A generally prolate-spheroidal, inflatable game ball with a plurality of air-turbulence-producing depressions distributed over a majority of the outer surface of the skin. The depressions produce a preferably circular surface shape, with a breadth of less than about one-quarter inch and preferably having a breadth to depth ratio of about 2 to about 6. The game ball of the present invention is preferably an American-style football, wherein the depressions are distributed substantially uniformly over the majority of the outer surface. A method for providing the game ball with altered aerodynamic performance may include forming depressions by embossing the skin or molding depressions therein.
FOOTBALL WITH A MODIFIED SURFACE
CONFEARING ALTERED AERODYNAMIC
PROPERTIES

FIELD OF THE INVENTION

[0001] This invention relates to game balls having a
generally prolate-spheroidal shape, particularly American-
style footballs, and to altering the aerodynamic behavior of
the balls by providing air-turbulence-generating depressions
in the surface thereof.

BACKGROUND OF THE INVENTION

[0002] In sports involving throwing, hitting, kicking or
otherwise impelling a game ball, the performance character-
stics of the ball can greatly affect the play of the game.
Properties of the ball such as the inflation pressure, rigidity,
and surface characteristics all influence the speed with
which the ball can be projected and the attributes of its flight.
Although the size, shape and weight of a particular kind of
ball are typically governed by the traditions and rules of the
given game, it is possible to modify or improve the perfor-
manee properties of a ball through altering its surface
properties. For instance, tennis balls with differing surface
properties of their felt coverings and different rigidities or
inflation pressures are well known to be used under different
circumstances.

[0003] Golf balls, which are of solid construction having
an enameled surface covering and a relatively dense resilient
core formed of rubber or synthetic plastics, ordinarily are
covered by dimples. In the history of development of the
golf ball, the surface was originally smooth, but it was
discovered from the experience of golfers that a dent ball
whose surface had been more or less covered with minute
depressions caused by impacts on the ball of hard objects
flew farther. Golf balls were then deliberately covered with
dents or dimples, small depressions in the surface, substi-
tually over their entire surface. This surface texturing pro-
vided such a distinct advantage that today all golf balls are
covered with such dimpling. The depressions on a typical
golf ball are about 0.5-1.5 mm in depth and are distributed
over the surface uniformly. The physical basis underlying the
improved flight characteristics of the dimpled golf ball has been explained as resulting from
turbulent flow of the air around a dimpled ball which in turn
causes less "flow separation" and a reduced aerodynamic
resistance to the ball's travel. Lift may also be generated by
a traveling golf ball which has been hit to impart a backspin.

[0004] Few other examples of surface texturing designed
to affect the aerodynamic performance, as opposed to the
grip, of game balls appear to be known. Another solid and
not inflatable ball, the baseball, has been modified by
covering the surface with depressions of a size similar those
found on golf balls. Thus, U.S. Pat. No. 4,256,304 discloses
a baseball suitable for use in an automated pitching machine
that is substantially covered with a multiplicity of cup-like
or hemispherical depressions. This modification is disclosed
to enable the ball to travel greater distances with enhanced
accuracy.

[0005] Depressions on an inflatable spherical game ball have
also been disclosed in U.S. Pat. No. 5,518,234, although the
depressions are much larger than those used on
golf balls. The depressions are stated to be for the purpose
of improving the player's grip on the ball. Each depression
is of an approximate size to a fingertip to allow the player to
grasp a ball having a larger convex surface than is otherwise
possible. No disclosure is provided regarding any alteration
of aerodynamic properties of this ball.

[0006] The type of ball used in the game of American-
style football possesses an almost unique shape among the
various types of game balls; perhaps only the ball used in the
game of rugby resembles the elongate American-style foot-
ball. The term "generally prolate-spheroidal shape" is used
herein as a convenient characterization of a ball having, in
essence, the shape of an American-style football, and not in
the strict mathematical sense of an ellipse rotated about an
axis. When the term "football" is used herein, it is under-
stood to refer to an American-style football, rather than to
the spherically shaped "football" or "soccer ball" that much
of the world outside the United States usually understands
the word to mean.

