



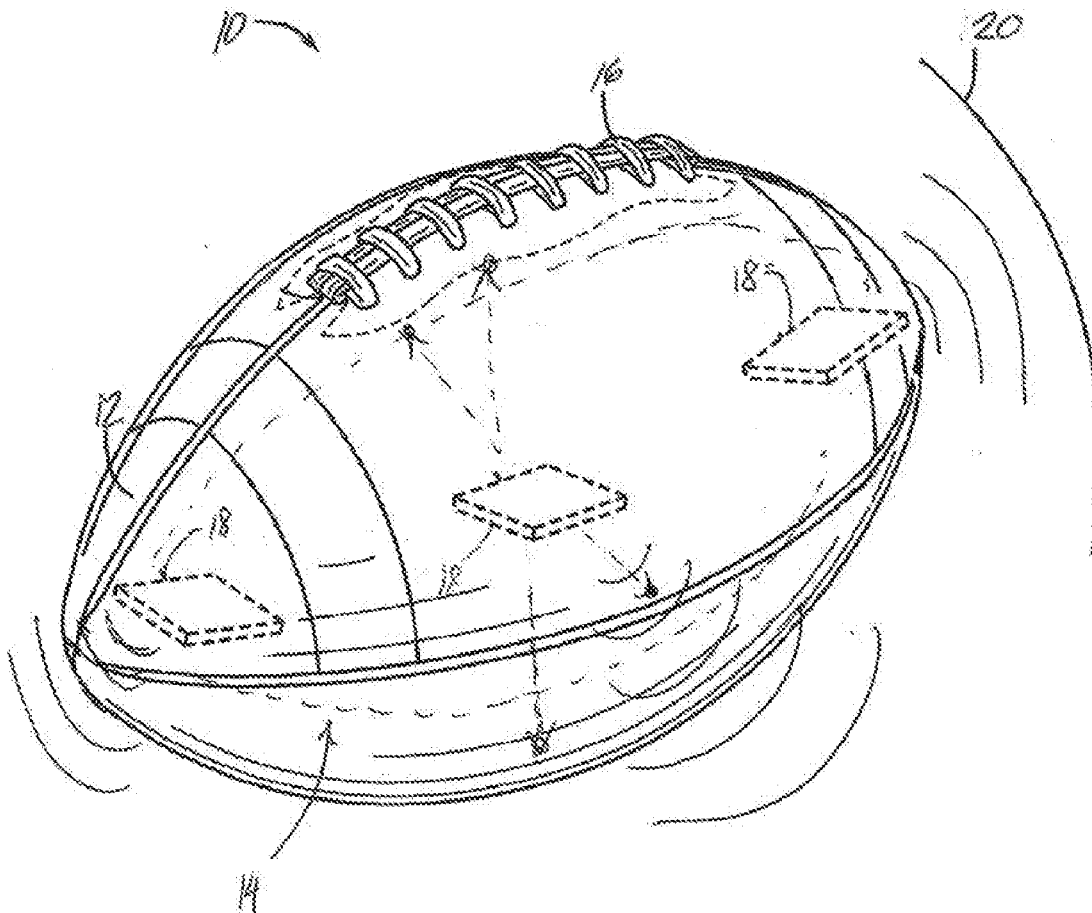
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(19) **United States**(12) **Patent Application Publication**
Bergman(10) **Pub. No.: US 2018/0193694 A1**(43) **Pub. Date: Jul. 12, 2018**(54) **RFID-BASED LOCATION IDENTIFICATION
IN ATHLETIC EQUIPMENT AND ATHLETIC
PLAYING FIELDS**(52) **U.S. Cl.**CPC *A63B 24/0021* (2013.01); *A63B 43/002*
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37/00 (2013.01); *A63B 2024/0025* (2013.01);
A63B 41/00 (2013.01)(71) Applicant: **Rick C. Bergman**, Grafton, WI (US)(72) Inventor: **Rick C. Bergman**, Grafton, WI (US)(21) Appl. No.: **15/864,830**(22) Filed: **Jan. 8, 2018****Related U.S. Application Data**(60) Provisional application No. 62/443,456, filed on Jan.
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(57)

ABSTRACT

A system for determining a position of one or more pieces of athletic equipment on an athletic playing surface is provided. The system includes one or more pieces of athletic equipment each including therein an RFID chip, the RFID chip comprising an electronic circuit configured to produce and transmit an RF signal. The system also includes an array of sensors positioned on or in proximity to the athletic playing surface and configured to receive RF signals from the RFID chip of each of the one or more pieces of athletic equipment. The system also includes a processing system operably connected to the array of sensors to receive data from the array of sensors, the processing system programmed to process the data from the array of sensors to determine a position of each of the one or more pieces of athletic equipment on the athletic playing surface.



