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(71) Applicant(s):
Fram3 Limited
117 Abbotsford House, Trawler Road,
Maritime Quarter, SWANSEA, West Glamorgan,
SA1 1YH, United Kingdom

(72) Inventor(s):
Muddasir Lakhani
Muzzamil Lakhani

(74) Agent and/or Address for Service:
Urquhart-Dykes & Lord LLP
UDL Intellectual Property, 7th Floor, Churchill House,
17 Churchill Way, Cardiff, CF10 2HH, United Kingdom

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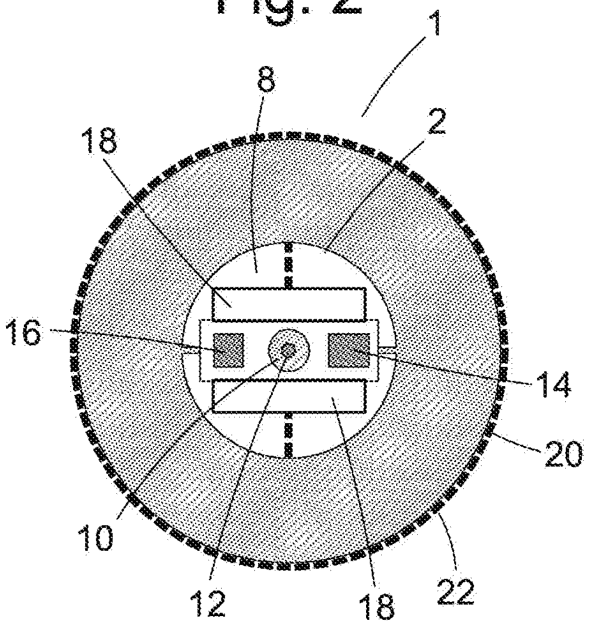
(54) Title of the Invention: **Smart sports equipment**
Abstract Title: **Sports ball including sensor module and communication means**

(57) A ball 1 comprises: a body 2 and includes within the body 2 a sensor module 8 comprising at least one sensor for producing sensor data, the at least one sensor measures acceleration and/or angular momentum and/or orientation and/or location and/or magnetic field and/or pressure; the sensor module further comprises communication means 14 to communicate sensor data or data derived from the sensor data to an external location. The ball 1 is a sports ball and is preferably a cricket ball. The mass of the sensor module 8 is preferably balanced either side of a symmetry plane and may include a balance element. Sports equipment including a sensor module that is suitable for hitting a ball is also disclosed,