[0007] The unusual shape of the American-style football
produces some unique properties of flight when it is thrown,
as rotation imparted to the ball such that it rotates about its
longitudinal axis produces quite a different resulting flight
than does rotation imparted to the ball about any other axis.
The football being circular in transverse section but oval
shape in longitudinal section, the first kind of rotation
produces a "spinning" flight in which the ball translates
along a path defined by the longitudinal axis of the ball while
spinning about that axis, whereas the second kind of rotation
results in the ball tumbling end over end. In a spiraling flight,
rotation or "spin" of the football about its longitudinal axis
provides for lessened aerodynamic resistance to forward
travel as the ball is gyroscopically stabilized to translate
point first through the air, a configuration that is more
streamlined than a tumbling flight produces. The rotation of
the ball also provides for a more stable trajectory, similar to
the stability of flight imparted to a bullet fired from a rifled
barrel. Minor imperfections in the surface which would
otherwise result in deviation from the planned flight path or
unpredictability of position after the ball has traveled some
distance, are averaged out by the spinning action, so the
flight is more true.

[0008] The surface of the football is typically smooth but
may be slightly convexly textured to aid in gripping the ball.
A common form of surface texturing to aid in gripping
the ball on a football is a knobby texture consisting of small
bumps projecting outwardly from a base, covering the
exterior of the ball. While regulation footballs also have a
laced seam whereby an air bladder is placed inside the outer
skin of the ball, which may also be griped by the player and
where the fingertips of someone endeavoring to throw the
football are placed in common practice, many footballs such
as those molded from plastic do not have a separate air
bladder which must be inserted into the shell, but are inflated
with a needle and thus do not have laces, or have only
simulated laces. Otherwise, apart from the surface texturing,
the football typically has a featureless surface.

[0009] A number of examples of texturing of the surface of
a football can be found. U.S. Pat. No. 2,866,644 discloses
a football with a "non-slip" surface for improving the grip
of the ball by the player. The surface is covered with ribbing
whose main axis is at an angle of about 30 degrees to the
longitudinal axis of the football. U.S. Pat. No. 4,772,020
discloses a football with helical groove that provides for improved handling. U.S. Pat. Nos. 5,851,161 and 5,984,812 disclose a grippable surface for throwable objects including footballs which comprise a mesh panel that fits over the surface of the ball. U.S. Pat. Nos. D3488,524 and D491,240 show a football with pyramidal pebble texturing of the surface. However, these various texturing features address the handling of the football, rather than the aerodynamic properties of the football.

**SUMMARY OF THE INVENTION**

**[0010]** The present invention provides a generally prolate spheroidal game ball with a plurality of air-turbulence-producing depressions distributed over a majority of the outer surface of the skin. The depressions are preferably circular in shape, with a breadth of less than about one-quarter inch and preferably having a breadth to depth ratio equaling about 2 to about 6, and a surface density of about 23 to about 27 depressions per square inch. The game ball of the present invention is preferably an American-style football, substantially covered by a regular array of the depressions. When the football transits through the air, particularly when the football is thrown in a spiral pass wherein it rotates only around its longitudinal axis while translating through the air, air turbulence induced by the depressions alters the aerodynamic properties of the football. The depressions reduce separation of the flow of air by the translating ball and thus reduce air resistance, resulting in a longer flight for a given initial impetus. The depressions also reduce air resistance to the spinning motion, thus allowing for a more prolonged spin and a decreased rate of loss of rotational velocity for a given initial rotational impetus, which results in improved, longer-lasting gyroscopic stabilization of the flight.