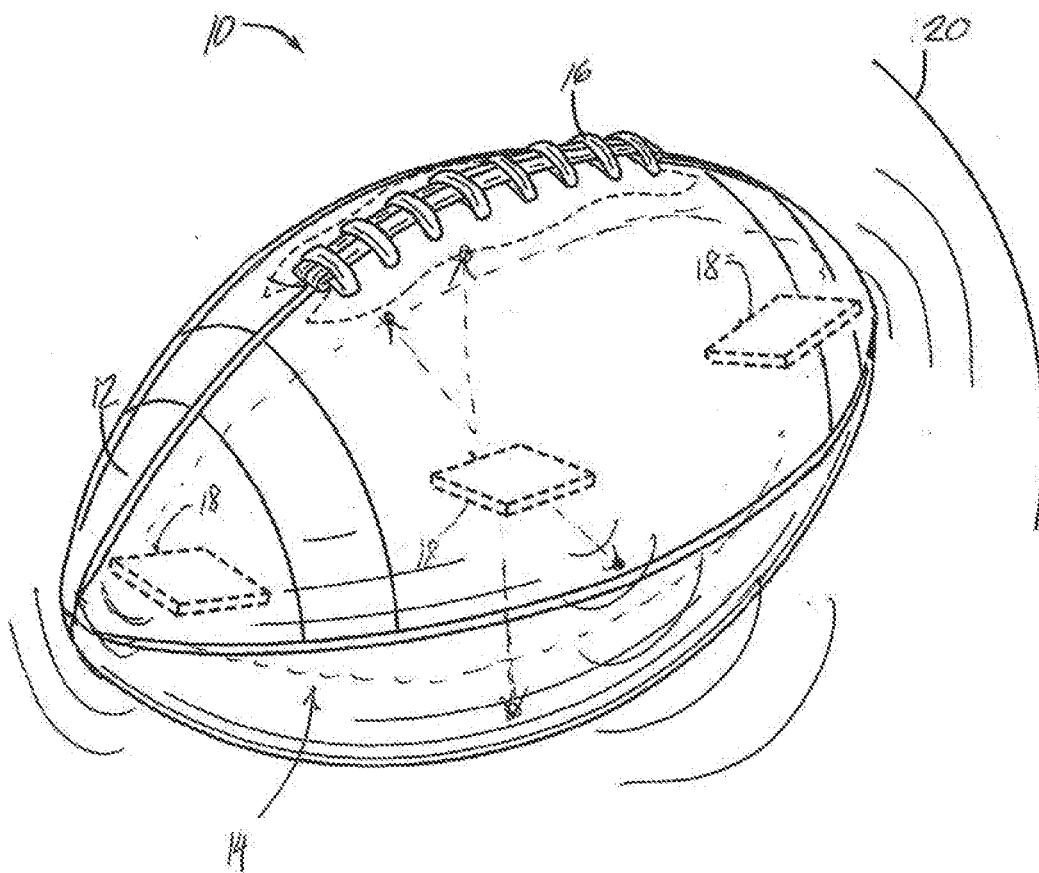


FIG. 1

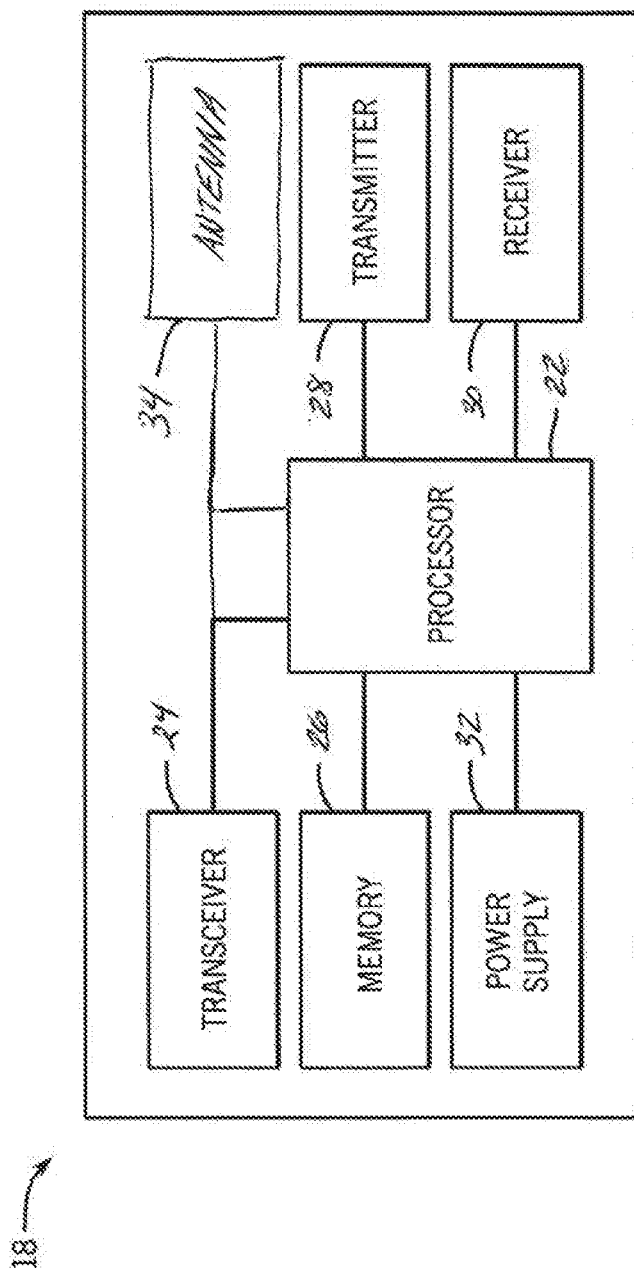


FIG. 2

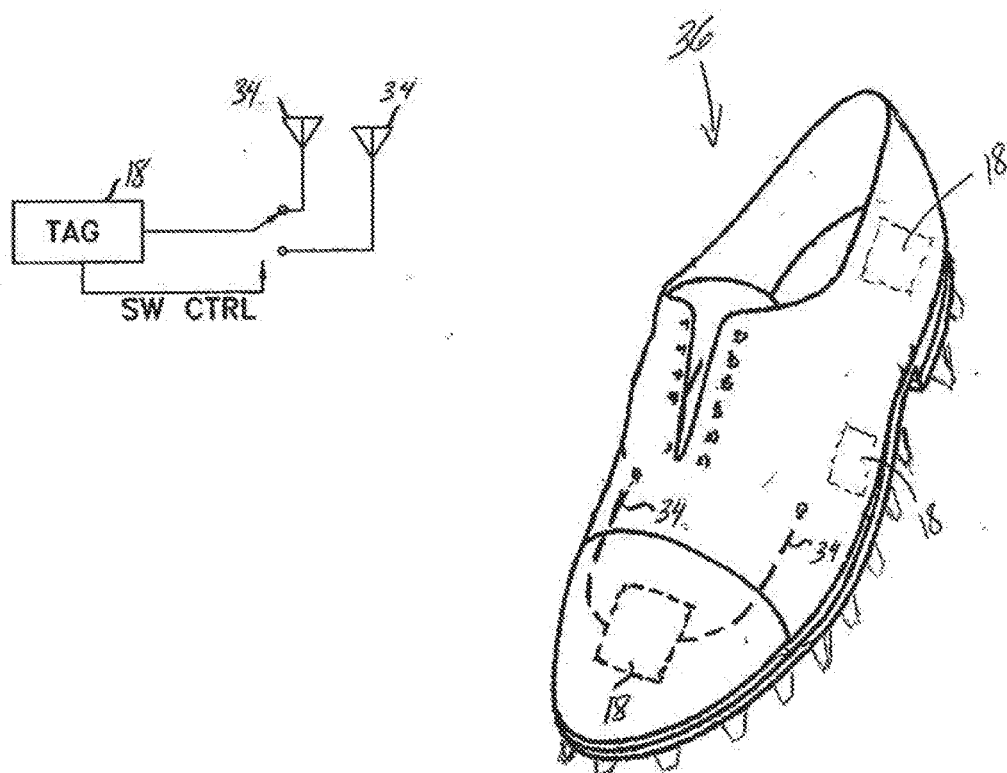


FIG. 3

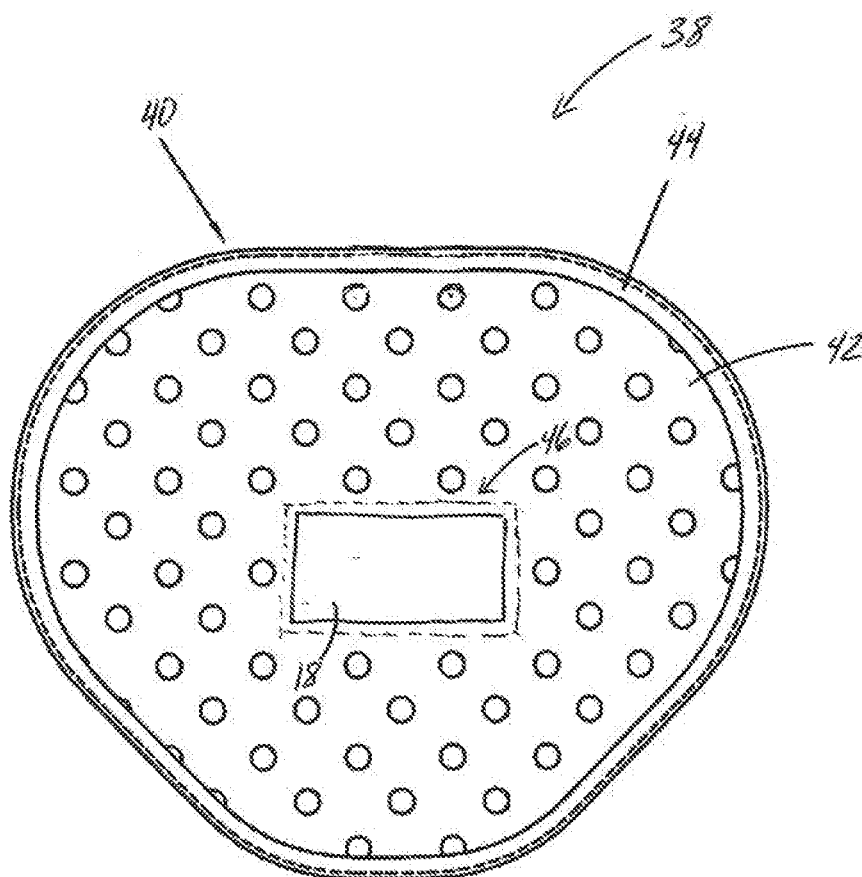


FIG. 4

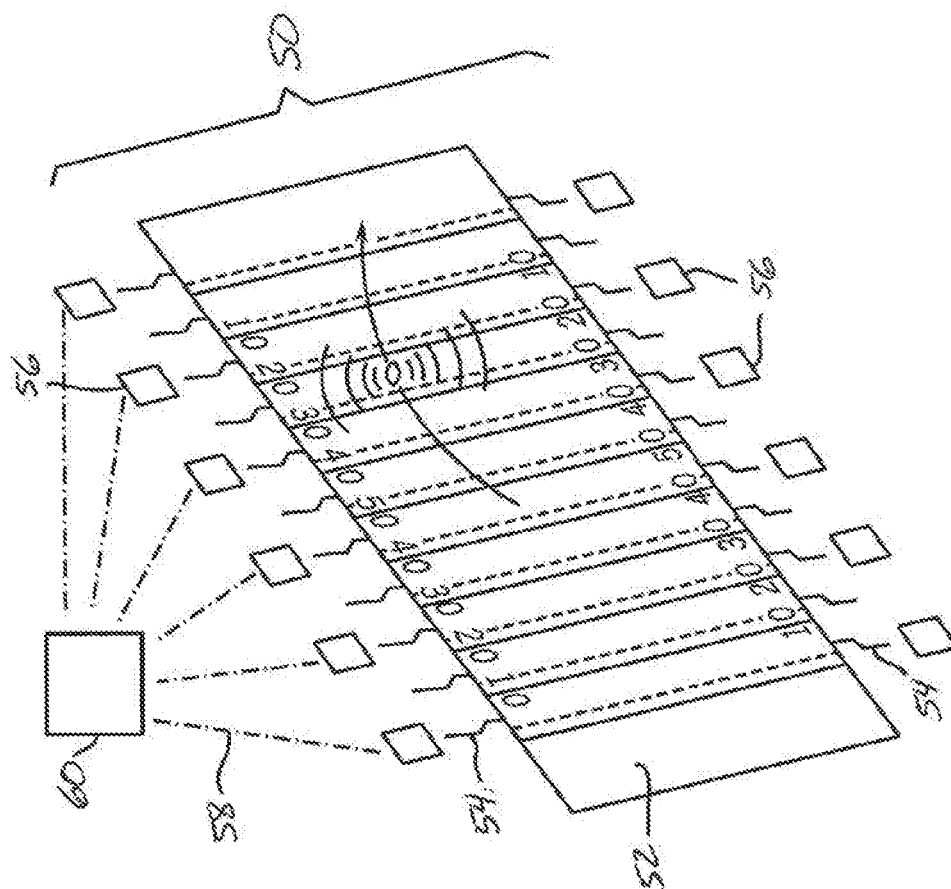


FIG. 5

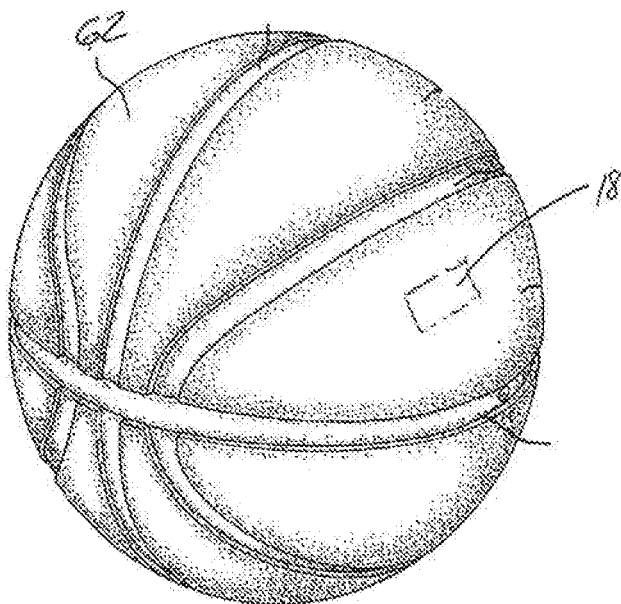


FIG. 6

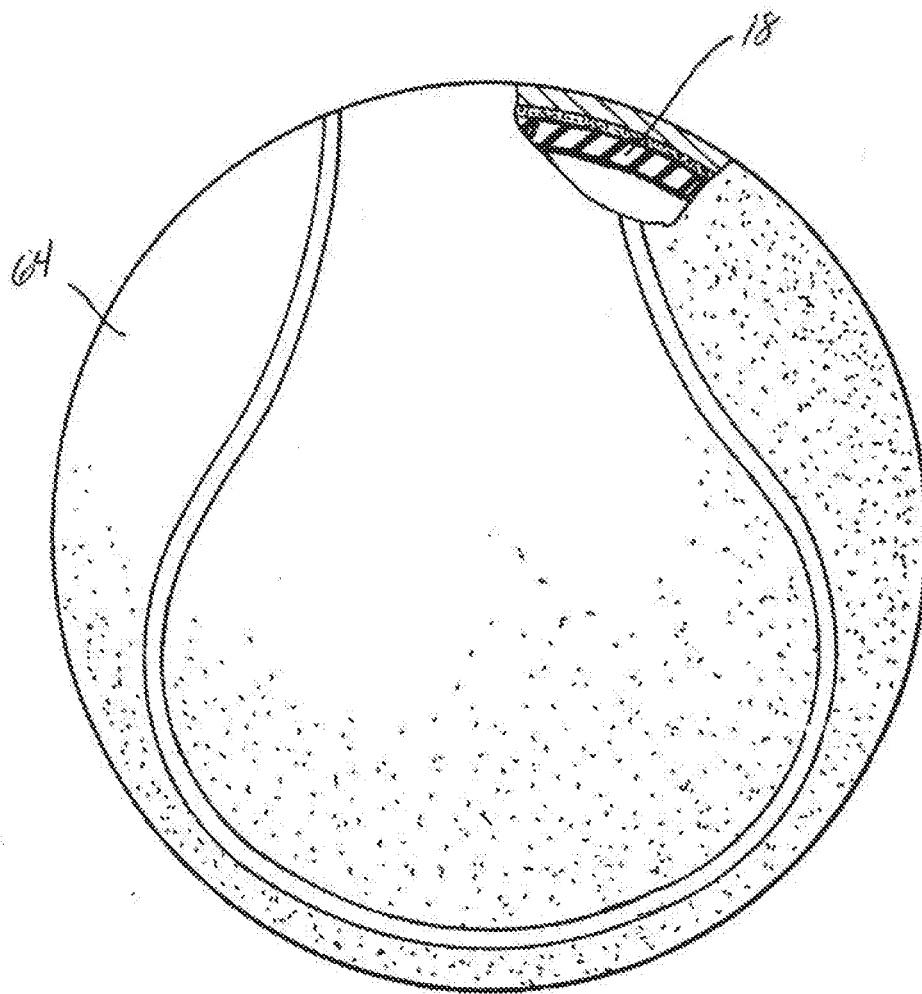


FIG. 7

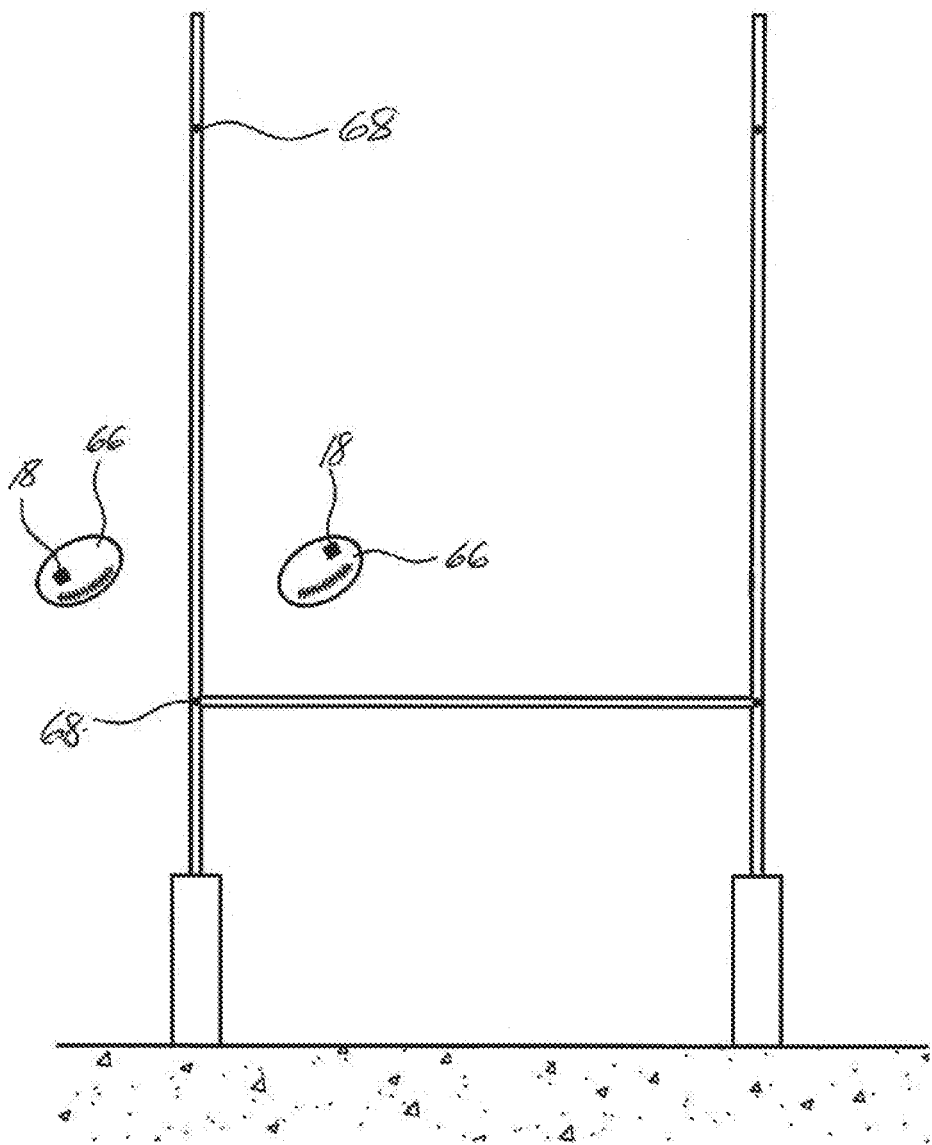


FIG. 8

RFID-BASED LOCATION IDENTIFICATION IN ATHLETIC EQUIPMENT AND ATHLETIC PLAYING FIELDS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application is a non-provisional of, and claims priority to, U.S. Provisional Patent Application Ser. No. 62/443,456, filed Jan. 6, 2017, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] Embodiments of the invention relate generally to sporting events and, more particularly, to the use of RFID-based location identification in athletic equipment and athletic playing fields in various sporting events.

[0003] Over the 20 years, the popularity of amateur and professional sports has continued to grow exponentially. By some estimates, amateur and professional sports and the activities associated therewith brings roughly \$14.3 billion in earnings a year in the United States, for example. Part of the appeal of amateur and professional sports is the fast-paced, action-packed nature of such events, with sports such as American-style football, basketball, baseball, rugby, tennis and soccer being some of the more popular sports watched by consumers.