Fig. 2



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

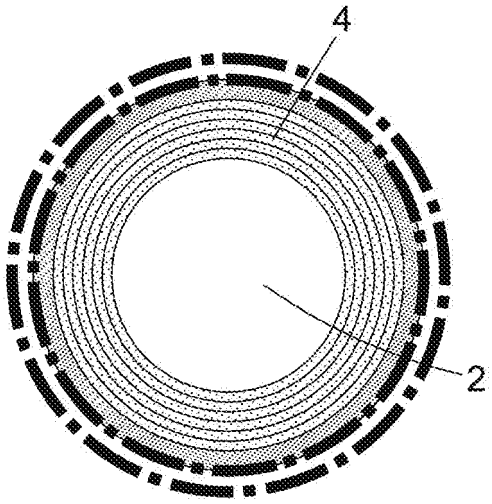

Fig. 1

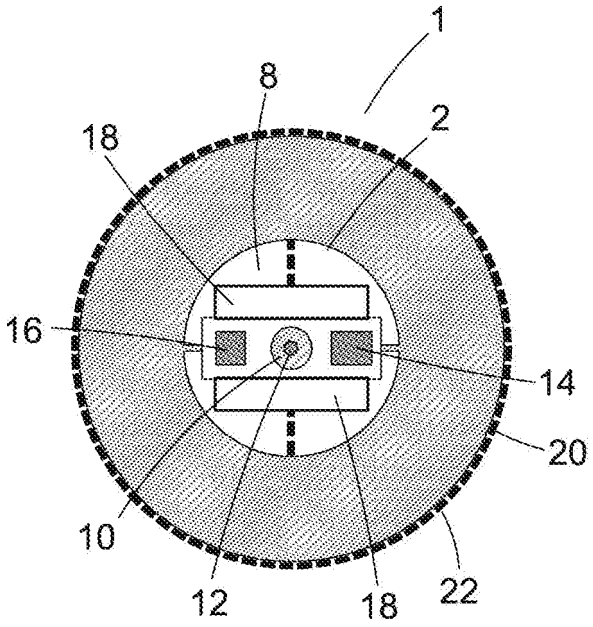

Fig. 2

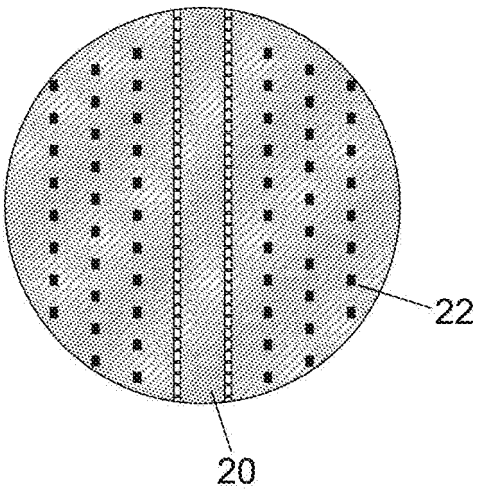

Fig. 3

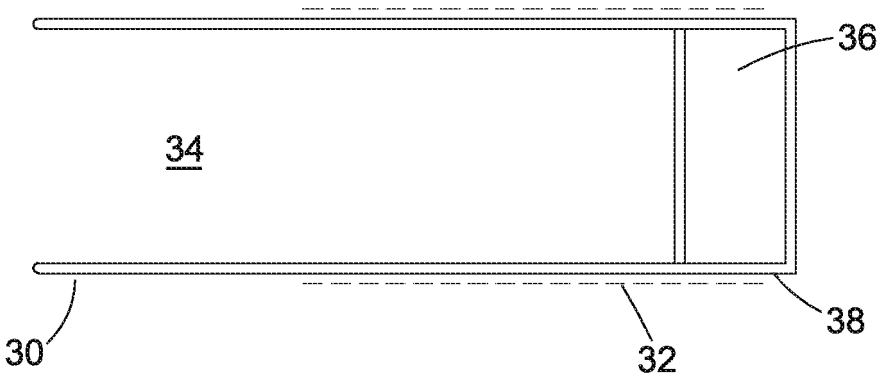

Fig. 4

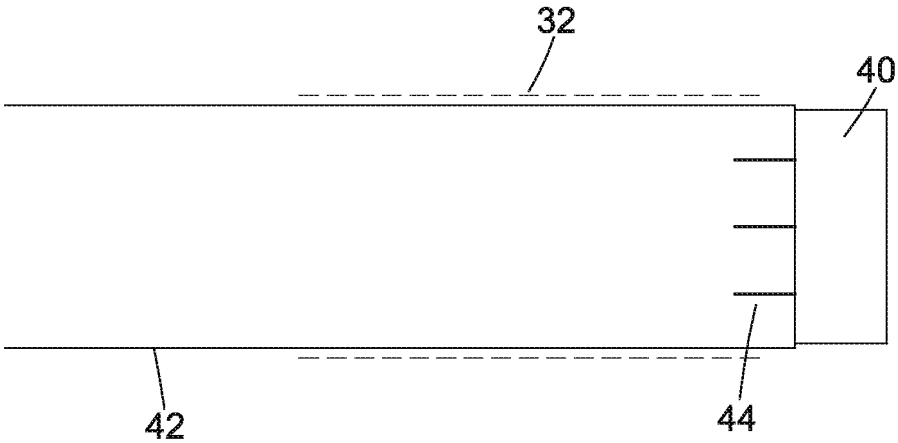

Fig. 5

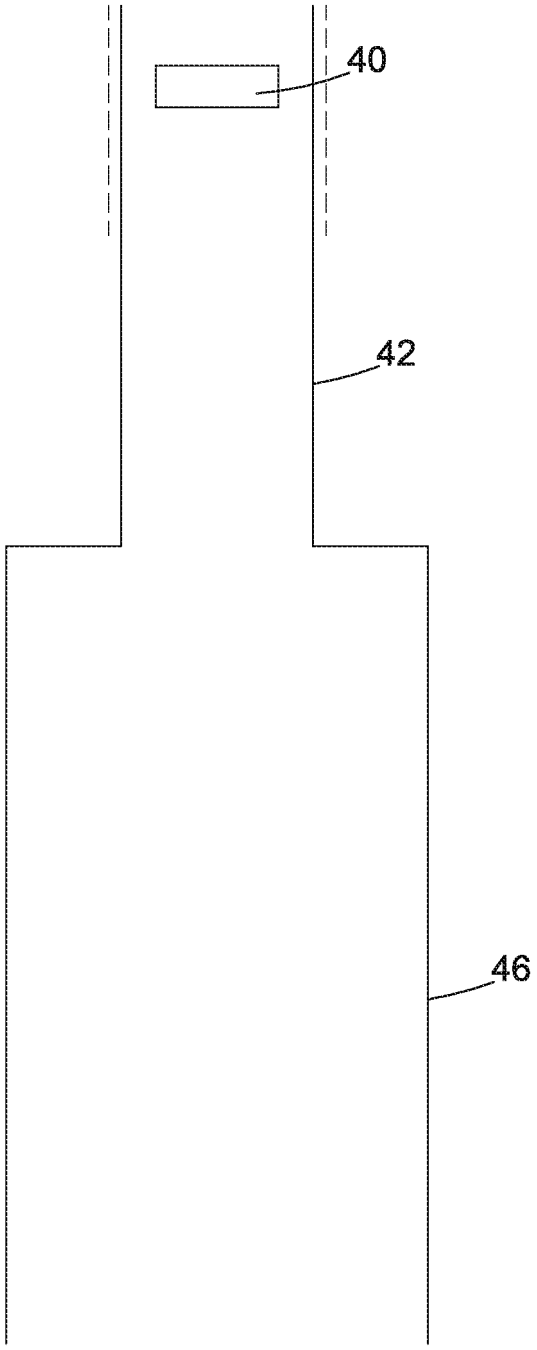

Fig. 6

SMART SPORTS EQUIPMENT

The present invention relates to an item of sports equipment capable of relaying to a remote location information relating to movement, orientation and/or location of the item.

In many sports technology using equipment to analyse either the performance of an individual directly or to analyse how a piece of sports equipment is affected by the action of a user is available. For example, arrangements to determine power output of a cyclist using strain measurements can be used to accurately determine the effectiveness of a cyclist and how their position on a bike impacts their power output can be compared. Other sports equipment maybe the provision of a speed gun to monitor the bowling speed of a ball in cricket or for determining the speed of a golf swing. The equipment may also require high quality cameras for recording motion of a golf swing or movement of a cricket bat. This equipment is often extremely expensive, complicated and difficult to use meaning that it is typically only used for professional sports persons.

In the sport of cricket for example, significant variation upon the effect a bowler has on a cricket ball can be achieved through how the bowler releases the cricket ball, the speed that they release the cricket ball and the position of the seam relative to the hand as the ball is released. Significant time and expense is associated with training cricketers, particularly in the art of spin, swing and seam bowling. The line and length of the ball after it is released is also very important in determining the quality of the ball, for e.g. where the ball lands on the pitch, the position of the ball when making impact with the bat or the batsman. Of additional importance is to monitor the player when holding the ball, for example during the bowlers approach to the wicket to deliver a ball, his speed, rhythm, distance and consistency of the run up can also be measured. An example of an existing arrangement is known as 'Hawk Eye' which is a video based system available to broadcasters and international cricket boards which can be used to store, analyse and subsequently predict the flight/direction of a moving object such as a cricket ball. However, this system is extremely expensive to buy and install. Other video based systems exist involving a single camera and web based software however the accuracy of these cheaper systems is reduced. Video technology is also used to monitor and analyse movement of a batsman and bat,

however again this technology is expensive and difficult to initially set up and subsequently relocate.

