This invention relates to writing instruments, and more particularly to an improved steel ball for ball point pens and the method for producing same.

The improved ball of the present invention is characterized by its exceptional durability and by the excellent writing properties that it imparts to a ball point writing instrument, as well as by the relatively low cost of producing such a ball.

The method of producing the improved ball of the present invention comprises the steps of subjecting a steel ball to a hardening operation to form a wear resistant crust or shell of appreciable thickness and with a minutely cavitated exterior surface.

In the past, the writing instrument industry has utilized several different types of steel balls in its ball point pens, e.g., carbon steel balls, polished stainless steel balls, stainless steel balls that have been subjected to a chemical etch to produce a roughened surface, and stainless steel balls that have been subjected to a mechanical abrasive action to produce a roughened surface.

The prior carbon steel ball was utilized by the writing industry when the so-called “oil based” inks were in vogue. However, when the so-called “quick dry” inks that are now used in the industry became available, the carbon steel ball was found to be no longer suitable because the chemicals used in these “quick dry” inks caused corrosion of the carbon steel ball.

The principal disadvantage of the polished stainless steel ball is its inability to grip the paper and to write on a greasy or slick surface.

Stainless steel balls that have been subjected to mechanical or chemical etching to develop a roughened surface have the disadvantage that they are unable to write on an oiled or slick surface after they have been used for a short while, because their roughened surfaces are quickly polished smooth by the abrasive action of the writing paper upon the roughened surface of the ball as it is rotated.

 Attempts to solve the problems encountered with various steel balls, by using a tungsten carbide ball or a synthetic sapphire ball, have not been commercially successful because both of these types of balls are so expensive and hence not suitable in economically-priced ball pens.

The ball of the present invention overcomes the advantages and limitations of all of the prior balls. This new ball has a hardened crust or shell of appreciable thickness or depth, that surrounds and encloses a core of a lesser hardness. The hardened shell provides durability and lasting properties in the ball, and the exterior exposed surface of the hardened shell has a minutely cavitated construction that is important to the efficient function of the ball in writing. These and other features of the ball of the present invention are illustrated in the accompanying drawings, in which:

FIG. 1 is a 200 power photomicrograph of a cross section taken through the center of the ball of the present invention, showing the nitrided crust or shell in the form of a ring that circumscribes the ball and extends inwardly for an appreciable distance and surrounds the unnitrided core of the ball; and

FIG. 2 is a 1400 power photomicrograph of a portion of the outer surface of the ball of the present invention, showing the closely spaced, cavitated exterior surface.

The deep, minutely spaced cavities on the surface of the ball, as seen in FIGS. 1 and 2, provide a reservoir for the writing ink and cause the pen to have excellent “starting” characteristics. This is made possible because the ball is initially mechanically textured during the preliminary grinding operation that is carried out to form the ball, and by the reaction between the chromium in the steel and the nitrogen supplied during the nitriding or hardening operation. The latter causes the formation of very small crystalline nitrides with consequent deepening of the cavities and production of more cavities per unit area. The case hardening operation gives permanence or durability to the closely spaced, minutely cavitated, textured surface so that this surface is not worn smooth by the abrasive action of paper upon the ball.

The ball of the present invention is resistant to corrosion by the chemicals in the “quick dry” inks. Also, in view of the fact that only the outer perimeter of the ball is hardened, the ball is not brittle. The ball of the present invention has the added advantage that it can be produced for about 1/3 the cost of a jewel ball and about 1/3 the cost of a tungsten carbide ball.

In general, the method of producing the ball of the present invention comprises the steps of mechanically generating a textured surface on a stainless steel ball through controlled grinding, and next nitriding the ball to perpetuate the textured surface and form a hardened, wear resistant, outer case with more closely spaced and deeper cavities upon its outer surface, and the hardened case extending in depth below the textured surface.

A more specific illustrative example of the method of producing the ball of the present invention is as follows:

Stainless steel wire having a diameter of 0.049±0.001” is cut along its length at intervals of 0.001” to form individual particles of steel wire or “chunks.” These steel “chunks” are next placed in a filing machine, and made round by repeated cycling between two steel plates. The lower plate of the filing machine has filing portions machined on its surface and the upper plate has wide grooves formed therein for containing and guiding the “chunks” during the repeated cycling. The pressure maintained on the “chunks” between the spaced plates varies from 3,300 p.s.i. to 4,400 p.s.i., and kerosene is introduced between the plates as a coolant. Approximately 150 hours are required to thus file the “chunks” into roughened round balls having a diameter of approximately 0.048±0.001”.