[0004] In many sports, the location of a player or ball being used relative to an out-of-bounds boundary or other playing field marker/location is important to the game. That is, the occurrence of a player or ball contacting an out-of-bounds boundary may cause stoppage of a play (American football), possession of the ball to go to an opposing team (basketball, soccer) or points being awarded to a player (tennis). Thus, it is recognized that the accurate determination of if/when a player or ball contacts an out-of-bounds boundary is important to the outcome of the game.

[0005] An exemplary illustration of the importance of the accurate determination of a player or ball is provided in American football. Organized football games typically include several officials (referees, umpires, head line men, line judges, back judges, field judges and side judges) whose primary responsibilities are to monitor play including the position of the football. In recent years, professional football leagues (including the National Football League®) and amateur leagues (including the NCAA®) have adopted the use of video replays to assist officials in reviewing disputed calls during the course of a football game. Often the position of a football during the play is the primary issue under dispute. For example, whether the football crossed the goal line of the end zone during a play, or whether a player's forward progress with the football during a play passed the first down marker on the field of play. The goal line is an imaginary plane extending upward from the line of paint at the edge of the end zone (goal line) on the field of play. These decisions or calls by the officials on the field or in the replay booth can be very difficult at times due to line of sight limitations of the officials and/or the cameras used to film the game action.

[0006] Further, the players themselves can increase the difficulty of tracking or determining the position of a football during a play. Because football plays involve tackling and blocking, often the players themselves obstruct a clear view of the football during a play. It is also not uncommon for an

official to make an incorrect call on a play due to the position of the official during the play and the angle of the official's view of the play itself. Even video replays can result in incorrect decisions or inconclusive evidence based upon the positions of the video cameras taping the football game. Additionally, player's often attempt to reposition and improve the position of the football after the play has been whistled dead or over by the official. In some instances, the official may not detect such late repositioning of the football by a player. An incorrect goal line or first down call can be a determinative factor in the outcome of a football game.