Aspects of the present invention provide improved arrangements.

The first aspect of the present invention provides a ball capable of providing information relating to the ball to a location external of the ball. This provides an extremely simplified, cheaper and effective system that maybe utilised by a much wider population.

According to the present invention there is a ball for use as a sports apparatus having a body and including within the body a sensor module comprising at least one sensor for producing sensor data, the at least one sensor arranged to measure acceleration and/or angular momentum and/or orientation and/or location and/or magnetic field, and/or pressure, the sensor module further comprising communication means to enable communication of the sensor data or data derived from the sensor data to a location external of the body.

The body is beneficially symmetrical about at least one symmetry plane and wherein the sensor module is positioned in the body such that the mass of the sensor module is substantially balanced on either side of the symmetry plane. It has been determined that the balancing of the mass in this manner is extremely important. It is particularly important in a cricket ball or baseball for example where any unbalanced mass will have a significant effect on the trajectory of the ball. In bowling a cricket ball for example depending upon how the ball is released from a bowlers hand the effect of how the ball moves through the air can be changed. As such, it is important that the sensor module does not have any impact upon how the ball will travel through the air.

It is further beneficial that the body is symmetrical about a plurality of symmetry planes, and wherein the sensor module is positioned in the body such that the mass of the sensor module is substantially balanced on either side of the plurality of symmetry planes. Further aiding in ensuring the flight of the ball is not affected by the sensor module is the provision of at least two symmetry planes wherein the sensor module is positioned in the

body such that the mass of the sensor module is substantially balanced on either side of these two symmetry planes. The two symmetry planes are beneficially perpendicular relative to each other. It is further beneficial that the sensor module is balanced on either side of additional symmetry planes thus further reducing any effect the sensor module can have on the flight of the ball.

The sensor module beneficially comprises at least one balancing element for balancing the mass of the sensor module either side of the at least one symmetry plane. The at least one balancing element may comprise at least one discrete element positioned to balance the mass of the sensor module either side of the at least one symmetry plane. Alternatively, the at least one balancing element may comprise an encapsulating portion for one or more of the components of the sensor module. In the event that the sensor module includes a plurality of additional components such as, for example, additional sensors, power source, location sensor/module, processor, data storage device and/or wireless communication module then such components are positioned on a sensor module substrate at mass balanced position in order that the mass is substantially balanced about the one or more symmetry planes.

The sensor module beneficially comprises a substrate for supporting the at least one sensor. The substrate beneficially comprises a first side facing a first direction and a second side facing a second opposing direction away from the first side, wherein the at least one sensor is positioned on the first side and at least one of a further sensor, power supply, processor and/or wireless communication module is positioned on the second side. This is to achieve balancing of the mass of the sensor module and it further means that the sensor module can be reduced in size to minimise the size of the sensor module and thus the core of the ball thereby having zero or minimal impact upon the flight of the ball.

The substrate beneficially comprises a plate, and preferably comprises a disk. The benefits associated with the plate and preferably a disk is that components can be mounted with relatively ease for manufacturing purposes to a disk. The disk is not essentially circular, and may in fact be other shapes such a spherical or rectangular for example. Beneficially however it will be appreciated that the depth of the disk is beneficially less than the

maximum length across the surface of the disk. It is beneficial that the body is symmetrical about at least one symmetry plane and the disk comprises a first face and a second opposing face, and the first face and preferably the second face are in a plane substantially parallel to the symmetry plane. There could be more than one/two faces depending on the shape. The sensor module may be layered. This would still mean two outer faces, but also internal tracks where other sensors may be placed. This strategy is used in case more sensors are desirable, or to reduce the circumferential size of the sensor module.

The body beneficially comprises an external seam extending around the circumference of the body substantially in or parallel to the symmetry plane. This further reduces the possibility of imbalance of the mass whilst also ensuring ease of manufacturing capability as the disk is effectively aligned with the external seam of the ball. Balls that typically have an external seam are cricket balls and baseballs. The seam may comprise or include a conductive material that may be utilised for example in charging of a power source.

The body beneficially comprises a core and the sensor module is beneficially encapsulated in the core. The core may be of non-uniform construction in order to aid in balancing of the mass. The core may be moulded about the sensor module.

The sensor module beneficially comprises an impact absorbent coating. The impact absorbent coating may comprise a polymeric material such as, for example, polyurethane. It has been proved that thin coatings of impact absorbent materials such as polyurethane enables significant withstanding of impact forces.

A sensor module beneficially further comprises a processor for processing sensor data. It is a further beneficial that the sensor module further comprises a data storage device for storing sensor data or processed sensor data and/or algorithms for data collection/analysis. This means that data in respect of the acceleration, and/or orientation, and/or location, and/or magnetic field can be recorded over time as the ball moves. As such, off-line data can be recorded. The data storage device may store raw data, recorded data and/or calculated data permanently or temporarily. The processor may be arranged to implement

programmes which may be stored in the data storage device. The processor beneficially is arranged to be capable of implementing algorithms in order to reduce the sensor data or process the sensor data received from the at least one sensor.

