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(54) **FOOTBALL TRAINING APPARATUS**

(71) Applicant: **ELITE SKILLS ARENA LTD**, Poole (GB)

(72) Inventor: **Mitchell Eddie**, Poole (GB)

(73) Assignee: **Elite Skills Arena Ltd.**, Poole (GB)

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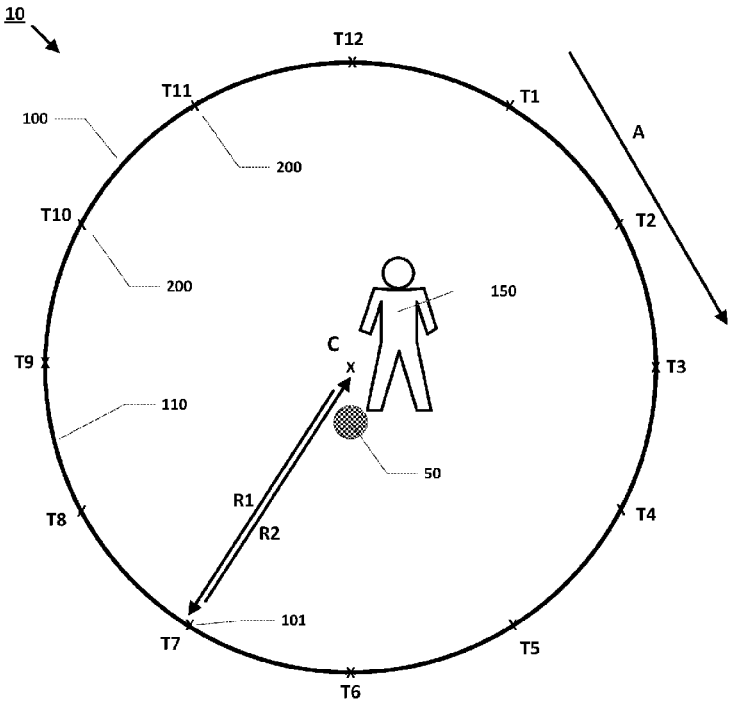
(57) **ABSTRACT**

Apparatus for football training is provided which includes a circular wall having an inward facing surface to support rebound of a football, which has been struck in a radial direction against this surface, back along said radial direction towards the centre of the circular wall. Multiple target indications are provided at respective angular locations around the circular wall. The apparatus has a control system for activating a series of target indications in sequence, and a monitoring system for determining whether the inward facing surface of the wall has been struck at the angular location corresponding to an activated target indication.