[0007] Video replays have improved the integrity and accuracy of the game official's decisions or calls during a game. However, in many cases, the process of stopping the game to review the video tape evidence of a disputed play can take several minutes. Spectators of football games often find such delays to be too long, boring and/or disruptive to the flow of the game. Many coaches believe a few minute delay to review a disputed call can negatively affect a team's emotional level, and overall momentum. Others believe the time needed to complete a football game in general has been too long, even before the introduction and incorporation of replay reviews of disputed plays.

[0008] Therefore, it would be desirable to provide a system or method that improves the monitoring and observation of the football game action to minimize the occurrences of incorrect decisions by officials, particularly those decisions involving the position of the football during a play. It would further be desirable for such a system or method more accurately monitor the football game during play, including the position of the football, without introducing undesirable delays to the football game. Such improving of the monitoring and observation of a game action to minimize the occurrences of incorrect decisions by officials is also desirable in numerous other sports, including but not limited to basketball, baseball, rugby, tennis, hockey and soccer, for example.

BRIEF DESCRIPTION OF THE INVENTION

[0009] In accordance with one aspect of the present invention, a system for determining a position of one or more pieces of athletic equipment on an athletic playing surface is provided. The system includes one or more pieces of athletic equipment each including therein an RFID chip, the RFID chip comprising an electronic circuit configured to produce and transmit an RF signal. The system also includes an array of sensors positioned on or in proximity to the athletic playing surface and configured to receive RF signals from the RFID chip of each of the one or more pieces of athletic equipment. The system also includes a processing system operably connected to the array of sensors to receive data from the array of sensors, the processing system programmed to process the data from the array of sensors to determine a position of each of the one or more pieces of athletic equipment on the athletic playing surface.

[0010] In accordance with another aspect of the present invention, a wearable location tag system includes a wearable article comprising a shoe or kneepad worn by a football player and one or more RFID chips incorporated into the wearable article and configured to produce and transmit an radio-frequency RF signal therefrom. Each of the one or more RFID chips comprises an electronic circuit that includes a processor configured to store data, instructions, and programs thereon, including timing instructions for

generating RF signals to be transmitted, and a transceiver and antenna operably connected to the processor to send and receive RF signals to exchange information and data with one or more remote outside sensors incorporated into a football field. Interaction of the one or more RFID chips with the one or more remote outside sensors enables determination of a position of the wearable article on the football field.

[0011] In accordance with yet another aspect of the present invention, an athletic ball includes an outer layer and one or more RFID chips embedded in the athletic ball under the outer layer and configured to produce and transmit an radio-frequency RF signal therefrom. Each of the one or more RFID chips comprises an electronic circuit that includes a processor configured to store data, instructions, and programs thereon, including timing instructions for generating RF signals to be transmitted, and a transceiver and antenna operably connected to the processor to send and receive RF signals to exchange information and data with one or more remote outside sensors incorporated into an athletic playing surface. Interaction of the one or more RFID chips with the one or more remote outside sensors enables determination of a position of the athletic ball on the athletic playing surface.

[0012] Various other features and advantages will be made apparent from the following detailed description and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The drawings illustrate embodiments presently contemplated for carrying out the invention.

[0014] In the drawings:

[0015] FIG. 1 is a diagram of a football that incorporates an electronic chip/RFID tag circuit therein, according to an embodiment of the invention.

[0016] FIG. 2 is a schematic diagram of the electronic chip/RFID tag circuit of FIG. 1, according to an embodiment of the invention.

[0017] FIG. 3 is a diagram of a shoe that incorporates an electronic chip/RFID tag circuit therein, according to an embodiment of the invention.

[0018] FIG. 4 is a diagram of a kneepad that incorporates an electronic chip/RFID tag circuit therein, according to an embodiment of the invention.

[0019] FIG. 5 is a schematic diagram of a monitoring system for monitoring the location of a football and/or player athletic equipment, according to an embodiment of the invention.

[0020] FIG. 6 is a diagram of a basketball that incorporates an electronic chip/RFID tag circuit therein, according to an embodiment of the invention.

[0021] FIG. 7 is a diagram of a tennis ball that incorporates an electronic chip/RFID tag circuit therein, according to an embodiment of the invention.

[0022] FIG. 8 is a diagram of a rugby ball that incorporates an electronic chip/RFID tag circuit therein, according to an embodiment of the invention.

DETAILED DESCRIPTION

[0023] Embodiments of the present invention are directed to the use of RFID-based location identification in athletic equipment and athletic playing fields in various sporting events. An RFID tag is incorporated in a ball or in piece of

athletic equipment worn by a player, in order to identify the location of the ball or equipment on the field or court. An associated monitoring system is arranged on the field or court that interact with the RFID tag to provide for such location identification. Based on the identified location of the ball or piece of athletic equipment, events of interest within the game can be determined/identified—such as a player or ball contacting an out-of-bounds boundary or particular line/marker on the field.

[0024] Referring to FIG. 1, an American football—such as might be used in football games conducted by the NFL® and NCAA®—is indicated generally at **10** according to an exemplary embodiment. The football **10** is one example of an inflatable game ball in/with which embodiments of the invention may be incorporated; however, other aspects and features of the present invention are applicable to other sports games, balls and equipment, such as, for example, basketballs, volleyballs, soccer balls, baseballs, softballs, lacrosse balls, tennis balls, hockey pucks, and rugby balls.

[0025] With respect to the football **10** illustrated in FIG. 1, the football is an inflatable object having a major longitudinal dimension and a minor transverse dimension. The football **10** is configured to be grasped, thrown, caught, kicked, and carried by a player during use. The football **10** includes, a cover **12**, a bladder **14**, a lacing **16**, and electronic chips **18**. It is recognized that a rugby ball would have a similar construction to football **10** shown in FIG. 1 regarding inclusion and placement of electronic chips **18** therein.

[0026] The electronic chips **18** or circuits are optimally positioned on or within the football **10** to optimize the effectiveness of the electronics and to minimize or eliminate any negative impact the electronics may have on the play, feel and/or performance of the football **10**. The positioning of the electronic chips **18** can also improve the feel, play and/or performance of the football **10**. Each electronic chip **18** is a circuit including one or more devices and may be configured to actively transmit one or more electronic signals **20** used to indicate the location and movement of the football. Alternatively, the electronic chip **18** can include a passive circuit that allows for the detection of the location and movement, of the football to be ascertained when subjected to a magnetic field or other sensing system. The electronic chip **18** has a weight and size that does not affect performance of the football during use, with a weight of less than 1 ounce, and more preferably, a weight of less than 0.5 ounce, being desirable.

[0027] In an exemplary embodiment, the electronic chips **18** are thin, flexible radio frequency identification (RFID) tags/chip circuits that can be applied to the football, i.e., to the bladder or an intermediate layer of the football. Each RFID tag circuit **18** is an integrated circuit for storing and processing information, and modulating and demodulating a radio-frequency (RF) signal. The RFID tag circuit **18** also includes at least one antenna for receiving and transmitting the signal. The RFID tag circuit **18** can be passive or active, with an active tag including a battery as a power source. In other alternative preferred embodiments, the RFID tag circuit **18** can be a wire mesh, or a pattern or a circuit configured to affect a magnetic field or create a voltage change as it moves through or about a sensing area. In other alternative preferred embodiments, the RFID tag circuit **18** is configured with one or more receivers, transmitters, transceivers, power sources, processors, micro-controllers and switches. The RFID tag circuits **18** can be applied as a

patch or a layer at desired locations about or within the football 10 including on the inner or outer surface of the cover 12, within the cover 12, on or within the bladder 14 or within other layers such as winding layers, linings, and padding layers. An RFID tag circuit 18 can also be advantageously positioned beneath the lacing 16 for additional protection and positioning away from the kicking region of the football 10.