The means to enable communication of the sensor data to a location external of the body beneficially comprises a wireless communication module. The wireless communication module may communicate over a personal or local area network using, for example, a number of different protocols such as Bluetooth or low energy Bluetooth or any suitable wireless protocol such as Wi-Fi, RFID, GSM, GPS or other location modules. The wireless communication module is beneficially arranged to enable the one or more sensor module to be switched on and off. It will be appreciated that the wireless communication module may be a two way communication or one way transmitter. It will also be appreciated that means to enable communication of the sensor data to a location external of the body may be via a physical communication means such as a USB interface. It will further be appreciated that, however, that this is not beneficial due to the impact this has upon the mass balance of the sensor module leading to the effect on the flight of the ball. The transmission can be through an active or passive RFID chip inside the ball or on the surface, supported by a special antenna that can collect information wirelessly, or a reader that can collect information in near proximity (NFC).

The wireless communication module may be paired to one or more locations external of the body. The one or more locations is/are one or more computing devices arranged to display sensor data. The computing device may be configured to process the sensor data for display. The one or more computing devices can be used to track performance of one or more balls/players at any one time. This pairing can be supported by several technologies, such as Bluetooth, Wi-Fi, Cloud Computing, RFID, etc. NFC/RFID may be used to help establish pairing between a device and the ball.

The sensor module beneficially further comprises a power supply for supplying power to the at least one sensor. It will be appreciated that it is beneficial that the power supply, processor, data storage device, and one or more sensors (or as many components are present) are in operative communication. The at least one sensor is beneficially selected

from the group comprising one or more accelerometers, a magnetometer, a gyroscope and a position receiver.

The one or more accelerometers are beneficially three axis accelerometers. It is beneficial that the one or more accelerometers comprise a first and a second accelerometer, wherein the first accelerometer is a low range high frequency accelerometer for measuring acceleration of the ball as the ball travels through air, and the second accelerometer comprises a high frequency low range accelerometer for measuring the acceleration of the ball upon certain spikes in acceleration or deceleration. The low range high frequency accelerometer is useful in accurately measuring acceleration in the time between impacts. These impacts may be when the ball is suddenly released, when the ball hits the ground, and when the ball hits the bat. A further accelerometer, preferably a high range low frequency accelerometer is provided to detect spikes in the peak forces and the impulse of forces over time. This is beneficial in detection of the start of the ball for play, i.e. for identifying that the ball should wake up ready for use, and detects major milestones in a delivery such as the release, impact with the pitch, impact with the bat or batsman, a throw, etc. Furthermore, the accelerometer can measure trajectory, speed, acceleration and deceleration. The benefit of the three axis accelerometer usage is that it is capable of measuring acceleration in three orthogonal directions. One or more accelerometers are used to capture the full range of activity on the ball at the highest possible frequencies and ranges.

A magnetometer is beneficially provided and acts as a compass giving direction/orientation of movement of the ball. The plurality of sensors are beneficially provided in order to improve accuracy identifying how the ball is moving through the air giving effective cross checks. From the sensor data from the accelerometer the output can be integrated to determine velocity and double integrated to determine distance. A magnetometer captures the orientation of the ball against the magnetic field of the earth. So in stationary position, it will measure the gravitational pull to determine orientation of the ball. It will also be used to correct the drift in measurements that may be created by the accelerometer and/or gyroscope.

A gyroscope is beneficially provided to provide pitch and yaw of the ball. The gyroscope may be used to measure the counter-rotation or lateral movement imparted on the ball.

A pressure sensor is beneficially provided to provide pressure of and/or on the ball. This is measured in terms of force per unit area. The pressure sensor may be used to measure pressure ranges, temperature ranges of operation, the type of pressure and the impulse of forces. These may be indirectly used to detect and predict flow, speed, altitude, swing/seam/spin movements of the ball. The pressure sensor may be used to monitor deterioration of the balls' surface and inner construction, thereby correcting the overall data analysis, measuring and predicting swing/seam and spin movements; including reverse swing, and notifying the user of the estimated ball quality, remaining life and subsequent performance.

The power source beneficially comprises a battery which is preferably rechargeable to enable four to eight hours use (for use in cricket this allows use in line with the various cricket formats, such as training, Twenty-20, One Day (50 Overs) or Test Matches (5 days). Charging can be achieved in a number of ways through the means of energy harvesting, for example, of piezo-electric accelerometers, vibration induced charging, magnetic coils which allow charging through shaking the ball, etc. Magnetic or inductive charging may be achieved or charging using metallic ink which may also be used for branding of the ball could be utilised, and/or foil or conductive elements on the surface of the ball or on the seam/stitching. A further option is solar charging and optionally charging through a physical port such as a USB port.

The sensor module may comprise a position receiver such as a GPS or other location module receiver capable of determining its location and the location of the ball. This is beneficial as it can provide increased precision and resolution of measurement through sensor data fusion, such as correction of dead reckoning and drift correction. It is further beneficial that data in respect of ball movement after impact with a bat for example can be determined.

The at least one sensor is beneficially in a fixed position in the body. This means that the at least one sensor is not moveable within the body as is preferably retained on the substrate which is effectively retained within the core.

The body beneficially comprises a user contact portion to be gripped by a user including one or more touch sensitive elements for determining contact and beneficially contact pattern with the grip of a user on the ball to provide contract sensor data. The communication means is arranged to enable communication of the contact sensor data to the remote location. The sensor module beneficially comprises a processor or related electronic components for determining from the one or more touch sensitive elements information relating to users grip and/or release of the ball. It will be appreciated that one more touch sensitive elements are beneficially spaced around an external surface of the body. It is possible that the touch sensitive elements are provided underneath an exterior cover. Such touch sensitive elements may be resistive touch, acoustic wave, capacitive touch utilising surface capacitance, projected capacitance, mutual capacitance and self-capacitance. Further options may be an infrared grid, an infrared acrylic projection, optical imaging, dispersive signal technology, UV Maps, and/or acoustic pulse recognition. The benefit of the provision of a user contact portion including one or more touch sensitive element is to collect touch data for the user such as the position of release of the ball, holding position, and pressure applied at various points on the ball. The provision of touch sensitive zones are therefore beneficially provided to aid in determination of the position of a user's grip, ball release and ball grasp times. From this information it can be accurately determined how a ball is released meaning that, for example, the last contact point of a user's grip with the ball can be determined to identify how a ball is released and how this has impact upon the flight of the ball through the air, whether this is from a bowler or a fielder.