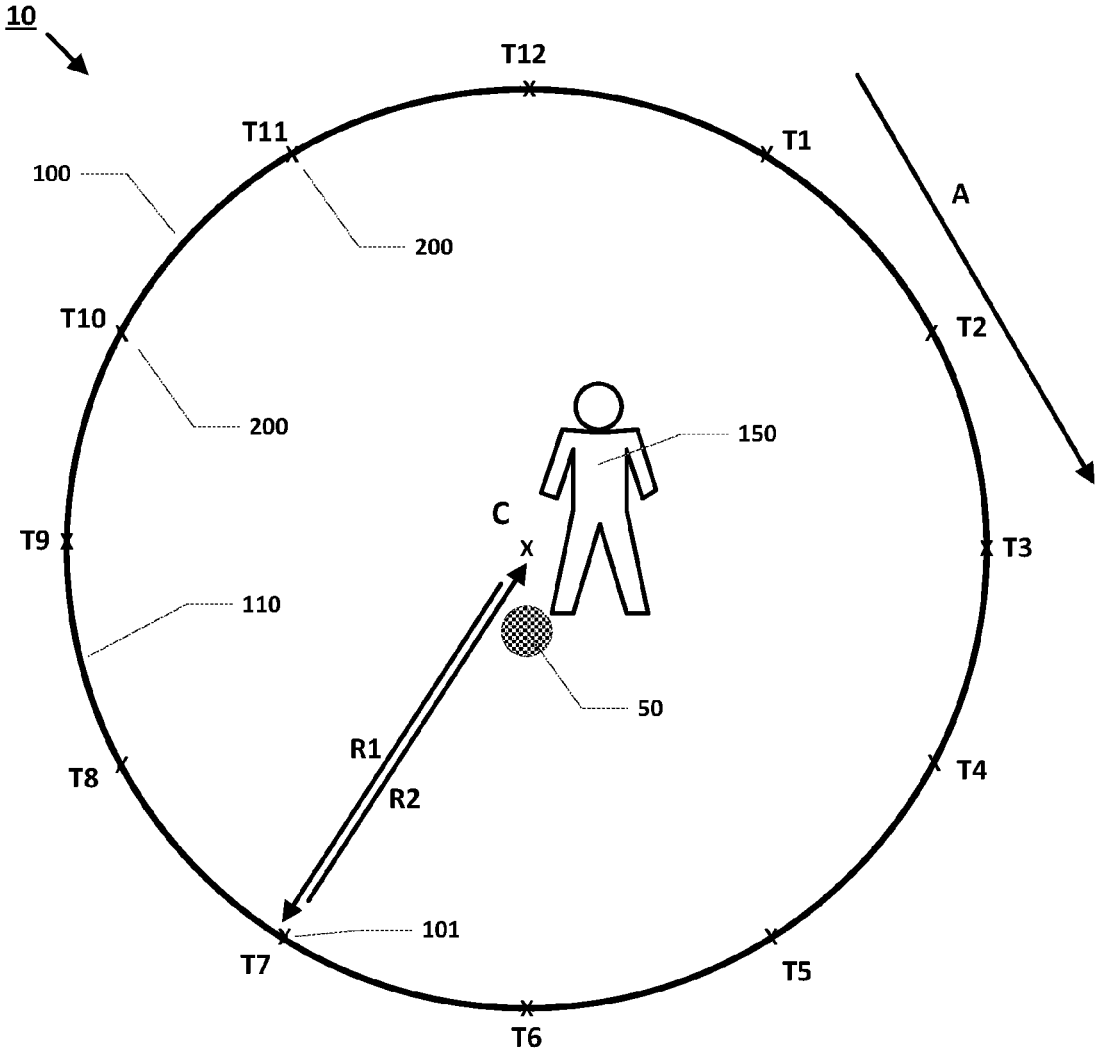

10
T12
T11
T1
100
200
A
T10
T2
200
150
C
T9
T3
110
50
R1
R2
T8
T4
101
T7
T5
T6

Figure 1

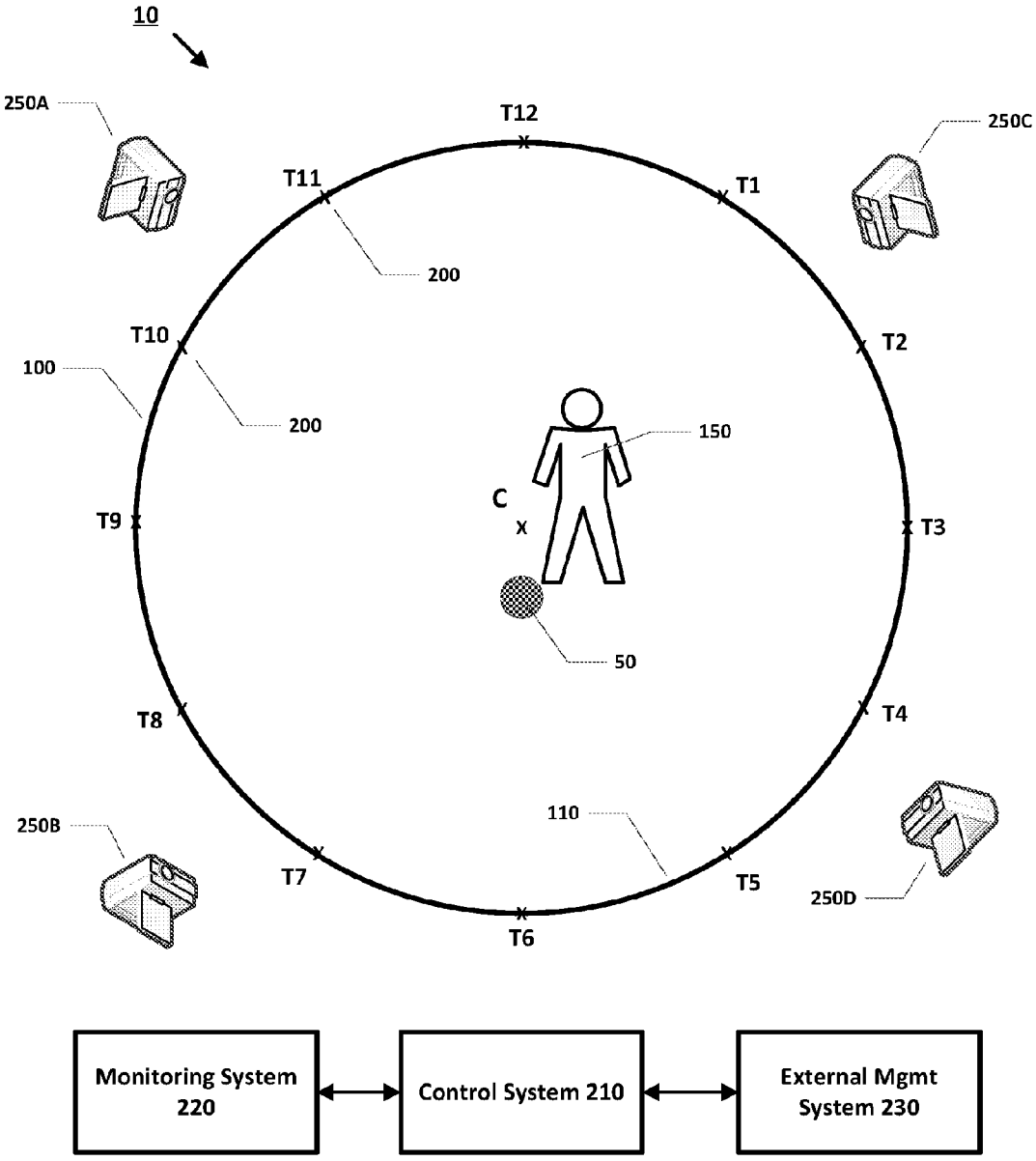

10
250A
T12
250C
T11
T1
200
T10
T2
100
200
150
C
T9
T3
50
T8
T4
250B
110
T7
T5
250D
T6
Monitoring System 220
Control System 210
External Mgmt System 230

Figure 2

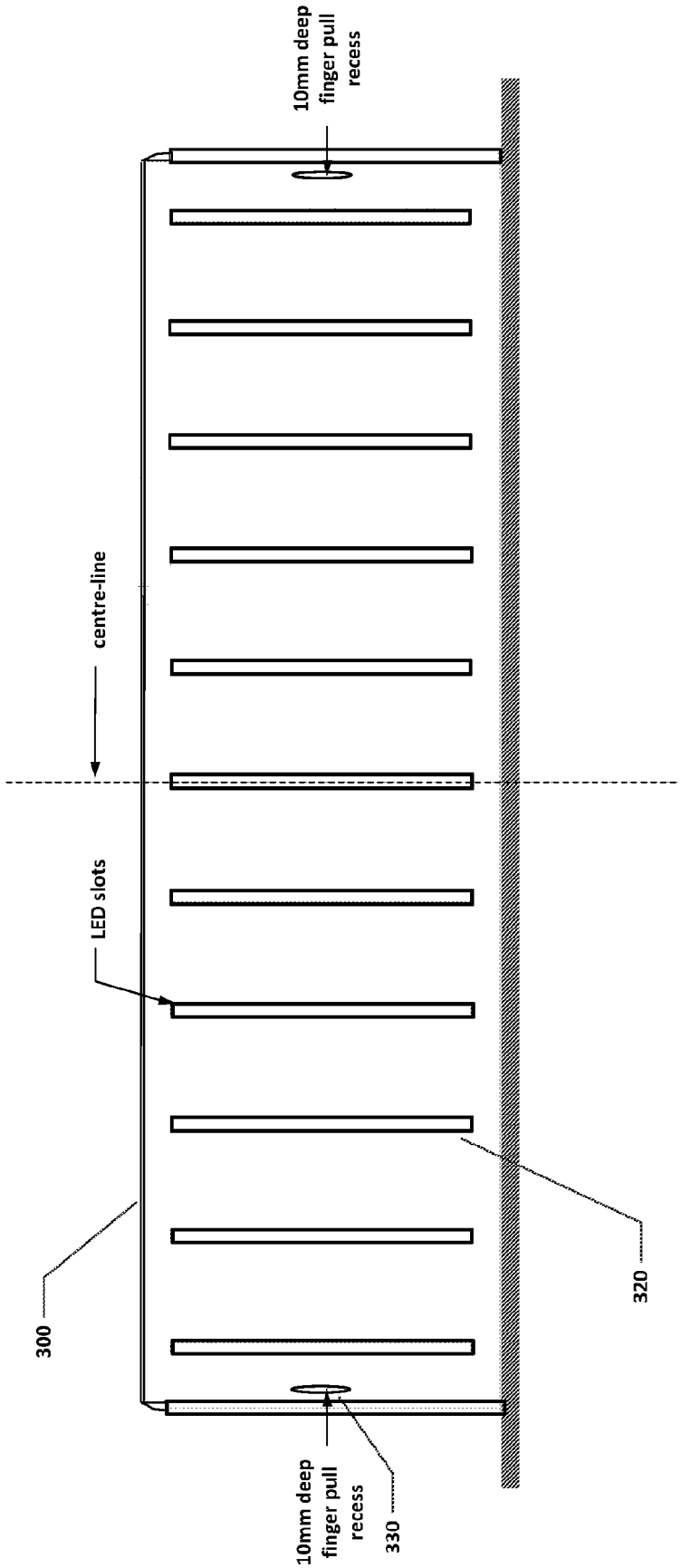

10mm deep finger pull recess
centre-line
LED slots
300
320
10mm deep finger pull recess
330