[0028] As shown in FIG. 1, in an exemplary embodiment, a plurality of RFID tag circuits 18 are included in the football 10 at locations generally corresponding to the ends of the football and each of four sides of the football 10. Positioning of the tag circuits 18 at such locations allows for a sensing of each end and surface of the football, which is desirable in determining where the nose of the ball is positioned on a field, as well as sides of the ball—which may be necessary in determining if the ball has crossed the goal line during play, has reached a first down marker, etc.

[0029] Referring to FIG. 2, an electronic chip/RFID tag circuit 18 is shown in more detail. The electronic chip 18 includes a plurality of electronic devices such as, for example, sensors, receivers, transmitters, transceivers, power supplies, memory, micro-processors, micro-controllers, analog to digital converters, and combinations thereof. The electronic chip 18 can be arranged with a wide range of combinations of one or more of these components. In the particular embodiment of FIG. 2, the electronic chip 18 includes a circuit having a processor 22, a transceiver 24, memory 26, a transmitter 28, a receiver 30 and a power supply (i.e. battery 32). The processor 22 is preferably a micro-processor or a micro-controller capable of processing algorithms, routines, programs and/or applications. The processor 22 can include a timer or sample rate capability. The memory 26 is operably associated with the processor 22 and is used to store data, instructions, programs, and files. The memory 26 can include read only memory and random access memory.

[0030] The transceiver 24 is a combination of a receiver and a transmitter that is operably coupled to the processor 22. The transceiver can be coupled to an antenna 34. The transceiver 24 can send or receive a signal, such as the electronic signal 20, and to exchange information and data with a remote outside sensor, a receiver, a server, a computer, a network of computers or the Internet. The transmitter 28 and the receiver 30 can also be used to send and receive, respectively, a signal representing information and data for communication with a remote sensor, transmitter, receiver, server, computer, computer network or the Internet. The transmitter 28 and receiver 30, along with the battery 32 and the sensor 76, are also operably coupled to the processor 22. Accordingly, the electronic chip/RFID tag circuit 18 is capable of receiving and transmitting data that, as will be explained in greater detail below, can be used to identify the location of the football 10 to a precise degree within a field of play.

[0031] While FIGS. 1 and 2 illustrate the inclusion of an electronic chip/RFID tag circuit 18 within a football 10 (or rugby ball) for purposes of tracking a location of the ball, it is recognized that other positioning information may be of use during the course of play of an athletic event, such as in a football game. As an illustrative example, it may be highly desirable to be able to determine when a ball carrier has stepped out of bounds during a play and/or if a ball carrier has made contact with the ground during a play such that he

should be ruled down. To provide for such determinations, embodiments of the invention are further directed to the incorporation of an electronic chip/RFID tag circuit 18 within other athletic equipment besides the ball itself, such as in the footwear or kneepads of a player, for example.

[0032] FIG. 3 depicts a shoe 36 that includes electronic chips/RFID tag circuits 18 embedded therein, such as in the top-front portion of the shoe 36, the heel of the shoe 36 and in outer edge/side of the shoe—so as to enable positional determination of a player's toes/heel/sidefoot on a field relative to an out-of-bounds line, for example. Antennas 34 are embedded in the sides of the shoe 36, with one of the antennas running along the convex side of the shoe 36 and the other of the antennas running along the concave side of the shoe 36. The placement of electronic chip/RFID tag circuits 18 in the FIG. 3 shoe 36 can be accomplished during manufacture of the shoe 36, which might easily achieve water tightness of electronic chip/RFID tag circuit 18. Alternatively, electronic chip/RFID tag circuits 18 may be purchased separately, and installed into the shoe 36 by placing a tag in a pocket that is manufactured in the shoe 36 for that purpose.

[0033] FIG. 4 illustrates a perspective view of one embodiment of a kneepad 38 that includes an electronic chip/RFID tag circuit 18 embedded therein. The kneepad 38 may have a generally conventional construction and thus be formed a single foam board 40 made of PE (polyethylene) or EVA (ethylene vinyl acetate) cut into a pad-shaped main unit 42 in a pre-determined shape. The peripheries of the pad-shaped main unit 42 may be defined with edge wrapping by a side strap 44 made of fabric or rubber. In one embodiment, a recessed portion or cavity 46 may be formed in the foam board 40 that may be shaped/sized to receive the electronic chip/RFID tag circuit 18 therein. While electronic chip/RFID tag circuit 18 is shown in FIG. 4 as generally being centered on kneepad 38, it is recognized that the RFID chip will be placed where a player's knee ends, which can be determined generally from a player's height, or more specifically from the specific team and information provided thereby, so as to monitor a vertical positioning of the kneepad relative to the field and thereby enable proper determination of when a player's knee contacts the ground, for example.

[0034] The electronic chip/RFID tag circuit 18 included in the football 10 and/or athletic equipment 36, 38 illustrated in FIGS. 1-4 can be used in association with a monitoring system 50 that monitors the football 10 and/or equipment 36, 38 over an entire football field 52. According to one embodiment, the football field 52 can be configured with an array of wires 54 for creating a magnetic field about the football field 52. Preferably, the array of wires 54 are configured to run beneath the football field 52. The array 54 can extend from one side of the field to the other at spaced apart intervals. The intervals can range from being quite small (within inches) to larger distances (100 yards apart or greater). Alternatively the array can take other paths about or beneath the field. A plurality of sensors 56 can be positioned adjacent the array of wires 54 beneath, over or near the football field 52. According to one embodiment, the sensors 56 transmit one or more signals 58 representative of data or information relating to changes in the magnetic field due to movement of the football 10 and/or equipment with respect to the field. According to another embodiment, the sensors 56 transmit one or more signals 58 representative of data or

information relating to RF signals received from the football 10 and/or equipment—and a change in timing with respect to the receipt of those RF signals—due to movement of the football 10 and/or equipment with respect to the field. The signals 58 are received by a receiver 60 which can be coupled to a remote reader, microprocessor, computer, transmitter, server, network of computers and/or the Internet. The sensors 56 and/or the receiver 60 can also process the signal 58 to desired usable information. The monitoring system can be used to monitor, detect and report: the exact position of the football 10 and/or equipment 36, 38 on the football field 52 and the movement of the football 10 and/or equipment 36, 38 on and about the football field 52. The accuracy of the system 50 can be improved by the number and orientation of the array of wires 54 and/or the number of sensors 56 under, on, or about the football field 52. The system 50 can be configured to detect movement of a football 10 and/or equipment 36, 38 on the football field 52 to within the nearest 10 millimeters. In other preferred embodiments, the electronic chip can include a GPS transmitter, receiver and/or transceiver.

[0035] The combination of the electronic chip/RFID tag circuit(s) 18 included in the football 10 and/or equipment 36, 38 and in the monitoring system 50 provides for a precise determination of a location of the football 10 and/or equipment 36, 38 within football field 52. Based on the identified location of the ball 10 or piece of athletic equipment 36, 38, events of interest within the game can be determined/identified—such as a player or ball contacting an out-of-bounds boundary or particular line/marker on the field 52.