It will be appreciated that invention relates to a ball and has been described in particular with respect to a cricket ball. It will equally be appreciated that the invention may extend to other types of ball for example, a baseball or American type footballs. These are examples only.

According to a second aspect of the present invention there is an apparatus for providing information relating to the use of an item of sports equipment designed for striking a ball, the apparatus comprising:

- a sensor module comprising at least one sensor for producing sensor data, the at least one sensor arranged to measure acceleration and/or angular momentum and/or orientation and/or location and/or magnetic field and/or pressure, and/or contact with the grip of a user, the sensor module further comprising communication means to enable communication of the sensor data to a remote location;
- a sensor module carrier for securing the sensor module to an item of sports equipment.

The item of sports equipment may be a bat, such as a baseball bat, a cricket bat, a stick such as a hockey stick, a racquet or a golf club as examples only. In particular, it is beneficial to provide information relating to an item of sports equipment that requires precise positioning and movement relating to individual discrete strikes of a ball such as a cricket bat, baseball bat, golf club, or the like.

The provision of such an apparatus enables sensor data to be transferred to a remote location and analysis of the use of the sports equipment can be determined. The provision of a sensor module carrier for securing the sensor module to an item of sports equipment enables ease of modification of an item of sports equipment to become "smart". For example, it is beneficial that the sensor module carrier comprises a sports equipment grip portion. This means that a standard item of sports equipment can be modified with relative ease. As described with respect of the first aspect of the invention, significant amounts of sensor data may be provided from the at least one sensor. For example, the provision of at least one accelerometer enables information to be determined relating to movement of the item of sports equipment and subsequent impact with a ball and then subsequent further movement of the item of sports equipment. The provision of a magnetometer acts as a compass giving direction about orientation of movement of the item of sports equipment. A gyroscope may be provided to pitch and yaw of the item of sports equipment and if applicable a position receiver may be provided to determine location of the item of sports equipment. A touch sensitive element is beneficial to determine how a user is grasping the

item of sports equipment and as such determine the individual's grip pattern and the effectiveness of their grip in hitting a ball.

The apparatus preferably comprises a power source as described with respect to the first aspect of the invention.

The grip portion beneficially comprises a first end and a second end, wherein the first end comprises an opening extending to a bore for receipt of a handle of an item of sports equipment. This further provides ease of modification or adaptation of an item of sports equipment to become an item of 'smart' sports equipment.

At least one of the sensor and communication means is beneficially located at the second end of the grip portion. Beneficially the at least one sensor and communication means are located adjacent to the distal end of the bore and may be positioned within the bore. It is beneficial that a second end of the grip portion comprises a cap for capping an end of the handle of an item of sports equipment, and at least one of the sensor and communication means are positioned in communication with the cap. The at least one sensor and preferably communication means are beneficially provided partially and preferably wholly encapsulated within the cap which has the benefit of protecting the at least one sensor and/or communication means. The at least one sensor and communication means are beneficially retained at the distal end of the bore and as such effectively slightly increase the length of the handle. Encapsulation is beneficial to reduce the possibility of damage of the at least one sensor and communication means. It will be appreciated that the communication means has been described with respect to the ball according to a first aspect of the invention and is appropriately suitable for use in the second aspect of the invention.

The at least one sensor is beneficially selected from the group comprising an accelerometer, a magnetometer, a gyroscope, a pressure sensor, a touch sensitive element and a position receiver. A plurality of each type of sensor may be provided if appropriate such as a plurality of accelerometers. It is beneficial to provide two or more sensors of different types, and even more preferably beneficial to include a first sensor selected from

the group comprising an accelerometer, a magnetometer, a gyroscope, a pressure sensor, and a position receiver and further to include in combination with these one or more additional touch sensitive elements. It is therefore beneficial to determine movement of the item of sports equipment in combination with the users grip in a bat or racket for example. As such, provision of an accelerometer for example, in combination with at least one touch sensitive element enables determination of movement of the item before and after impact with the ball and further enables information as to how the user was grasping the item during these stages. Due to the low size and cost of the described sensors, it is beneficial that the sensor module comprises a plurality of sensors of different types and to include one or more of each type such that capability is provided for determination of accurate movement of the item.

The sensor module beneficially comprises a substrate for carrying the communication means and one or more of the accelerometer and/or the magnetometer and/or the gyroscope and/or pressure sensor and/or the position receiver, and preferably the power source. This allows ease of manufacture and retaining of the at least one sensor by the substrate. The substrate is beneficially positioned at the second end of the grip portion and preferably in communication with and optionally and at least partially encapsulated within the cap.

The substrate beneficially comprises a plate and preferably comprises a disk.

The sensor module preferably further comprises a processor for processing the sensor data. The processed sensor data may then be transferred to the remote location for subsequent display and/or further processing. This reduces the amount of data transferred.

The sensor module preferably further comprises a data storage device for storing sensor data and/or processed sensor data. This is beneficial to avoid the requirement for constant data streaming.

The at least one sensor preferably comprises one or more touch sensitive elements for determining contact with a grip of a user, the one or more touch sensitive elements

disposed around an outer surface of the grip portion. It will be appreciated that the one or more touch sensitive elements are on an outwardly facing surface of the grip portion. The one or more touch sensitive elements beneficially comprise a plurality of fingers disposed about the grip portion. A plurality of touch sensitive elements are beneficially disposed in a spaced apart configuration about the grip portion. The touch sensitive elements may therefore be interspersed around the grip. This ensures that contact and beneficially a contact pattern with the grip of a user on a handle of the item of sports equipment can be determined.

A plurality of touch sensitive elements are beneficially disposed in a spaced apart configuration about the grip portion.