The roughened steel balls obtained from the above filing operation are next subjected to a grinding operation. To carry out this grinding operation, the roughened balls are placed between grooved machinest plates and are repeatedly cycled under a pressure of 3,300 p.s.i. Kerosene is utilized as the carrying medium and coolant between the plates, and aluminum oxide—100 grit—is introduced between the machinest plates to serve as the cutting abrasive for the grinding. The balls are thus ground for approximately 150 hours and are reduced in diameter to 0.043±0.001” with uniform sphericity.

The ground balls are next placed in a sealed container and hardened in a hardening furnace for two hours at 1900° F. When the balls are removed from the furnace, they are quenched in an agitated oil bath maintained at room temperature. This produces balls having a hardness within the range of 45 to 60 Rockwell “C” units.

The hardened balls are next aged by soaking them for two hours in a mixture of alcohol and Dry Ice, maintained at a temperature ranging between −70° F. and −75° F. The balls are removed from the mixture and allowed to return to room temperature.

The aged balls are next subjected to another grinding operation in order to generate textured surfaces upon the
 exteriors of the balls. The grinding machine with meehanite plates that was described above is again utilized. Aluminum oxide—600 grit—is introduced between the plates as the cutting abrasive in a kerosene carrying medium and coolant. The balls are subjected to a pressure of 2,200 p.s.i. and are ground for about 350 hours, until the diameter reaches \(0.03937 \pm 0.00001"\) (1 mm.). In this manner a textured surface is imparted to the exterior of the ball.

The textured balls are next subjected to a nitriding process, which comprises heating the textured balls to a temperature within the range of 950° F. to 1000° F. preferably to 975° F., and subjecting the balls to an atmosphere of dissociated ammonia gas at that temperature for a period of seven to eight hours, preferably 71/2 hours. The balls should be continuously agitated in a retort during this nitriding process so that the entire surface of each ball will be exposed to the dissociated ammonia gas, and the hardened case of each ball will be of generally uniform depth.

In the nitriding process, the nitrogen formed by dissociation of the ammonia in contact with the metal penetrates the metal for a considerable depth and combines with the chromium present in the steel to precipitate very tiny acicular crystalline nitrides. In addition to the nitrides of chromium, iron can form into nitrides and carbonitrides during the nitriding process. The presence of these hard particles imparts exceptional hardness to the nitrided case, and closely spaced, deepened, minute cavities are formed on the textured exterior surface. This hardness provides great resistance to wear, and the cavities of the textured surface impart desirable writing properties.

The hardened outer case produced by the above nitriding process extends into the ball a distance in excess of the depth of the textured surface, or to a total depth of about 0.005". The hardened outer case has a hardness rating of about 65 to 70 Rockwell "C" units, and the inner core has a hardness rating of about 45 to 60 Rockwell "C" units.

The present invention has been described in detail above for purposes of illustration only and is not intended to be limited by this description or otherwise except as defined in the appended claims.

I claim:

1. A highly durable, corrosion resistant, stainless steel ball for ball point writing instruments that minimizes ball socket wear, is capable of writing on slick surfaces and is capable of imparting good starting characteristics to the writing instrument, characterized in that the ball has a nitride hardened outer case with a closely spaced minutely cavitated surface, and a less hard central core.

2. An improved stainless steel ball for ball point writing instruments, characterized in that the ball has a closely spaced, minutely cavitated, textured exterior surface, a nitride hardened outer case that extends inwardly within the ball a distance in excess of the depth of the textured exterior surface, and a less hard central core.

3. A ball as defined in claim 1, and in which the outer case has a hardness within the range of 65 to 70 Rockwell "C" units and the central core has a hardness within the range of 45 to 60 Rockwell "C" units.

4. A ball as defined in claim 1, and in which the nitride hardened outer case extends inwardly within the ball to a depth of .005 inch.

5. A method of producing a highly durable, corrosion resistant, stainless steel ball for ball point writing instruments that minimizes ball socket wear, is capable of writing on slick surfaces and is capable of imparting good starting characteristics to the writing instrument, comprising mechanically generating a textured exterior surface upon the ball and case hardening the ball by a nitriding process.

6. A method of producing improved balls for ball point writing instruments, comprising cutting steel wire into chunks, rounding the chunks into balls, hardening the balls by heating them to high temperature and quenching them in oil, aging the balls, generating a textured exterior surface upon the balls, and heating the textured balls at about 950° F. to 1,000° F. in dissociated ammonia gas for about seven to eight hours.

References Cited in the file of this patent

UNITED STATES PATENTS

2,437,249 Fieo Mar. 9, 1948
2,536,124 Bolvin et al. Jan. 2, 1951
2,557,563 Reed June 19, 1951
2,788,302 Dew Apr. 9, 1957