**DESCRIPTION OF THE DRAWINGS**

**[0011]** FIG. 1 shows side view of an inflatable, prolate spheroidal game ball according to the present invention.

**[0012]** FIG. 2 shows a cross-sectional view of a section of the skin of a game ball according to the present invention.

**[0013]** FIG. 3 shows a detailed view of a preferred embodiment of the depressions in a game ball skin according to the present invention.

**DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT**

**[0014]** Referring to FIG. 1, a preferred embodiment of a prolate spheroidal game ball according to the present invention comprises an American-style football 10. As viewed from the side, the football is substantially oval-shaped, although the ends 12 are typically blunt rather than smoothly curving as in a perfect ellipse. However, the ends may be smoothly curving as in a rugby ball, rather than blunt, without departing from the principles of the present invention. Elsewhere the outer surface 14 of the football forms a smooth monotonic curve. In the preferred embodiment, the football has a length of about 11½ inches, a diameter of about 6½ inches, and a measurement from end to end over the surface of the football of about 13½ inches. The football 10 is circular in any cross-section taken perpendicular to the longitudinal axis of the ball. The cross section taken along the mid-point line of FIG. 1 in the plane of longitudinal symmetry of the ball has the greatest diameter.

**[0015]** Thus, a football according to the present invention has a generally prolate spheroidal shape, that is, the solid figure obtained by rotating an ellipse about its major axis. It may however deviate somewhat from the ideal form by not being prolate spheroidal in the strict mathematical sense, for instance not being truly elliptical in longitudinal cross-section, or as indicated above, in having the two blunt ends typical of the American-style football.

**[0016]** The football 10, which is hollow and formed of an at least moderately flexible skin 16, sometimes enclosing an air bladder 18 as is shown in FIG. 2, preferably assumes substantially the dimensions stated upon inflation with air or another suitable gas. The skin is preferably formed of leather, rubber, plastic, or similar suitable material that is both at least moderately flexible and is resistant to tearing or puncturing. The preferred air bladder, which may be constructed of any suitable material, pressurizes the skin upon inflation.

**[0017]** Alternatively, the skin of the football may be supported by a foam material in which the air pressure in the foam cells is introduced at the time of formation of the foam. In this alternative embodiment, the game ball is not hollow in the strict sense of the word, but is filled with an elastic foam which contains many minute individually hollow cells. Regardless, the skin 16 is preferably tough enough to withstand damaging abrasion during handling and play and to protect the air bladder, if any, from puncture and the resulting loss of air pressure.

**[0018]** Typically, the football is inflated to a pressure within a range suitable to confer sufficient elasticity and rigidity to allow it to be firmly grasped, to maintain its shape when subject to acceleration upon being thrown or kicked, but also permitting elastic deformation allowing the football to bounce, or to be kicked substantial distances. Normally the football is filled with air via a port (not shown) in the skin and bladder that allows for insertion of a hollow needle attached to a source of compressed air, the port then closing to seal the air in the bladder when the needle is removed. Alternatively, the ball may be filled with an elastic foamed material, preferably a plastic, wherein the gas that induces the foaming in the resin used to form the foam is trapped within the cells of the foam, providing resiliency. When the term “inflated” or “inflatable” is used herein, it is defined as covering both means of providing internal air pressure to keep the ball elastic.

**[0019]** If the skin is formed of leather, it typically comprises several segments of elongated shape that are stitched together at their edges and at the ends to form the covering. If the skin is formed of rubber or plastic, it may be molded into shape. During construction of the football, the air bladder is inserted into the interior prior to the final closing of the skin by stitches, adhesives or the like.

**[0020]** Turning to FIGS. 2 and 3, the game ball according to the present invention is provided with depressions 22 on the surface of the ball; the skin is preferably substantially covered by the small depressions. The depressions serve to create air turbulence when the ball is moving relative to the air. The amount of turbulence created is dependent upon a number of factors including the size, breadth and depth of
the depressions 22, as well as their shape, their density and distribution over the surface, the total proportion of the surface that is covered by the depressions, and the relative velocity of the skin of the ball to the air. Preferably, about 23 to about 27 depressions per square inch cover the surface of the football 10.