Also according to the second aspect of the present invention there is a method of providing information relating to the use of an item of sports equipment designed for striking a ball, the method comprising the steps of providing a sensor module comprising at least one sensor for producing sensor data, communication means arranged to enable communication of the sensor data to a remote location and a sensor module carrier for securing the sensor module to an item of sports equipment; measuring acceleration and/or angular momentum and/or orientation and/or location and/or magnetic field, and/or pressure and/or contact with the grip of a user with the at least one sensor to produce the sensor data and communicating the sensor data to a remote location.

Also according to the invention there is an item of sports equipment designed for striking a ball comprising a body and including a sensor module comprising at least one sensor for producing sensor data, the at least one sensor arranged to measure acceleration and/or angular momentum and/or orientation and/or location and/or magnetic field and/or pressure and/or contact with the grip of a user, the sensor module further comprising communication means to enable communication of the sensor data to a remote location.

The sensor module beneficially comprises at least one sensor arranged to measure acceleration and/or angular momentum and/or orientation and/or location and/or magnetic field and contact with the grip of a user. It is beneficial to provide sensor data relating to

both grip of a user and positioning information in combination. The sensor data may be processed before or after transmission to a remote location. The sensor module may comprise a processor.

The at least one sensor and communication means are beneficially encapsulated in the body. It is beneficial that the body comprises a handle and an impact portion, and the at least one sensor and communication means are encapsulated in the handle.

It will be further appreciated that aspects of the invention extend to optionally include a remote device for receiving and displaying sensor (processed and/or unprocessed) data. The remote device may be paired to one or more items of sports equipment and thus may be used to compare sensor data from different items such as balls/bats.

Aspects of the present invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a schematic cross sectional view of a cricket ball currently available.

Figure 2 is a cross sectional view of a ball according to an exemplary embodiment of the first aspect of the present invention.

Figure 3 is a schematic view of a cricket ball according to an exemplary embodiment of the present invention.

Figure 4 is a schematic cross-sectional view of an apparatus for providing information relating to use of an item of sports equipment designed for striking a ball according to an exemplary embodiment of the present invention.

Figure 5 is a schematic cross-sectional view of a second exemplary embodiment of the second aspect of the present invention.

Figure 6 is a schematic cross-sectional view of an exemplary embodiment according to an aspect of the present invention.

Referring to Figure 1 a traditional cricket ball is presented. Construction may vary however the cricket ball typically comprises an inner core or nucleus (2) comprising cork and rubber, and is bonded with layers of cork and rubber and wool composite. Externally of this is a leather casing along with small stitches for 2/4 piece balls. An indented seam 6 is provided around the circumference.

Figure 2 is a schematic cross sectional view of the core in particular of a ball according to an exemplary embodiment of an aspect of the present invention. Provided within the core (2) is a sensor module (8) comprising at least one sensor for producing sensor data. Presented in Figure 2 is a sensor (10) comprising combined accelerometer, gyroscope, magnetometer and pressure sensor. In addition an accelerometer (12) is also provided. A wireless communication module (14) is further provided on the sensor module as is a processor (16). Power source (18) are also provided. The sensor module (8) is provided within the nucleus or core (2) and in the embodiment presented the components have been shown schematically as an example only on one side of the sensor module. The sensor module has the appearance of a disk however in a preferred embodiment the components are balanced in a plurality of symmetry planes on the ball on either side of the disk in order that the mass is balanced within the core. As such, for manufacturing purposes it is beneficial to manufacture the sensor module as a disk having a first side and a second side and wherein components of the sensor module are positioned on opposing sides in order to achieve balance of the mass, and/or space utilisation or reduction. As shown in Figure 2 it will also be appreciated that the ball comprises a body (1) which is symmetrical about at least one symmetry plane and a disk has a first face and second opposing face which are in a plane substantially parallel to the symmetry plane. It will further be appreciated that the body (1) comprises an external seam (20) typical of a cricket ball wherein the first and preferably second faces are in a plane substantially parallel to the symmetry plane and also wherein the external seam extends around the circumference of the body substantially in or parallel to the symmetry plane.

Around the external peripheral edge of the body (1) is beneficially provided one or more touch sensitive elements (22) as shown in Figure 3. This enables detection of a human grip and from data relating to user contact over time release times as well as the holding pattern of the ball can be determined. How the ball is held and/or released determines its resulting flight path and movement. Presented in Figure 3, is a clear indication of the touch sensitive elements (22) and seam (20). This is important in collecting statistics about the performance of a player and guide to development for best practises for the way in which they release the ball. This is particularly important in the game of cricket whereby the release of the ball has a significant influence on the flight path of the ball through the air.

As it will be appreciated from Figure 2, the ball may be constructed in a traditional manner wherein the sensor module is encapsulated in cork and/or rubber and subsequently bonded with layers of cork, rubber and wool composite and encased in leather. Alternatively, a variety of other materials can be utilised such as natural and synthetic materials which may be composite EVA, PU, metals and PVC materials.

Not shown in Figure 2 is the provision of one or more balancing elements. These may be added as required to ensure that the mass of the ball is balanced. As the ball comprises an infinite number of symmetry planes it is beneficial that the mass is balanced about every symmetry plane. Whilst in reality this is very difficult to achieve the mass should be balanced on opposing sides of at least a first symmetry plane and at least a second symmetry plane substantially perpendicular to the first symmetry plane. Balancing of the mass on either side of further symmetry planes further improves the capability of the ball to act a normal cricket ball in flight. Therefore, any influence the bowler provides on the ball can be measured by the at least one sensor and thus detailed information about the movement of the ball can be determined. From the accelerometer, and the sensor data received from the accelerometer, velocity can be obtained through integration of the sensor output and further integration can be carried out to determine the distance. The provision of an angular momentum sensor, which may for example be a gyroscope to measure the angle momentum or orientation of the sensor module may be provided and may be used to calibrate measurements made by the acceleration sensor. If present, this may further calibrate measurements made by a magnetometer. Significant amounts of information

therefore may be obtained regarding movement of the ball from the point at which the bowler holds the ball to the point at which the ball stops following impact from the batsman. It will be appreciated that there will be a sudden spike in the speed when the ball leaves the hand which can be compared to the output from the touch sensitive elements to accurately determine time of release and how the ball is released. The speed of the ball will decrease and upon impact with the ground deviation of the ball can be determined through the sensor output from the magnetometer. Upon impact with the bat the sudden deceleration and then sudden acceleration will appear as a sudden decrease and sudden increase of the speed and is therefore readily measurable over time. The position sensor such as a GPS module can be used for further collaboration and to determine the ball position after it has been hit in particular.