[0036] Footballs 10 and/or equipment 36, 38 built in accordance with the present invention will thus allow for more information about the game to be available to officials, football league representatives, and fans. The present invention can be used to significantly improve the accuracy and integrity of official's decisions regarding important game issues such as determining whether the football crossed the goal line or a first down marker during a play, the forward progress of the football during a play, the knee of a player making contact with the ground during a play, and/or a player making contact with the out-of-bounds boundary during play. The present invention will enable an official to access such information quickly and easily.

[0037] Footballs 10 and/or equipment 36, 38 built in accordance with the present invention can also be used to reduce the number of plays that require a replay review, or can be used to shorten the timeframe used to review a play. The present invention will reduce the likelihood of an incorrect call being made during a game that can improperly affect the outcome of a game. The present invention allows for the accurate position of the football 10 equipment 36, 38 to be determined regardless of whether: the official had the proper view of the play; the replay cameras had a proper angle of the play; the players' bodies obscured the view of the football; and/or the player(s) repositioned the football after the play had been ruled dead.

[0038] While a detailed description of embodiments of the invention being incorporated into a football 10 and related football equipment 36, 38 has been set forth above, it is recognized that embodiments of the invention are not limited specifically to football. That is, the system of the present invention could be applied to various kinds of ball games, including football, rugby, volleyball, baseball, basketball,

etc., to provide the referee, umpire, or judge with positional information that helps hopefully avoid inaccurate judgments or rulings in the game.

[0039] In one embodiment, the electronic chip/RFID tag circuit(s) 18 may be employed in a basketball game. In such an embodiment, the electronic chip/RFID tag circuit(s) 18 would be incorporated into a basketball 62 (FIG. 6) as well as the shoes 36 (FIG. 3) of the players. In a basketball game, the ball 62 or shoes 36 of a player touching the ball that contact any of the end lines and sidelines is considered as being out-of-bounds. However, it is very possible that the referee is blocked by ball players and may not see that the ball 62 or shoes 36 of a player touches a borderline. Inclusion of the electronic chip/RFID tag circuit(s) 18 within the ball 62 or shoes 36 of players—along with use of a monitoring system 50 within the court (such as shown in FIG. 5) may be used to sense when the ball 62 or shoes 36 of a player touches a borderline, thereby removing the inaccuracy/inability of a referee to spot all such occurrences. In the system of the present invention, a ball 62 or shoe 36 touching the end line or sideline would cause the monitoring system 50 to detect such an occurrence and notify the referee.

[0040] In another embodiment, the electronic chip/RFID tag circuit(s) 18 may be employed in a tennis match. In such an embodiment, the electronic chip/RFID tag circuit(s) 18 would be incorporated into a tennis ball 64 (FIG. 7). In a tennis match, a ball 64 that contacts any of the boundary lines or service lines is considered as being in-bounds. However, it is very possible that the umpire and/or line judges may not clearly see whether the ball strikes a line during play due to the high speed of the ball and the closeness of the ball to the line. Inclusion of the electronic chip/RFID tag circuit 18 within the ball 64—along with use of a monitoring system 50 within the court (such as shown in FIG. 5) may be used to sense when the ball 64 touches a line, thereby removing the inaccuracy/inability of the umpire and/or line judges being able to make such a determination. In the system of the present invention, a ball 64 touching the boundary lines or service lines would cause the monitoring system 50 to detect such an occurrence and notify the umpire.

[0041] In still another embodiment, the electronic chip/RFID tag circuit(s) 18 may be employed in a rugby match. In such an embodiment, the electronic chip/RFID tag circuit(s) 18 would be incorporated into a rugby ball 66 (FIG. 7). In a rugby match, it may be desirable to know when the ball 66 passes through goal posts 68 during a drop goal attempt. However, in some instances, it may be difficult for a referee to determine when the ball 66 passes through the goal posts 68 during such an attempt. Inclusion of the electronic chip/RFID tag circuit 18 within the ball 66—along with use of a monitoring system 50 within the field (such as shown in FIG. 5) may be used to sense when the ball 66 passes through the goal posts 68, thereby removing the inaccuracy/inability of the referees being able to make such a determination. Additionally, and as described with respect to FIG. 5 (and FIG. 6), it may also be desirable to determine when the shoe 36 (FIG. 3) of a player strikes a boundary line on the rugby field, and usage of electronic chip/RFID tag circuit(s) 18 in the shoes of the players would enable the monitoring system 50 to detect such an occurrence and notify the referees.

[0042] Beneficially, embodiments of the invention thus provide a system and method that improves the monitoring and observation of the sporting event action to minimize the occurrences of incorrect decisions by officials, particularly those decisions involving the position of the ball during a play and or the ball/player being in-bounds or out-of-bounds during a play. An RFID tag is incorporated in a ball or in piece of athletic equipment worn by a player, in order to identify the location of the ball or equipment on the field or court. An associated monitoring system is arranged on the field or court that interact with the RFID tag(s) to provide for such location identification. Based on the identified location of the ball or piece of athletic equipment, events of interest within the game can be determined/identified—such as a player or ball contacting an out-of-bounds boundary or particular line/marker on the field.

[0043] While a number of sports and associated balls/equipment have been shown and described above in/with which embodiments of the invention may be implemented, it is recognized that embodiments of the invention may also extend to almost any sport in which a ball is used during gameplay. Such sports include: Angleball, Baseball, Basketball, Basque pelota, Bocce, Boules, Bowling, Bowls, Candlepin bowling, Carpet bowls, Duckpin bowling, Five-pin bowling, Nine-pin bowling, Ten-pin bowling, Irish road bowling, Molkky, Canoe polo, Codeball, Cricket, Croquet, Cue sports (e.g., billiards), Carom billiards, English billiards, Pool (or pocket billiards), Snooker, Cycle ball, Dodgeball, Downball, Fistball, Fives, Flickerball, Floorball, Football, Association football (Soccer), Futsal, Indoor Soccer, Australian rules football, Beach soccer, English public school football games, Gaelic football, Gridiron football, American football, Canadian football, Indoor football, Arena football, Football tennis, International rules football, Medieval football games, Rugby football, Rugby league, Rugby union, Underwater rugby, Wheelchair rugby, Underwater football, Footvolley, Four square, Golf, Grifball, Half-rubber, Handball, American handball, Australian handball, Gaelic Handball, Hooverball, Hurling, Jai alai, Jorkyball, Juggling, Kickball, Kick-to-kick (includes end-to-end footy), Klootschieten, Korfball, Lacrosse, Lawn bowls, The Mesoamerican ballgame, Netball, Newcomb ball, Omnikin Ball, Paddle ball, Pelota mixteca, Pétanque, Polo, Bicycle polo, Canoe polo, Elephant polo, Horseball, Polocrosse, Segway polo, Yak polo, Push ball, Quidditch, Racquetball, Rapid ball, Ringball, Ringo, Rock-It-Ball, Rounders, Rugby, Rugby league, Rugby union, Sepak takraw, Shinty, Skee ball, Soccer, Softball, Squash, Stickball, Stickball (Native American), Streetball, Table football (foosball), TagPro (Browser game), Tchoukball, Team handball, Tee ball, Tetherball, Ulama, Valencian pilota, Escala i corda, Llargues, Raspall, Valencian fronto, Underwater sports, Volleyball, Beach volleyball, Wheelchair volleyball, Waboba, Water basketball, Water polo, Wiffleball, and Wireball.