Figure 3A

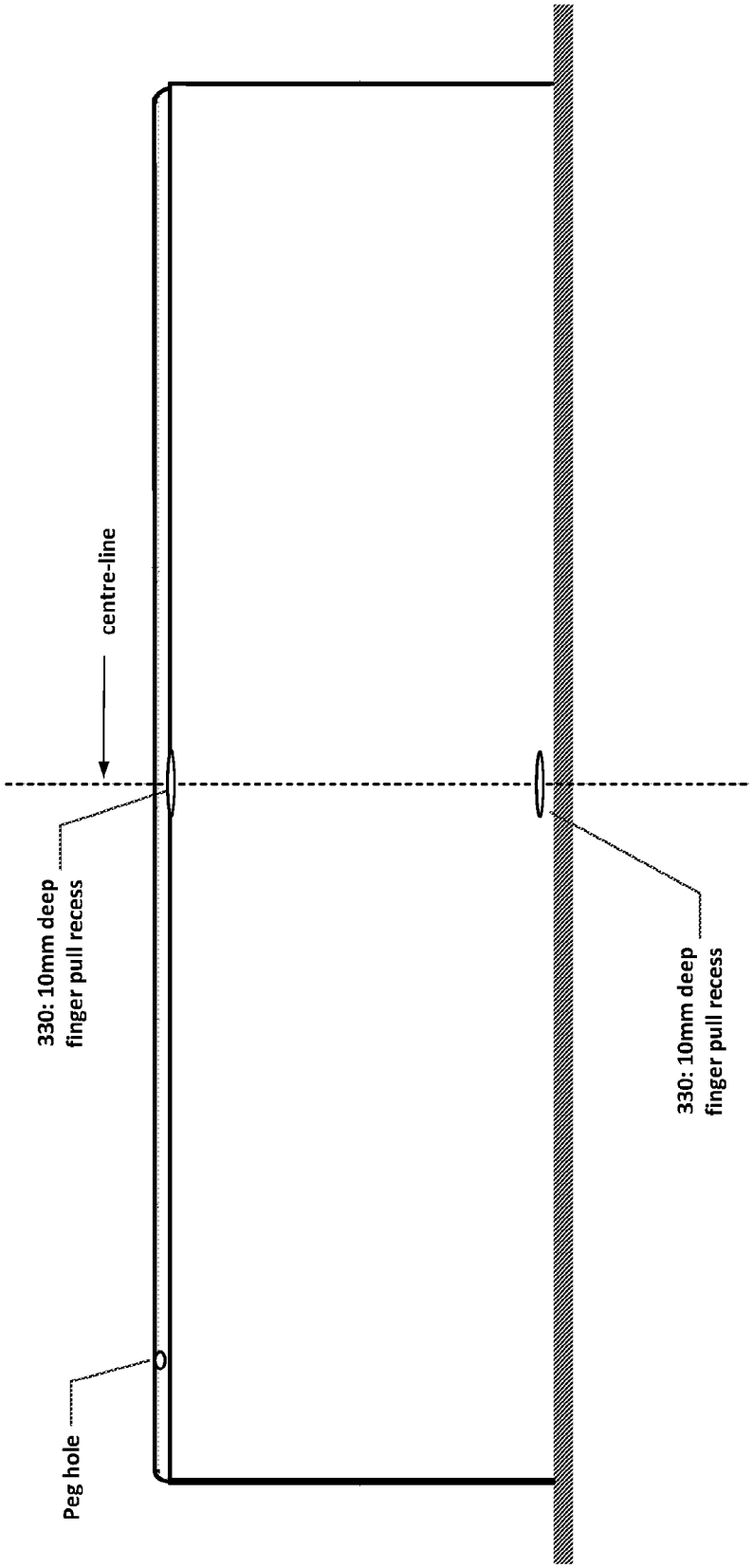

centre-line
330: 10mm deep
finger pull recess
330: 10mm deep
finger pull recess
Peg hole

Figure 3B

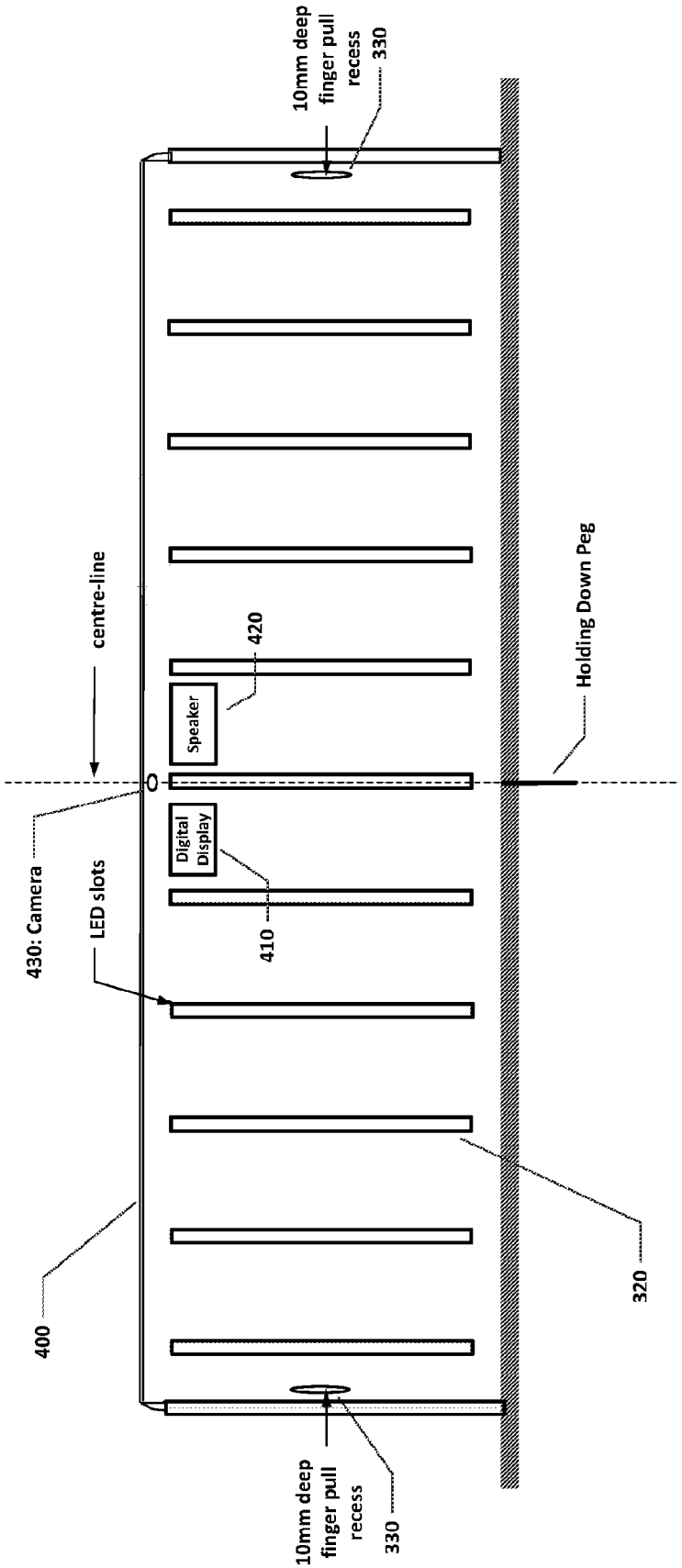

10mm deep finger pull recess
330
centre-line
420
Speaker
Holding Down Peg
Digital Display
410
430: Camera
LED slots
400
320
10mm deep finger pull recess
330