It will be appreciated that the impacts associated with a ball such as a cricket ball are significant. As such the sensor module is encapsulated in a core. For further impact resistance the sensor module is beneficially coated in a material such as a polymeric material, beneficially polyurethane, known to have significant impact resistance properties. This may be a thin coating following which the sensor module is encapsulated in a core. Alternatively, this material may comprise a spherical core material with the sensor module encapsulated therein.

It will be appreciated that the means to enable communication of the sensor data to any location external of the body may be made continuously in the event the ball is retained within a network or alternatively sensor data may be recorded by a data storage device provided on the sensor module and subsequently transferred upon instruction or upon location into a predefined wireless network. Data may be transferred, for example, via known Bluetooth technology.

Referring now to Figures 4 to 5 exemplary embodiments of the second aspect of the present invention are described. Presented in Figure 4 is an apparatus for providing information relating to the use of an item of sports equipment designed for striking the ball. Such an item may, for example, be a racquet, bat, or club as examples only. Presented is a grip portion 30 which is arranged to fit over the handle of an item of sports equipment

designed for striking a ball. The external surface of the grip portion 30 may comprise one or more sensors for producing sensor data relating to contact with the grip of a user. Such sensors have been identified by reference 32. These sensors may be provided integrated with the grip and may be provided in a spaced apart configuration separated by portions of grip. Alternatively, they may be provided as a continuous external surface of a part of whole of the grip portion. This is important in collecting statistical data relating to how a player grasps the item of sports equipment.

A grip portion 30 defines a bore 34 adapted to accommodate the handle of an item of sports equipment. At least one sensor and communication means are preferably located at the second end of the grip portion 36 and the opposing end to the opening of the bore 34 at a first end of the grip portion. The second end of the grip portion beneficially comprises a cap 38 where the cap encapsulates at least one sensor and the communication means. This protects the at least one sensor and communication means from impact. As described with respect to the first aspect of the invention, the sensor module provided in the cap 38 may comprise a substrate on to which at least one sensor and communication means are secured. The substrate may comprise a plate and preferably comprises a disk.

Referring to Figure 5, in this embodiment the sensor module 40 has been secured to an end of a handle 42 via a sensor module carrier which may comprise one or more pins 44. Alternatively or in addition the sensor module carrier may include an adhesive. A sensor module carrier is there adhered to the distal end of the handle. One or more touch sensitive elements 32 may be provided about the handle 42.

Information relating to movement, position, and orientation of the item of sports equipment plus information relating to a user's grip in a form of sensor data may be transferred to a remote location for analysis.

Referring now to Figure 6, it will be appreciated that a sensor module 40 may be incorporated into or embedded within an item of sports equipment. Presented in Figure 6 is a cricket bat having a handle 42 and blade 46. The sensor module in this embodiment may be formed within the handle 42 during manufacture of the item.

Information relating to movement, position, grip, orientation and location of the item of sports equipment may be determined and such data analysed for the purpose of improved performance.

Aspects of the invention have been described by way of example only and it will be appreciated to the skilled address that modifications and variations may be made without departing from the scope of protection afforded by the appended claims.

CLAIMS

1. A ball for use as a sports apparatus having a body and including within the body a sensor module comprising at least one sensor for producing sensor data, the at least one sensor arranged to measure acceleration and/or angular momentum and/or orientation and/or location and/or magnetic field and/or pressure, the sensor module further comprising communication means to enable communication of the sensor data or data derived from the sensor data to a location external of the body.

2. A ball according to any preceding claim wherein the body is symmetrical about at least one symmetry plane, and wherein the sensor module is positioned in the body such that the mass of the sensor module is substantially balanced on either side of the symmetry plane.

3. A ball according to claim 2 wherein the body is symmetrical about a plurality of symmetry planes, and wherein the sensor module is positioned in the body such that the mass of the sensor module is substantially balanced on either side of the plurality of symmetry planes.

4. A ball according to any of claims 2-3 wherein the sensor module comprises at least one balancing element for balancing the mass of the sensor module either side of at least one symmetry plane.

5. A ball according to any preceding claim wherein the sensor module comprises a substrate for supporting the at least one sensor.

6. A ball according to claim 5 wherein the substrate comprises a first side facing a first direction and a second side facing a second opposing direction away from the first side, wherein the at least one sensor is positioned on the first side and at least one of a further sensor, power supply, processor and/or wireless communication module is positioned on the second side.

7. A ball according to any of claims 5-6 wherein the substrate comprises a plate, and preferably comprises a disc.

8. A ball according to claim 7 wherein the body is symmetrical about at least one symmetry plane and the disk has a first face and a second opposing face, and the first face and preferably the second face are in a plane substantially parallel to the symmetry plane.

9. A ball according to any of claims 2-8 wherein the body comprises an external seam extending around the circumference of the body substantially in or parallel to the symmetry plane.

10. A ball according to any preceding claim wherein the body comprises a core and the sensor module is encapsulated in the core.

11. A ball according to any preceding claim wherein the sensor module comprises an impact absorbing coating.

12. A ball according to claim 11 wherein the impact absorbing coating comprises a polymeric material.

13. A ball according to any preceding claim wherein the sensor module further comprises a processor for processing sensor data.

14. A ball according to claim 13 wherein the sensor module further comprises a data storage device for storing sensor data or processed sensor data.