[0021] Preferably the depressions 22 on the preferred football 10 are circular in shape, about 1/8 inches in diameter, and about 1/8 inch deep with a hemispherical profile as shown in FIG. 3. They preferably substantially uniformly cover a majority of or substantially the entire surface of the ball, such as in a close-packed hexagonal array, but other arrangements may be employed without departing from the principles of the present invention. The preferred size, shape and distribution of the depressions 22 results in a game ball the size and shape of the preferred football 10 shown in FIG. 1, a total number of about 3500 depressions being disposed on the football.

[0022] Turning to FIG. 2, a cross-sectional detail of a section of the football’s covering shows the skin 16 and an air bladder 18 respectively on the outer and inner surfaces thereof. The depressions 22 are preferably hemispherical in contour in the depth dimension. The unmodified skin areas 24 between the depressions 22 form a substantially continuous surface or network over the surface of the football. Depending on the size and spacing and thus the density of the depressions, the unmodified skin areas may constitute a greater or lesser proportion of the total surface area of the football. In the preferred embodiment wherein there are about 23 to about 27 depressions per square inch, each depression being a circle of diameter 1/8 inches, the skin areas 24 comprise about 30% and the depressions 22 comprise about 70% of the total surface area of the football 10.

[0023] However, the depressions may be of other shapes, sizes and distributions over the outer skin of the ball without departing from the principles of the present invention. For example, the depressions may be polygonal, or even irregularly shaped. For example, the depressions could be hexagonal in form. The depressions may be close packed, or may be substantially separated from each other over the outer skin of the game ball.

[0024] The depressions serve to alter the aerodynamic properties of the game ball when it is traveling through the air after being thrown or kicked. The aerodynamic properties of a game ball according to the invention are altered to a greater or lesser degree depending upon the variables as outlined above. Analogously to the operation of depressions on a golf ball as described above, the depressions on the game ball according to the present invention serve to create air turbulence as the ball flies, which lessens aerodynamic resistance by diminishing “separation of the flow.” However, due to the relative asymmetry of a football, compared to the spherical symmetry of a golf ball, the football according to the present invention displays some unique aerodynamic properties.

[0025] Particularly when a football is thrown in a “spiral” pass, as discussed above, the depressions on the surface of the football 10 according to the invention alter the aerodynamic properties of the ball and thus the trajectory of the flight. While a football that is kicked generally tumbles end over end in flight, a spiraling pass will cause the football to rotate only on its longitudinal axis as it translates through the air. The special two-fold motion of the spiraling pass, that is, the forward translational motion and the rotational motion on the longitudinal axis, results in the depressions on the ball’s skin bringing about desirable aerodynamic effects. In this type of motion especially, the presence of depressions 22 have an effect compared to when the ball is not spinning or is tumbling more slowly than the spiraling rotation. The reduced air resistance to translational motion of a ball covered with depressions, due to diminished separation of the flow of the surrounding air, allows a pass thrown with a given force to travel further due to the reduction in air resistance of the ball in flight. In addition, the reduced air resistance to rotation induced by the depressions allows a ball thrown with an initial rotational impetus to continue to rotate longer and at a higher rate, providing for enhanced stability of flight due to gyroscopic stabilization of the ball’s flight.

[0026] Thus, both an increased distance that can be achieved by a throw of a given force, and an increased accuracy over the enhanced distance obtained from the throw of a given force, are desirable aerodynamic results. Contrary to the result that is obtained with a baseball, where spin put on the ball results in a “curve” or deviation from the theoretical flight path due to the spin of a baseball about an axis other than the axis defined by the baseball’s direction of flight, the spin of the football along its longitudinal axis in a football according to the principles of the present invention enhances the gyroscopic stabilization of the flight of the football.