Figure 4A

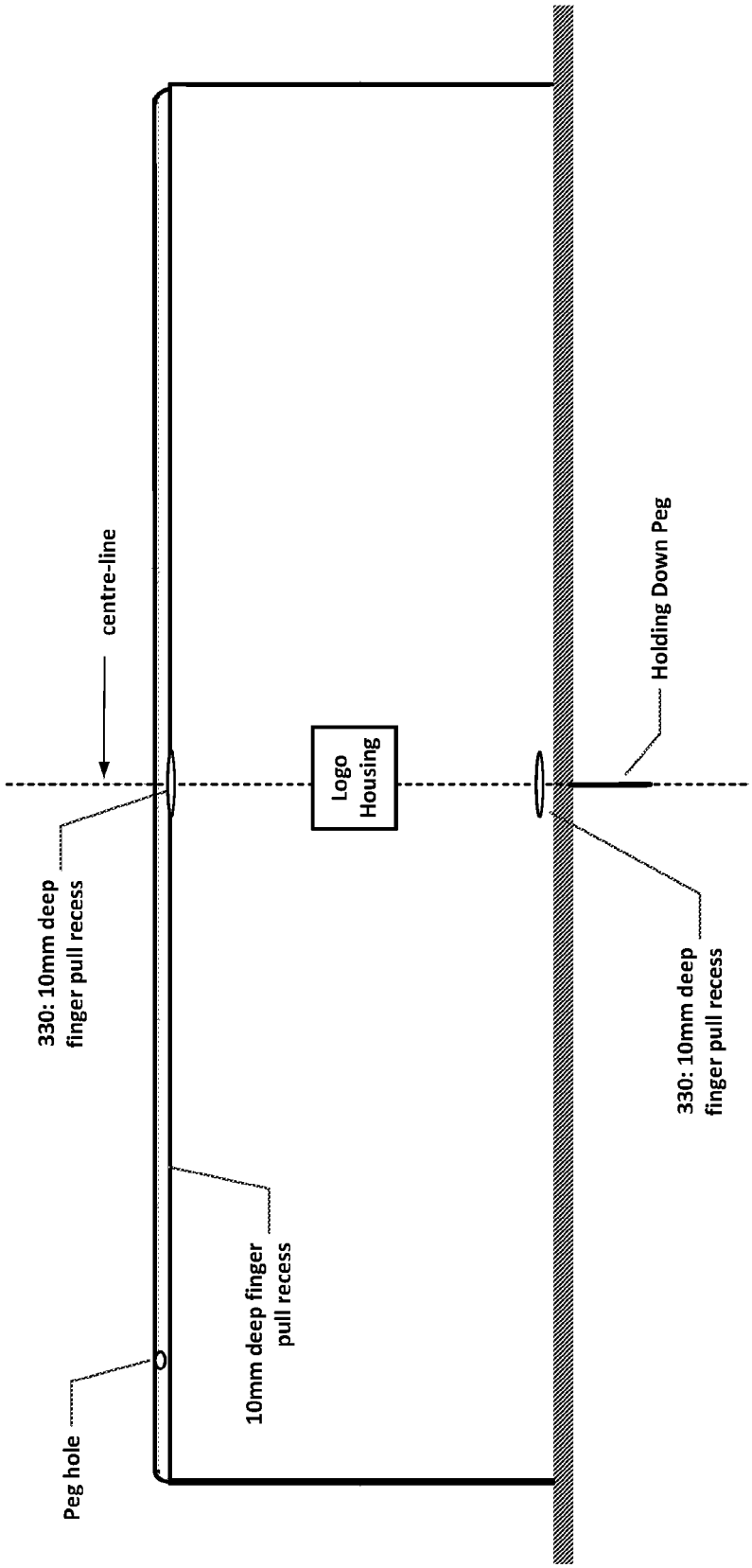

centre-line
Logo Housing
Holding Down Peg
330: 10mm deep finger pull recess
330: 10mm deep finger pull recess
10mm deep finger pull recess
Peg hole

Figure 4B

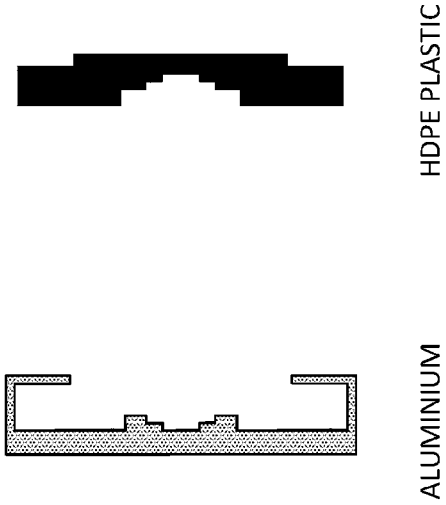


Figure 6

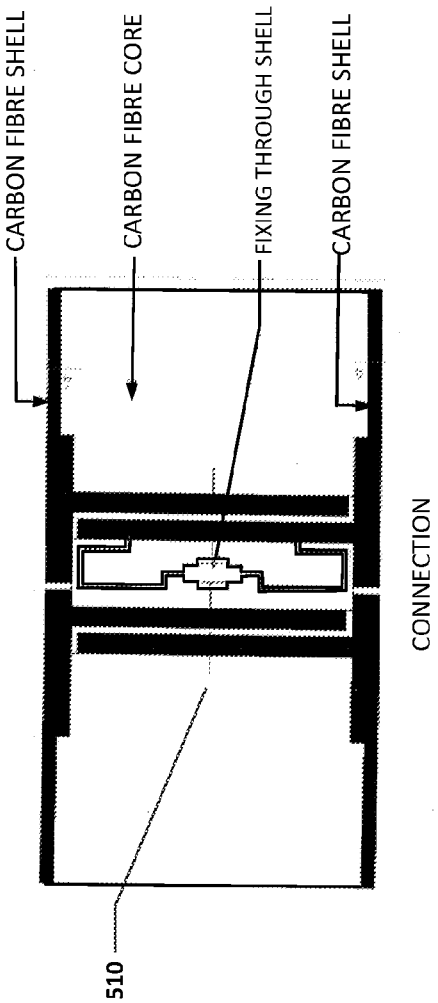


Figure 5

FOOTBALL TRAINING APPARATUS

FIELD OF THE INVENTION

[0001] The invention relates to an apparatus for football training.

BACKGROUND OF THE INVENTION

[0002] Football is arguably the world's most popular and important sport, and is widely played in many different countries. One style of football that has achieved great success over the past decade is known as "tika-taka". Tika-taka places an emphasis on retaining possession, and players make large numbers of quick, short passes (hence the name). Barcelona and the Spanish national football team have both achieved major success by adopting this style of football.

[0003] Although football is a sport, the commercial and business side of the game cannot be overlooked. For example, Gareth Bale became the most expensive footballer in history when he transferred from Tottenham to Real Madrid in September 2013 for £85 million (see http://www.bbc.co.uk/sport/0/football/23538218). Gareth Bale originally trained at Southampton football club before being sold as a teenager to Tottenham.

[0004] This summer Southampton football club sold two further teenage footballers, Luke Shaw to Manchester United for £27 million and Calum Chambers to Arsenal for £16 million (http://www.bbc.co.uk/sport/0/football/28593032). From a purely financial perspective, this shows the significant monetary rewards that can be obtained by training and developing talented footballers.

[0005] The World Cup of 2014 was won by Germany, with Gotze scoring a goal in extra time to beat Argentina. The Sun newspaper on 10 Aug. 2014 included an article "Why the Germans beat us at footie" (pages 28-29). This article describes a £1.5 million training machine, referred to as the "footbonaut" that the German players use in training. This machine is based on a rectangular playing area with panelled walls. The machine fires balls at players from projection systems inside the panelled walls, so that the players receive the ball in different directions, at different heights, and at different speeds. A sound effect indicates where the ball is coming from while a wall panel lights up for the player to shoot into. The article suggests that training in the footbonaut machine helped Gotze prepare for the one-touch chest control and first time volley that produced his winning goal in the World Cup final. Accordingly, it is clear that the appropriate football training equipment can contribute to success at the very highest level of world football.

SUMMARY

[0006] The invention is defined in the appended claims. The invention is defined in the appended claims.

[0007] Some embodiments provide an apparatus for football training comprising: a circular wall having an inward facing surface to provide rebound of a football, which has been struck in a radial direction against this surface, back along said radial direction towards the centre of the circular wall; multiple target indications provided at respective angular locations around the circular wall; a control system for activating a series of target indications in sequence; and a monitoring system for determining an angular location of an impact between the football and the inward facing surface of the wall; wherein the apparatus is configured to compare the angular location of an impact between the football and the inward facing surface of the wall with the angular location of the activated target.

[0008] Some embodiments provide an apparatus for football training comprising: a circular wall having an inward facing surface to provide rebound of a football, which has been struck in a radial direction against this surface, back along said radial direction towards the centre of the circular wall; multiple target indications provided at respective angular locations around the circular wall, wherein the targets indications are located substantially all around the circumference of the circular wall, and wherein the target indications comprise lights which are illuminated upon activation by the control system; a control system for activating a series of target indications in sequence; and a monitoring system for determining an angular location of an impact between the football and the inward facing surface of the wall; wherein the apparatus is configured to compare the angular location of an impact between the football and the inward facing surface of the wall with the angular location of the activated target; and wherein the control system is configured to activate a sequence of multiple adjacent lights in turn to provide a simulated moving target. For example, a sequence of adjacent lights may be activated temporarily, one after another, to simulate a moving player is to receive a pass.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a schematic diagram (not to scale) of a football training apparatus in accordance with some embodiments of the invention, illustrating in general terms the use of such apparatus.

[0010] FIG. **2** is a schematic diagram (not to scale) of the football training apparatus of FIG. **1** showing some additional components.

[0011] FIGS. **3**A and **3**B are schematic front and back views respectively of a first type of panel used for forming the football training apparatus of FIG. **1** in accordance with some embodiments of the invention.

[0012] FIGS. **4**A and **4**B are schematic front and back views respectively of a second type of panel used for forming the football training apparatus of FIG. **1** in accordance with some embodiments of the invention.

[0013] FIG. **5** is a section showing the connection between the first and/or second types of panel from FIGS. **3** and **4** in accordance with some embodiments of the invention.

[0014] FIG. **6** is a detail of the connection of FIG. **5**.