15. A ball according to any preceding claim wherein the means to enable communication of the sensor data to a location external of the body comprises a wireless communication module.

16. A ball according to any preceding claim wherein the sensor module further comprises a power supply for supplying power to the at least one sensor.

17. A ball according to any preceding claim wherein the at least one sensor is selected from the group comprising one or more accelerometers, a magnetometer, a gyroscope, a pressure sensor and a position receiver.

18. A ball according to claim 17 wherein the one or more accelerometers are three axis accelerometers.

19. A ball according to any of claims 17-18 wherein the one or more accelerometers comprises a first and a second accelerometer.

20. A ball according to any preceding claim wherein the at least one sensor is in a fixed position in the body.

21. A ball according to any preceding claim wherein the body comprises a user contact portion to be gripped by a user including one or more touch sensitive elements for determining contact with the grip of a user to provide contact sensor data, and wherein the communication means is averaged to enable communication of the contact sensor data to a remote location.

22. A ball according to claim 19 wherein the one or more touch sensitive elements are spaced around an external surface of the body.

23. A ball according to any preceding claim further comprising one or more pressure sensors for providing pressure sensor data.

24. A ball according to any preceding claim comprising a cricket ball.

25. Apparatus for providing information relating to the use of an item of sports equipment designed for striking a ball, the apparatus comprising:

- a sensor module comprising at least one sensor for producing sensor data, the at least one sensor arranged to measure acceleration and/or angular momentum and/or orientation and/or location and/or magnetic field and/or pressure, and/or contact with the grip of a user, the sensor module further comprising communication means to enable communication of the sensor data to a remote location;
- a sensor module carrier for securing the sensor module to an item of sports equipment.

26. Apparatus according to claim 25 wherein the sensor module carrier comprises a sports equipment grip portion.

27. Apparatus according to claim 26 wherein the grip portion comprises a first end of a second end, wherein the first end comprises an opening extending to a bore for receipt of a handle of an item of sports equipment.

28. Apparatus according to claim 27 wherein at least one of the sensor and communication means are located at the second end of the grip portion.

29. Apparatus according to claim 28 wherein the second end of the grip portion comprises a cap for capping an end of a handle of an item of sports equipment, and at least one of the sensor and communication means are positioned in communication with the cap.

30. Apparatus according to any of claims 25 – 29 wherein the at least one sensor is selected from the group comprising an accelerometer, a magnetometer, a gyroscope, a touch sensitive element and a position receiver.

31. Apparatus according to claim 30 wherein the sensor module comprises a substrate for carrying the communication means and one or more of the accelerometer and/or the magnetometer and/or gyroscope and/or pressure sensor and/or the position receiver.

32. Apparatus according to claim 31 wherein the substrate comprises a plate and preferably comprises a disk.

33. Apparatus according to any of claims 26-32 wherein the sensor module further comprises a processor for processing sensor data.

34. Apparatus according to any of claims 26-33 wherein the sensor module further comprises a data storage device for storing sensor data and/or processed sensor data.

35. Apparatus according to any of claims 26-34 wherein the at least one sensor comprises one or more touch sensitive elements for determining contact with a grip of a user, the one or more touch sensitive elements disposed around an outer surface of the grip portion.

36. Apparatus according to claim 35 wherein one or more touch sensitive elements comprise a plurality of fingers disposed about the grip portion.

37. Apparatus according to any of claims 35-36 comprising a plurality of touch sensitive elements disposed in a spaced apart configuration about the grip portion.

38. A method of providing information relating to the use of an item of sports equipment designed for striking a ball, the method comprising the steps of providing a sensor comprising at least one sensor for producing sensor data, communication means arranged to enable communication of the sensor data to a remote location and a sensor module carrier for securing the sensor module to an item of sports equipment; measuring acceleration and/or angular momentum and/or orientation and/or pressure and/or location and/or magnetic field, and/or contact with the grip of a user with the at least one sensor to produce the sensor data; and communicating the sensor data to a remote location.

39. An item of sports equipment designed for striking a ball comprising a body and including a sensor module comprising at least one sensor for producing sensor data, the at least one sensor arranged to measure acceleration and/or angular momentum

and/or orientation and/or pressure and/or location and/or magnetic field and/or contact with the grip of a user, the sensor module further comprising communication means to enable communication of the sensor data to a remote location.

40. An item according to claim 39 wherein the sensor module comprises at least one sensor arranged to measure acceleration and/or angular momentum and/or orientation and/or pressure and/or location and/or magnetic field and contact with the grip of a user.

41. An item according to any of claims 39-40 wherein the at least one sensor and communication means are encapsulated in the body.

42. An item according to claim 41 wherein the body comprises a handle and an impact portion, and the at least one sensor and communication means are encapsulated in the handle.

43. An apparatus or item as hereinbefore described with reference to the accompanying drawings.

Intellectual Property Office

Application No:	GB1508241.5	**Examiner:**	Dr David Palmer
Claims searched:	1-24	**Date of search:**	30 October 2015

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-24	US 2014/194232 A1 (KRYSIAK et al) See whole document especially the figures.
X	1-24	GB 2487209 A (NOURIE) See whole document especially the figures.
X	1-24	US 2015/057095 A1 (LEECH) See whole document especially the figures.
X	1-24	US 2008/015064 A1 (NELSON et al) See whole document especially the figures.
X	1-24	US 7614959 B1 (GENTILE) See whole document especially the figures.
X	1-24	JP 2012058066 A (UNIV SHINSHU et al) See the figures and WPI Abstract Accession No. 2012-D38282.
X	1-24	US 2011/159977 A1 (PELZ) See whole document especially the figures.
X	1-24	US 2015/094168 A1 (UNGER , SR et al) See whole document especially the figures.

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Field of Search:

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A63B

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

International Classification:

Subclass	Subgroup	Valid From
A63B	0043/00	01/01/2006
A63B	0024/00	01/01/2006
A63B	0071/06	01/01/2006