[0027] The depressions 22 may be introduced onto the surface of the football 10 using a variety of suitable methods. If the skin 16 is formed of leather, the depressions may be impressed into the surface through the use of a die under pressure. The leather surface then may optionally be coated, hardened or fixed as is known in the art. Alternatively, a flat leather surface may be ablated by suitable means, such as by drilling or grinding out the recesses, particularly in the case of circular depressions. The leather so-treated is then assembled into the intact ball. If the skin is to be formed of rubber the depressions may either be molded in place prior to vulcanization of the rubber, or may be embossed with a die or ground out as in the case of the leather. If the skin is to be formed of plastic, the depressions may similarly be formed in place during the molding operation when the plastic monomer is polymerized in a mold, or may be embossed or ground subsequent to the polymerization operation. In the case of a plastic ball which may be cast or molded in final three-dimensional form in a single operation rather than as a flat structure or set of structures that are assembled by stitching or gluing as in the case of a leather skin, the depressions may be emplaced at the time of formation of the intact football.

[0028] The terms and expressions which have been employed in the foregoing specification are used therein as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding equivalents of the features shown and described or portions thereof, it being recognized that the scope of the invention is defined and limited only by the claims which follow.
1. A game ball, comprising:
   a flexible, inflatable skin having a generally prolate-spheroidal shape when inflated; and
   a plurality of depressions formed in the skin, the depressions being distributed over the majority of the outer surface of the skin and having sufficient depth and breadth to cause turbulence when the ball is thrown through the air.
2. The game ball of claim 1, wherein the depressions are distributed substantially uniformly over the outer surface of the skin.
3. The game ball of claim 1, wherein the depressions are distributed in a substantially hexagonal array over the outer surface of the skin.
4. The game ball of claim 1, wherein the depressions form substantially circular shapes in the outer surface of the skin.
5. The game ball of claim 4, wherein the depressions have a diameter of less than about one-half inch.
6. The game ball of claim 4, wherein the depressions have a diameter of less than about one-quarter inch.
7. The game ball of claim 4, wherein the depressions have a surface diameter to depth ratio of about 2 to about 6.
8. The game ball of claim 4, wherein the depressions comprise a substantially hemispherical surface.
9. The game ball of claim 8, wherein the depressions have a surface diameter to depth ratio of about 2 to about 6.
10. The game ball of claim 1, wherein the ratio of the maximum surface breadth to depth of a majority of the depressions is about 2 to about 6.
11. The game ball of claim 1, wherein the surface density of the depressions is about 23 to about 27 depressions per square inch inclusive.
12. The game ball of claim 1, wherein the depressions have a diameter of less than about one-quarter inch.
13. The game ball of claim 1, wherein the skin comprises a material selected from among leather, rubber, or plastic.
14. The game ball of claim 1, wherein the skin forms a hollow inflatable interior.
15. The game ball of claim 1, wherein the skin is inflated by an air bladder.
16. The game ball of claim 1, wherein the skin is inflated by an elastic foam material.
17. A method for providing a generally prolate-spheroidal game ball with altered aerodynamic performance, comprising
   providing a flexible, inflatable skin having a generally prolate-spheroidal shape when inflated; and
   forming a plurality of depressions in the skin, the depressions being distributed over the majority of the outer surface of the skin and having sufficient depth and breadth to cause turbulence when the ball is thrown through the air.
18. The method of claim 17, further comprising distributing the depressions substantially uniformly over the outer surface of the skin.
19. The method of claim 17, wherein the skin provided is comprised of one of rubber or leather, and the depressions are formed in the skin by embossing the skin with a die.
20. The method of claim 19, wherein the skin is first formed as one or more substantially flat sections, all or a portion of the sections are embossed with the depressions, and the one or more sections are thereafter stitched into the hollow, inflatable form.
21. The method of claim 17, wherein the skin provided is comprised of plastic, and the depressions are formed by molding them into the plastic.