DETAILED DESCRIPTION

[0015] FIG. **1** is a schematic diagram (not to scale) of a football training apparatus **10** in accordance with some embodiments of the invention, and shows in general terms how the apparatus is used. The training apparatus comprises a circular wall **100** having a central position indicated by the cross and letter C. During a training exercise, a player **150** is located at or close to this central position and kicks a football **50** in a radially outward direction, as indicated by arrow R**1**, so as to strike the wall at location **101** (also marked as T**7**, as described below). The wall **100** is constructed so as to be substantially rigid, thereby supporting a (largely elastic) rebound of the ball from the wall. In addition, the inwardly directed surface of the wall **110**, i.e.

the surface facing the centre C, is substantially tangential (and hence normal) to the radial direction R1. Accordingly, a ball **50** struck by player **150** outwards from position C along radial direction R1 will rebound off the wall in the direction indicated by R2, back towards the centre C of the circular wall **100**. In other words, it will be appreciated that directions R1 and R2 lie along substantially the same radius of the circular wall, but point outwards and inwards respectively. In this manner, the ball is returned to the player **150** who is assumed to remain at location C at the centre of the circular wall **100**.

[0016] The circular wall is provided with multiple target indications **200**, which are spaced circumferentially around the wall **100** at different angular (azimuthal) locations. In particular, the implementation shown in FIG. **1** has 12 such target indications **200**, represented by T1, T2 . . . T12 (by way of example only). As discussed in more detail below, each of these target indications **200** may comprise a light which is illuminated in order to activate that target indication. The task of the player is therefore to strike the ball against a target indication **200** which is currently illuminated (activated). Thus in the situation depicted in FIG. **1**, if target T7 is activated, the strike represented by arrows R1 and R2 would be regarded as successful. Alternatively, if target T7 is not activated (and perhaps target T9 is activated instead), the strike represented by arrows R1 and R2 would be regarded as unsuccessful. The training apparatus **10** further includes a monitoring system (not shown in FIG. **1**) which determines whether or not a player manages to hit the ball **50** against the wall at the appropriate location required by an activated target indication **200**. As discussed in more detail below, this monitoring system may be implemented using a wide range of technologies, including audio sensing with microphones and video tracking.

[0017] In use of the training apparatus **10**, a control system (not shown in FIG. **1**) is used to activate a sequence of target indications **200**. For example, the control system may activate a sequence such as T2, T7, T9, T5 and so on. The player kicks or passes the ball towards the first activated target T2, and then receives the rebound from the inner surface **110** of the wall **100** back to the centre C. The player then directs the ball towards the next activated target T7, and so on. The player may be given a set time (say one minute) to hit as many targets as possible, where the targets may be activated in some predetermined or random sequence.

[0018] One key aspect of the football training apparatus **10** is that the player is continuously active: kicking or passing the ball **50** to the currently activated target, receiving the rebound, and repeating for the next target indication. Accordingly, this training apparatus focuses on aspects such as passing accuracy, spatial awareness of the activated target indications, stamina, control (as the ball rebounds back to the player from the wall surface **110**), and so on. Such training provides a better (and intense) simulation of continuous midfield passing, such as moving the ball quickly in one direction and then another, than the footbonaut system described above (which is more relevant to one-off goal-scoring and finishing).

[0019] It is also important that the football training apparatus **10** can provide a measurable (quantifiable) output, such as how many activated target indications were successfully hit by a player in a given sequence. This can then be used to rate or measure one player against another, as well as to track the improvement of a given player over time. The results can also be used for more sophisticated analysis of the strengths and weaknesses of a given player. For example, performance using the left foot for passing can be compared with performance using the right foot. Also, the speed of passing (and rebound control) may be assessed by activating a sequence of target indications more quickly—i.e. with shorter durations for the activations, and/or shorter intervals between two successive activations of target indications **200**. Other forms of analysis can be used to measure if players have particular preferred (or weaker) directions of passing and/or awareness.

[0020] The target indications may be provided using a wide range of techniques including:

a) painting the targets as players (or other appropriate representations) on the inner surface **110** of wall **100**, and suitably labelled such as by a name or number. These target indications may then be activated using an audio system, e.g. one or more loudspeakers that output the name or number of the activated target. Although this system is relatively straightforward to implement, player performance will be impacted according to how well they are able to remember the locations of the various labelled targets.

b) loudspeakers are positioned as different angular locations around the circumference of the wall **100**, for example at target locations T1, T2, T3, etc. A target location **200** is activated by emitting a sound from the loudspeaker at that location—e.g. a shout such as "pass", or "feet", potentially also including the name of the player undergoing the training exercise.

c) lights, e.g. light emitting diodes (LEDs), are positioned as different angular locations around the circumference of the wall **100**, for example at target locations T1, T2, T3, etc. A target location **200** is activated by illuminating the LED at that location.

[0021] Note that for approaches (b) and (c), the inner surface of the wall may again have painted target indications **200** or other similar graphical representations which are activated by the emission of sound or light from the location of the relevant target. In other implementations however, such graphical representations may be omitted, and the emission of sound or light by itself from a given location around circular wall **110** represents a target indication **200** (and the activation thereof).

[0022] It will be appreciated that some implementations may support more than one target activation mechanism. For example, there may be a light and a loudspeaker at the target locations, which can then be used together to provide both a shout and an illuminated light to represent activation of the target. It is also possible for different target activations in a sequence to have different activation mechanisms—for example, some activations may be by light illumination, others by sound emission (and some potentially by both light and sound activation together). In some such implementations, all target implementations **200** might support both light and sound activation, and it is the control system that selects which activation mechanism(s) to use for a given activation. In other implementations, different target indications **200** might support different activation mechanisms—e.g. T1, T4 and T7 and T10 have both audio and light activation available; T2 and T8 have audio only activation available; and T3, T5, T6, T9, T11 and T12 have light only activation. The skilled person will be aware of many other possibilities for different forms and combinations of mechanisms for providing and activating the target indications **200**.

[0023] The use of lights for the target indications, which can be illuminated to indicate activation, offers great flexibility. The following are examples of how such flexibility could be exploited by having the control system operating the lights of the target indications in an appropriate manner:

a) multiple targets may be activated simultaneously—thereby simulating a situation in which multiple possible passes are available to a player. The training apparatus **10** may be configured so that one direction, e.g. corresponding to target indication T**12**, represents forwards (towards an opponent's goal), while the opposite direction, namely corresponding to target T**6**, represents backwards (towards the player's own goal). A player using the training apparatus may receive a higher score if they pass to a target indication that represents a forward pass than if they pass to a target indication that represents a backward pass.

b) a target indication may be activated (illuminated) only for a limited period (which may be variable)—this simulates players initially being open to receive a pass, but then being closed down by the opposition if the pass is delayed. In some cases, a target indication **200** may remain activated, i.e. the light illuminated, until a player successfully passes to the position corresponding to the target indication. Receipt of this pass then in effect de-activates the target, thereby allowing the player to progress onto the next target illumination in the relevant sequence. It will be appreciated that with this configuration, a measure of the player score can be the number of targets successfully hit in a training session of fixed duration.

c) the size (angular width) of a target may be varied by illuminating more or fewer adjacent lights. For example, the activation of a target indication might comprise the illumination of two adjacent lights (say T**3** and T**4**). One motivation for this would be to make the target bigger and easier to hit, for example, to provide some form of "beginner" setting for player **150**.

d) a moving target indication may be simulated by illuminating a sequence of adjacent target indications. For example, if targets T**1**, T**2** and T**3** are illuminated in turn, this can be used to simulate a (potential receiving) player running in a direction shown by arrow A in FIG. **1**. In this case, the player **150** with the ball may be expected to aim slightly ahead of the currently illuminated target, for example, somewhere between T**3** and T**4**, in order for the ball to be counted as successfully received by this simulated receiving player. It will be appreciated that the speed of the simulated receiving player can be controlled by altering the timings of the illumination of successive targets (so that shorter timings correspond to a high seed). Note that the speed of the simulated receiving player may be varied, and/or the simulated receiving player may also be arranged to change direction (i.e. to return in the original direction, such as opposite to arrow A).

e) different colours may be used to represent different players or other relevant objects. For example, a target indication **200** may be illuminated with one colour to represent a player on the same side as player **150** (i.e. a potential receiving player) and another (different) colour to represent a player on the other team. Clearly the player **150** should not pass to a target indication representing the other team. However, the player **150** may also score higher if (for example), a pass goes to a player who is not close to (not marked by) a player of the opposite team (colour). Note that the different colours may be achieved either by having lights which can be illuminated in different colours as desired, and/or by having lights of different colours, and selecting which lights to illuminate according to the desired colour.

