give it a tensile strength of between 90,000 and 110,000 pounds per square inch, forming the stainless steel into slugs of a predetermined size having a coating of lubricating metal on at least the peripheral portion thereof, cold upsetting the coated slugs into balls of approximately the finished size, subjecting the cold pressed balls to a grinding operation to remove the lubricating metal therefrom and provide the balls with a surface having a uniform roughness, and polishing the balls by rotating them in a sodium carbonate solution containing aluminum oxide to give the balls a surface finish free from imperfections at a magnification of at least 54 diameters.

7. The method of producing stainless steel balls having a carbon content of from .9% to 1.1% comprising the steps of, coating the stainless steel with a die lubricating metal, annealing the coated steel to impart thereto a tensile strength of between 90,000 and 110,000 pounds per square inch, drawing the coated steel into wire having a predetermined size, cutting the wire into slugs of predetermined length, the slugs having a coating of the lubricating metal on at least the peripheral portion thereof, annealing the slugs to impart thereto a tensile strength of between 90,000 and 110,000 pounds per square inch, cold working the coated slugs by cold heading the slugs along their length into balls of approximately the finished size, subjecting the cold headed balls to a grinding operation to remove the lubricating metal therefrom and provide the balls with a surface having a substantially uniform roughness, and polishing the balls by rotating them in a polishing compound containing aluminum oxide to give the balls a surface finish free from imperfections at a magnification of at least 54 diameters.

8. The method of producing balls from high carbon stainless steel comprising the steps of, coating the stainless steel with a die lubricating metal, alternately annealing the steel to give it a tensile strength of between 90,000 and 110,000 pounds per square inch and effecting a reduction in cross sectional area to produce a steel wire of predetermined size, cutting the wire into slugs of a predetermined size having a coating of the lubricating metal on at least the peripheral portion thereof, cold pressing the coated slugs into balls of approximately the finished size, and grinding and polishing the balls formed by the cold upsetting to remove the coating of lubricating metal and give the balls a required size and surface finish.

9. The method of producing balls from high carbon stainless steel comprising the steps of, coating the stainless steel with a die lubricating metal, annealing the coated steel to give it a tensile strength of between 90,000 and 110,000 pounds per square inch, forming the steel into slugs of a predetermined size having a coating of lubricating metal on at least the peripheral portion thereof, cold pressing the coated slugs into balls of approximately the finished size, subjecting the cold pressed balls to a grinding operation to remove the lubricating metal therefrom and provide the balls with a surface having a substantially uniform roughness, heat treating the balls to impart hardness thereto, and polishing the balls with a polishing compound to give the balls a surface finish free from imperfections at a magnification of at least 54 diameters.

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