[0044] Therefore, according to an embodiment of the invention, a system for determining a position of one or more pieces of athletic equipment on an athletic playing surface is provided. The system includes one or more pieces of athletic equipment each including therein an RFID chip, the RFID chip comprising an electronic circuit configured to produce and transmit an RF signal. The system also includes an array of sensors positioned on or in proximity to the athletic playing surface and configured to receive RF signals from the RFID chip of each of the one or more pieces of

athletic equipment. The system also includes a processing system operably connected to the array of sensors to receive data from the array of sensors, the processing system programmed to process the data from the array of sensors to determine a position of each of the one or more pieces of athletic equipment on the athletic playing surface.

[0045] According to another embodiment of the invention, a wearable location tag system includes a wearable article comprising a shoe or kneepad worn by a football player and one or more RFID chips incorporated into the wearable article and configured to produce and transmit an radio-frequency RF signal therefrom. Each of the one or more RFID chips comprises an electronic circuit that includes a processor configured to store data, instructions, and programs thereon, including timing instructions for generating RF signals to be transmitted, and a transceiver and antenna operably connected to the processor to send and receive RF signals to exchange information and data with one or more remote outside sensors incorporated into a football field. Interaction of the one or more RFID chips with the one or more remote outside sensors enables determination of a position of the wearable article on the football field.

[0046] According to yet another embodiment of the invention, an athletic ball includes an outer layer and one or more RFID chips embedded in the athletic ball under the outer layer and configured to produce and transmit an radio-frequency RF signal therefrom. Each of the one or more RFID chips comprises an electronic circuit that includes a processor configured to store data, instructions, and programs thereon, including timing instructions for generating RF signals to be transmitted, and a transceiver and antenna operably connected to the processor to send and receive RF signals to exchange information and data with one or more remote outside sensors incorporated into an athletic playing surface. Interaction of the one or more RFID chips with the one or more remote outside sensors enables determination of a position of the athletic ball on the athletic playing surface.

[0047] While the invention has been described in detail in connection with numerous embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

What is claimed is:

1. A system for determining a position of one or more pieces of athletic equipment on an athletic playing surface, the system comprising:

one or more pieces of athletic equipment each including therein a radio frequency identification (RFID) chip, the RFID chip comprising an electronic circuit configured to produce and transmit an radio-frequency (RF) signal;

an array of sensors positioned on or in proximity to the athletic playing surface and configured to receive RF signals from the RFID chip of each of the one or more pieces of athletic equipment; and

a processing system operably connected to the array of sensors to receive data from the array of sensors, the processing system programmed to process the data from the array of sensors to determine a position of each of the one or more pieces of athletic equipment on the athletic playing surface.

2. The system of claim 1 wherein the processing system is further programmed to process the data from the array of sensors to track movement of each of the one or more pieces of athletic equipment on the athletic playing surface.

3. The system of claim 1 wherein the one or more pieces of athletic equipment comprises shoes worn by players competing on the athletic playing surface.

4. The system of claim 3 wherein the RFID chip in the shoe comprises RFID chips embedded in the shoe in a top-front portion of the shoe, a heel of the shoe, and in an outer edge of the shoe, so as to enable positional determination of a player's toes, heel, and sidefoot on the athletic playing surface relative to an out-of-bounds line.

5. The system of claim 1 wherein the one or more pieces of athletic equipment comprises kneepads worn by players competing on the athletic playing surface.

6. The system of claim 5 wherein the RFID chip in the kneepads enable determination of a vertical positioning of the kneepads relative to the athletic playing surface, so as to enable determination of when a player's knee contacts the athletic playing surface.

7. The system of claim 1 wherein the one or more pieces of athletic equipment comprises one of a football, basketball, volleyball, soccer ball, baseball, softball, lacrosse ball, tennis ball, hockey puck, or rugby ball.

8. The system of claim 7 wherein, when the one or more pieces of athletic equipment comprises a football or rugby ball, the RFID chip comprises RFID chips embedded in the football or rugby ball at locations generally corresponding to ends of the football or rugby ball and each of four sides of the football or rugby ball, so as to enable determining of the position of each end and surface of the football or rugby ball on the athletic playing surface.

9. The system of claim 7 wherein the athletic playing surface comprises one of a football field and a rugby field that includes goal posts thereon, and wherein the RFID chips in the football or rugby ball, and the interaction thereof with the array of sensors, enable the processing system to determine when the football or rugby ball passes through the goal posts during a kick.

10. The system of claim 1 wherein a weight of the RFID chip is less than 1 ounce, and wherein the weight and a size of the RFID chip does not affect performance of the ball or puck during use.

11. A wearable location tag system comprising:

a wearable article comprising a shoe or kneepad worn by a football player; and

one or more radio frequency identification (RFID) chips incorporated into the wearable article and configured to produce and transmit an radio-frequency (RF) signal therefrom;

wherein each of the one or more RFID chips comprises an electronic circuit that includes:

a processor configured to store data, instructions, and programs thereon, including timing instructions for generating RF signals to be transmitted; and

a transceiver and antenna operably connected to the processor to send and receive RF signals to exchange information and data with one or more remote outside sensors incorporated into a football field; and

wherein interaction of the one or more RFID chips with the one or more remote outside sensors enables determination of a position of the wearable article on the football field.

12. The wearable location tag system of claim 11 wherein, when the wearable article is a shoe, the interaction of the one or more RFID chips with the one or more remote outside sensors enables positional determination of a shoe's toe, heel, and sidefoot on the football field relative to an out-of-bounds line.

13. The wearable location tag system of claim 11 wherein, when the wearable article is a kneepad, the interaction of the one or more RFID chips with the one or more remote outside sensors enables determination of a vertical positioning of the kneepad relative to the football field, so as to enable determination of when the kneepad contacts the football field.

14. An athletic ball comprising:

an outer layer; and

one or more radio frequency identification (RFID) chips embedded in the athletic ball under the outer layer and configured to produce and transmit an radio-frequency (RF) signal therefrom;

wherein each of the one or more RFID chips comprises an electronic circuit that includes:

a processor configured to store data, instructions, and programs thereon, including timing instructions for generating RF signals to be transmitted; and

a transceiver and antenna operably connected to the processor to send and receive RF signals to exchange information and data with one or more remote outside sensors incorporated into an athletic playing surface; and

wherein interaction of the one or more RFID chips with the one or more remote outside sensors enables determination of a position of the athletic ball on the athletic playing surface.

15. The athletic ball of claim 14 wherein the athletic ball comprises one of a football, basketball, volleyball, soccer ball, baseball, softball, lacrosse ball, tennis ball, hockey puck, or rugby ball.

16. The athletic ball of claim 14 wherein interaction of the one or more RFID chips with the one or more remote outside sensors enables positional determination of the athletic ball relative to an out-of-bounds line or other boundary line on the athletic playing surface.

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