[0024] The above listing of potential simulations is not intended to be exhaustive, and other control patterns and training routines may be utilised. In addition, the implementation of particular training routines will depend on the facility of any given implementation—for example, if the angular spacing of the target indications **200** around the circumference of wall **100** is reduced, this supports a more realistic simulation of movement as per (d) above. In addition, while some implementations may support different coloured lighting as per (e) above, this may not be present in all implementations. Furthermore, it will be appreciated that features from two or more different schemes above may be combined together, for example, the use of different colours and movement, to provide more realistic and challenging training routines. Alternatively (or additionally), a sequence of target activations may employ different features from above at different stages of the sequence, thereby helping to test a variety of skills for player **150**.

[0025] The monitoring system for determining a location at which the ball has struck the circular wall **110** can be implemented using various technologies, including:

a) microphones—these can be positioned at different azimuthal locations around the circular wall. The microphone closest to where the ball hits the circular wall will generally receive: (i) the loudest sound, and (ii) the earliest sound (due to proximity to the point of contact). Accordingly, by comparing the volume or timing of the microphone signals (or both), the position of contact between the ball and the circular wall can be determined. This can include an assessment of an angular location intermediate two microphones.

[0026] For example, if the microphones have angular positions coincident with the target locations T**1**, T**2**, T**3** . . . T**12** shown in FIG. **1**, and the ball strikes directly against T**7**, then the microphone at T**7** will produce the loudest/earliest signal, with the microphones at positions T**6** and T**8** each producing a joint second loudest/earliest signal. Conversely, if the ball strikes exactly halfway between T**10** and T**11** (say), then the microphones at positions T**10** and T**11** will each produce a joint loudest/earliest signal. Furthermore, if the ball strikes between T**2** and T**3** (say), but closer to T**3**, the microphone at position T**3** will produce the loudest/earliest signal, the microphone at position T**2** will produce the second loudest/earliest signal, and the microphone at position T**4** will produce the third loudest/earliest signal. Thus by looking at the overall pattern of signals from multiple microphones and interpolating accordingly, the position of the contact between the ball and the circular wall **100** can be determined with good accuracy.

[0027] Note that if the target indications are provided as a sound (such as a shout), then the monitoring system has to discriminate between the impact sound of the ball hitting the wall and these target indications. In practice such discrimination is not difficult, since the impact sound is short and intense, whereas a shout is a longer and more diffuse sound.

b) vibration sensors (accelerometers)—these can be positioned at different azimuthal locations around the circular wall. These sensor detect vibrations in the wall **110** caused by the impact of the ball **50** against the wall **100**. In general, a sensor closer to the point of impact will generally receive a signal that is stronger (greater amplitude) and also earlier to arrive, as for a microphone. Accordingly, the output

signals of the vibration sensors can be processed to determine a position for the point of contact in substantially the same manner as a microphone outputs described above. N.B. although the positioning of the sensors or microphones may, in some implementations, be coincident with the target indications **200**, the numbering and/or spacing of the microphones or sensors may be different from the target indications **200**, depending upon the circumstances of any given embodiment.

c) magnetic ball tracking—this approach, as developed by CAIROS technologies AG (http://www.cairos.com/), has been sanctioned by FIFA for a goal-line decision system. A magnet is added to the ball and the location of the ball is determined by magnetic field sensors which detect the position of this magnet (and hence the ball). One implementation of this approach would position magnetic sensors at different angular locations around the wall **110**, and the location of contact between the ball and the wall would be determined from the magnetic sensor(s) that produced the strongest detection of the ball magnet (broadly analogous to the approach described above for using a microphone or vibration sensor).

d) video impact detection—video cameras can be positioned at different azimuthal locations around the circular wall, coincident with or close to the desired targets. As a ball approaches a given target position, the ball will appear larger in the field of view of that video camera. Therefore, the location of impact between the ball and the circular wall can be determined by the video camera that sees the largest image of the ball **50**. This may be determined, for example, by fairly straightforward image processing—e.g. looking for a change in image in any given video camera, or more specifically for an increasing size of the ball (which has a known shape, i.e. circular, and may also have a known colour).

e) video ball tracking—this approach, as developed by Hawk-Eye Innovations Ltd (http://www.hawkeyeinnovations.co.uk/), now part of Sony, has also been sanctioned by FIFA for a goal-line decision system. This approach uses multiple video cameras with a view inside the circular wall **110** to track and determine the position of the ball based on appropriate image processing algorithms. With this implementation, the position of the ball is continually monitored (rather than just determining the locations of impacts between the ball and the circular wall **110**). This system can therefore determine the point of impact as coincident with detecting a rebound motion of the ball.

f) active ball tracking—the Adidas smart ball system, see http://micoach.adidas.com/gb/smartball/, includes multiple accelerometers and a Bluetooth transmitter within the ball. The readings from the accelerometers within the ball allow the trajectory (and spin) of the ball to be sent by the Bluetooth transmitter to an external monitoring system to determine position. Similar to the Hawk-Eye system, this provides continual monitoring of the ball location.

g) radio ball tracking—the ball is provided with a radio transmitter (as for the Adidas system above), but without any accelerometers. In this case, multiple receivers at different locations are provided for these radio transmissions, which then allow the position of the ball to be determined by suitable triangulation of the received signal direction for the respective receivers. Similar to the Hawk-Eye system, this again provides continual monitoring of the ball location.

[0028] The above listing of monitoring systems is not intended to be exhaustive, and other monitoring systems may be available now or in developed the future. In addition, the number and positioning of the sensors of the monitoring systems (e.g. microphones, video cameras etc) provided in any given implementation will depend upon the desired positional accuracy to be achieved in that implementation. Furthermore, it will be appreciated that two or more different monitoring systems may be deployed together in some implementations to help improve accuracy, reliability, and so on.

[0029] The choice of which monitoring system(s) to use will depend upon the circumstances of any given installation of the training apparatus described herein. For example, a high-end permanent installation might use a video tracking system such as Hawk-Eye to give good accuracy, and also continuous positioning information. On the other hand, for a lower cost, portable (temporary) installation, the monitoring system may be based on microphones, since these are relatively inexpensive, and can be calibrated quickly. For example, one approach to microphone calibration, if needed, would be to place an isotropic audio emitter at the centre C of the circular wall. The output signal of each microphone can then be adjusted (normalized) by the monitoring system so that each microphone receives the signal from the isotropic audio emitter at the same volume (and same time).

[0030] The monitoring system **220** should also be robust against (or protected from) damage by contact with the ball, dirt, bad weather (rain, etc). It should also be able to operate successfully in different lighting conditions, especially if outdoors—e.g. ranging from overcast and gloomy to strong sunlight. N.B. as discussed below, the training system may in some cases by implemented as a permanent, weatherproof installation, which helps to avoid or at least mitigate such problems. Having multiple different technologies operating in parallel for monitoring system **220** can also help to provide consistent performance across a wide range of conditions.

[0031] FIG. **2** is a schematic diagram (not to scale) of the football training apparatus **10** of FIG. **1** showing some additional components. In particular, FIG. **2** shows in schematic form the control system **210** and the monitoring system **220**. The control system is connected electronically (by a wired or wireless link, such as Bluetooth) to the various target indications **200**, i.e. T**1**, T**2** etc. The control system is able to send activation signals to these target indications such that they are illuminated in accordance with a desired training sequence or pattern (we assume that the target indications **200** of FIG. **2** are provided by LED lighting).

[0032] FIG. **2** further shows a monitoring system **220** which is linked to and controls four video cameras **250**A, **250**B, **250**C and **250**D (again this link may be wired and/or wireless). The video images obtained by these video cameras **250**A, **250**B, **250**C and **250**D may be used to determine and monitor the location of ball **50** inside circular wall **100**. This monitoring (video) information can then be processed, e.g. within monitoring system **220** and/or within control system **210**, and correlated against the sequence of target activations provided by control system **210** to measure the performance of player **150**—e.g. to determine how frequently player **150** manages to pass the ball **50** to an activated target indication **200**. It will be appreciated that

other monitoring systems **220** may use different facilities as discussed above for following the position of ball **50**.

[0033] FIG. **2** further shows an external management system **230**, which may be connected to the control system by a wired link, e.g. USB, or by a wireless link, e.g. Bluetooth. In some implementations, the external management system **230** comprises a tablet, laptop computer or other such device. The external management system **230** may be used, for example, to create training routines, which may then be downloaded to the control system **210**. Such a training routine may include an activation sequence for the target indications **200**, and may further include information about scoring—e.g. how many points should be given (if any) if the player does not hit an illuminated target indication **200**, but nevertheless misses by only a small amount. In some cases the activation sequence may be fully predetermined, perhaps to test particular skills or situations. In other cases the activation sequence may be at least partly random—for example, after one target receives a successful pass for deactivation, the next target indication for activation by the control system **210** is selected on a random basis.

[0034] The external management system **230** may also receive results information from the control system **210**, for example, time taken, targets hit etc. The external management system **230** may then proceed to calculate the score for a player **150**, or else the score may first be calculated (in full or in part) using the control system **210**, with the (partial) result then being supplied to the external management system **230**. The external management system **230** may maintain performance records for different individuals, league tables of relevant scores for different individuals, etc. Such performance records or league tables etc may also be uploaded to a web-site or similar for wider access. Appropriate data analysis and display tools to support reviewing, analyzing and assessing performance may be provided on the external management system **230** and/or an appropriate web site.

[0035] In some implementations, the football training apparatus **10** is provided as a permanent installation, in which the walls are permanently installed and the control system and other electronics are powered by a mains supply. The playing surface for such an installation may be a **4**G artificial grass surface laid onto a shock-pad. For such a permanent installation, the walls may be full-height and support a roof to give weather protection within the training apparatus (both for the player and also for the various electronics). One portion of the curved wall in such an installation is constructed as a door to provide entrance into and exit from the apparatus. A viewing facility may be provided, e.g., through a transparent window or roof portion.

[0036] In other implementations, the football training apparatus **10** is provided as a portable installation, for example, for assembly on a training ground. In this case the underlying surface may be variable according to the location of the erection—e.g. natural or artificial grass. The circular wall is formed from panels which can be coupled together to form the wall **100**, and then uncoupled to dismantle the training apparatus **10** for transport and storage. The panels may be provided with a base of rubber or other such substance to protect the underlying surface. In addition, the football training apparatus **10** may be able to run from a portable battery (rather than the mains supply), for example, as a car battery.

[0037] In one particular portable installation, which will be described by way of example only, the training apparatus **10** comprises 12 curved panels, which when assembled form a circular wall of approximately 4 m radius and 0.6 m height. Each panel therefore represents an arc spanning 30 degrees of the circular wall **100**. There are 11 standard panels **300**, as shown schematically in FIG. **3**A and FIG. **3**B from the front and back respectively (where the front represents the view from inside the circle), plus one master panel **400**, as shown in FIGS. **4**A and **4**B, again representing the front and back respectively. Note that with this particular sizing, especially the height of the circular wall **100**, a player can step over the wall to gain access into the playing area within the wall (and likewise to leave the playing area), so there is no need for any panel to have an opening facility (although this can be provided if so desired). The control system **210** and the monitoring system **220** shown in FIG. **2** may be incorporated into one or more of the panels, e.g. the master panel, or may be provided in a separate unit.

[0038] As shown in FIGS. **3** and **4**, each of the panels (including the master panel) is provided with 11 LED lights (light bars) **320** extending in a vertical direction, of height approximately 0.5 m. These are arranged at a constant angular spacing around the panels, to give a total of 132 lights to serve as target indications **200**. It will be appreciated that this is considerably greater than the **12** target indications shown in FIGS. **1** and **2**, and helps to provide much more flexibility and also accuracy for the training routines. The panels **300**, **400** are also provided with finger recess holes **330** to assist in manipulation and assembly of the panels.

[0039] Turning now to the master panel **400** of FIG. **4**, this is also provided with an inwardly facing digital display **410** and speaker **420**. These may be used, for example, to give instructions to a player undertaking a training routine, such as indicating when the routine is about to start, or giving information about the remaining time for the routine—e.g. to represent a digital time. The display **410** may further be used to display the current score, which can act as a further incentive for a player if they are try to beat some known target. The speaker may also give feedback about the progress of the routine—for example, if the player makes a successful pass to an activated target indication, this might be indicated by an appropriate sound from the speaker. A further possibility is for the speaker to play real or simulated crowd noise, for example, to help a player learn to maintain concentration even in a noisy and relatively distracting environment.

[0040] The master panel **400** is also provided with a video camera **430**. This video camera may be utilized, for example, to record a video of the training session for subsequent review and analysis. Note that in general a single video camera by itself is not able to act as monitoring system **220**, rather this requires multiple video cameras such as shown in FIG. **2**. Accordingly, some of the standard panels **300** may also be provided with a video camera if this is the desired form of monitoring system. Likewise, some of the standard panels may also be provided with loudspeakers to support the provision of directional sounds to the player. Such sounds may then simulate a game, in which shouts arrive from different directions, and can be used to support activation of different target indications as discussed above.

[0041] In some implementations, the video camera(s) **250**, **430** (or similar monitoring system) are mounted on a struc-

ture (not shown in the Figures) which is separate from the panels. This can help to prevent vibrations caused by ball impacts on the panels from degrading the imaging quality. In other implementations, the video cameras may be provided on the panels but with suitable isolation mounts, and/or they may employ some digital image stabilization facility to compensate for vibrations. In other implementations, at least some portions of the wall may be made of a transparent material, such as perspex, to support viewing and/or camera monitoring. The perspex may form part of, or be mounted on top of, the circular rebound wall.

[0042] FIG. **5** illustrates a schematic horizontal section through the panels at the junction between two panels. As shown in FIG. **5**, each panel comprises a carbon fibre shell with a carbon fibre core. Each join comprises a male connector and a female connector. Typically each panel is therefore provided with one male connector and one female connector on opposite edges (in a consistent configuration across all panels). Alternatively half the panels (as female panels) may be provided with two female connectors, one on each side, while the other half of the panels (as male panels) may be provided with two male connectors, one on each side. In this case, the wall **100** would be constructed by alternating the male and female panels.

[0043] FIG. **6** illustrates the female connector (left), which is made of aluminium, and the corresponding male connector (right), which is made of plastic such as high density polyethylene (HDPE). During assembly of the panels, the male connector slides in a vertical direction down the female connector (or vice versa). A fixing such as a bolt or similar mechanism **510** can be used to fasten the two panels together in a rigid manner, thereby ensuring that the wall **100** is firm to give a good rebound for ball **50**.

[0044] It will be appreciated that the panel structures of FIGS. **3** and **4** and the particular fixings of FIGS. **5** and **6** are shown by way of example. Other implementations may use different panel structure and/or different fixings, or may not involve a panel arrangement at all.

[0045] The football training apparatus **10** described herein exploits the geometry of a circle, whereby if a player is located at or near the centre of the circle, any kick of the ball is necessarily directed along a radius of the circle. The ball will therefore strike the circle wall at a perpendicular (normal) angle and hence rebound back towards the circle. Accordingly, the player can experience a prolonged training routine involving substantially continuous working with the ball, i.e. a very high number of ball touches are produced compared with many other forms of training. Note that a similar result may be achieved if the wall is a shape that closely approximates to a circle, for example, a regular polygon with a large number of sides, e.g. forty.

[0046] The ball can be played against the wall on the ground or in the air (within the height limitations of the walls of any particular implementation). In some cases, the training routine may specifically involve passes at different heights. For example, the light bars shown in FIGS. **3** and **4** may be divided in the middle into an upper section and a lower section, with the former illuminated to specify a lofted pass, and the latter illuminated to specify a pass on the ground. The training apparatus may also have the facility to specify a different strength of pass, for example, a fully illuminated light might be used to specify a strong (well hit pass), while a partly illuminated length might be used to specify a softer pass. In some implementations, the desired properties of a pass, such as height and/or strength, might be indicated by vocal instructions, for example, as played through the speaker shown in FIG. **4**A, instead of (or as well as) the manner of illumination of a target indication **200**.

[0047] As noted above, adjacent lights (in a horizontal and/or vertical direction) may be combined into a single contiguous target indication. This can be used to control the size of an illuminated target to provide an easier or harder test of accuracy as desired. A similar variation in target size may be achieved if individual lights have multiple sections, and only a subset of the sections are illuminated for certain target activations.

[0048] A further possibility is that rather than illuminate a continuous block as a target, a target illumination might comprise (for example) two spaced light bars, with the target then comprising the space between the two illuminated light bars. This configuration simulates a goal, and may be incorporated into training sequences to help a player to recognize and exploit a shooting opportunity. Note that a player may receive greater credit (a higher score) for shooting into a corner of the simulated goal (rather than into the centre). A further possibility is that the position of the goal-keeper is also indicated, e.g. by illumination of a light of a particular colour, and greater credit is received by shooting away from the goal-keeper. In addition, greater credit may also be allocated to a harder shot, which can be detected e.g. because the rebound makes more noise or causes more vibrations, or based on a speed determination from a video tracking system.

[0049] The football training apparatus **10** can be used to develop a wide range of skills and attributes, including body strengthening, re-hab work, speed testing, jump height, body positioning, awareness, skill ball movement (trickery), footwork, body adjustment, and so on. The circle simulates the environment of a football player who receives the ball. Such a player will usually scan for a pass in front of him, i.e. in the direction he is facing to receive the ball, and if this fails, scan to the sides or perhaps to his rear. The football training apparatus **10** can help players to scan for available pass options prior to even receiving the ball—in essence to maintain a constant surveillance and awareness of their surroundings. This supports rapid first-time passing, but also requires the development of greater ball control skills, since a player is paying attention not only to the incoming football, but also the positions of surrounding players.

[0050] Overall, the football training apparatus **10** can support a great variety of different training routines to measure and enhance different skills and abilities. As indicated above, the facility to measure performance during a training routine is very important for an objective assessment of individual players, including the progress of any given player. The measurement facility also allows an analysis of the effectiveness of various training regimes and exercises (irrespective of whether they are implemented using the football training apparatus **10**). The measurements can be based on a number of different parameters, such as success rate (e.g. number of targets hit), accuracy (based on the size of the targets, or how close passes were to the centre of a target), speed, variation of distribution (whether or not all passes were made in a similar direction), ability to control the strength of a pass, ability to identify the best pass (by selecting an unmarked target over a marked target), and so on.

[0051] Although the football training apparatus **10** is well-suited to individual training routines, it can also be utilized for training sessions involving multiple players. For example, one player may be located at the centre of the circular wall **100**, as described above, while another player is able to move around this player, and in a defensive role tries to block or cut-out passes to the illuminated targets. Such a training exercise likewise can help a defensive player to develop awareness of the positions and movement of other players.

[0052] Another possibility is to include a centre pole with an elastic or resilient harness that tries to maintain the player close to the centre pole. Such a configuration can aid body strengthening, including for rehabilitation after injury.

[0053] The circular wall can have a wide range of radius, for example, from 1 m up to 30 m. The smaller sizes may be suitable for use by children, whether as a serious football skill development aid and/or as a toy for recreational purposes. Most implementations have a radius in a range of 2-10 m, for example, in the range, 3-8 m, to provide a suitable distance for pass testing. The height of the wall is generally at least 0.3 m, to return balls played along the ground reliably. In some cases the football training apparatus **10** may be provided with a roof and ceiling, and the wall **100** therefore extends from ground level to the ceiling—e.g. typically about 3 m. A higher wall such as this also allows heading of the ball to be utilized and developed during the training routines.

[0054] The wall may be made of any appropriate material, which will depend in part upon the nature of the installation (temporary, permanent, etc)—for example, materials such as carbon fibre, fiberglass, plastic UPVC, glass, wood, aluminium, steel and/or concrete might be used as appropriate. It will be appreciated that temporary, portable installations will tend to be made of lighter materials, whereas permanent installations will have a greater emphasis on materials with strength and durability.

[0055] In a high end system, the walls may have image display screens in order to provide a simulated or virtual reality experience of a football game. In this case, the target indications are players who are currently displayed on the virtual reality screen, depending upon their availability to receive—e.g. whether or not they are closely marked by the opposition, whether they are looking at the player with the ball to receive a pass, and so on. In some cases, the display screens may have insufficient resolution to provide realistic images, but nevertheless may have a pixel structure of lower resolution that allows greater flexibility in terms of illumination for different training exercises. Such a pixel structure may include support for different colours, for example by providing red, green and blue pixel elements.

[0056] In conclusion, the approach described herein provides a football training apparatus that supports high intensity and measurable training of a large number of footballing skills. Many different aspects of this football training apparatus have been described, by way of example and illustration, including large numbers of different features and facilities. Any given implementation of the football training apparatus may combine such different features and facilities as appropriate for the circumstances of the particular implementation. Accordingly, the scope of the invention is not limited to the above examples, but rather is determined by the scope of the appended claims and their equivalents.

1. Apparatus for football training comprising:
- a circular wall having an inward facing surface to provide rebound of a football, which has been struck in a radial direction against this surface, back along said radial direction towards the centre of the circular wall;
- multiple target indications provided at respective angular locations around the circular wall;
- a control system for activating a series of target indications in sequence; and
- a monitoring system for determining an angular location of an impact between the football and the inward facing surface of the wall;
- wherein the apparatus is configured to compare the angular location of an impact between the football and the inward facing surface of the wall with the angular location of the activated target.

2. The apparatus of claim **1**, in which the wall has a radius in the range 3 to 8 meters.

3. The apparatus of claim **1**, further comprising a ceiling, wherein the circular wall extends up to the ceiling.

4. The apparatus of claim **1**, wherein the circular wall is formed from a number of panels which can be disassembled in order to move or store the apparatus.

5. The apparatus of claim **1**, wherein the target indications comprise lights which are illuminated upon activation by the control system.

6. The apparatus of claim **5**, wherein the apparatus comprises at least 30 lights at respective angular locations around the circular wall which can each be illuminated by the control system.

7. The apparatus of claim **6**, wherein the apparatus comprises at least 100 lights at respective angular locations around the circular wall which can each be illuminated by the control system.

8. The apparatus of claim **5**, wherein multiple adjacent lights can be activated together to provide an extended target.

9. The apparatus of claim **5**, wherein multiple separated lights can be activated together to provide simultaneous different targets.

10. The apparatus of claim **5**, wherein a sequence of multiple adjacent lights can be activated in turn to provide a simulated moving target.

11. The apparatus of claim **5**, wherein the lights can be illuminated in different colors.

12. The apparatus of claim **11**, wherein the lights can be illuminated in a first color to indicate a team-mate and in a second color to indicate an opponent.

13. The apparatus of claim **1**, further comprising a speaker system for providing audio output.

14. The apparatus of claim **13** wherein said audio output is used to activate a target indication.

15. The apparatus of claim **1**, wherein the monitoring system only detects the impact between the ball and the circular wall.

16. The apparatus of claim **1**, wherein the monitoring system performs continuous tracking of the ball.

17. The apparatus of claim **1**, wherein the output of the monitoring system is passed to the control system to provide said comparison of the angular location of an impact between the football and the inward facing surface of the wall with the angular location of the activated target.

18. The apparatus of claim **1**, wherein the output of the monitoring system is used to determine whether the ball has hit a currently activated target indication.

19. A method of operating a football training apparatus comprising:

providing a circular wall having an inward facing surface to provide rebound of a football, which has been struck in a radial direction against this surface, back along said radial direction towards the centre of the circular wall, wherein multiple target indications are provided at respective angular locations around the circular wall;

activating a series of target indications in sequence;

determining an angular location of an impact between the football and the inward facing surface of the wall; and

comparing the angular location of an impact between the football and the inward facing surface of the wall with the angular location of the activated target.

20. The method of claim **19**, further comprising using the results of said comparison to produce a measured output score.

21. (canceled)

22. (canceled)

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