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(54) Title: BALL FOR A SPORTS GAME WITH A PLURALITY OF LOOP ANTENNAS

(57) Abstract: A ball for a sports game comprises a plurality of coils (4a-h) formed by conductors, the conductors of each coil enclosing a coil area. The coils are arranged such that a sum over projected coil areas of all coils of the ball differs by a maximum of 30% between any possible pair of projections along different chosen directions (8), wherein a projected coil area is obtained by a projection of a coil area onto a plane, the projection being performed in parallel to the chosen direction (8).

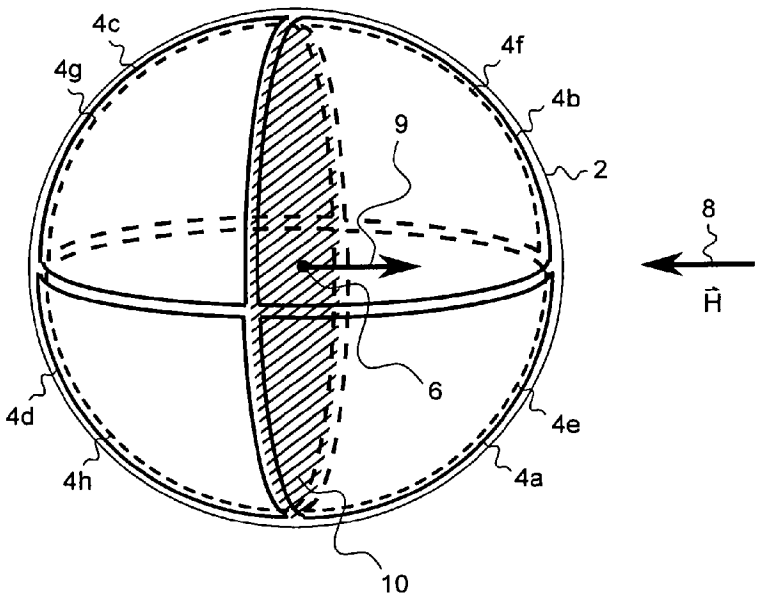

Fig. 1

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BALL FOR A SPORTS GAME WITH A PLURALITY OF LOOP ANTENNAS

Embodiments of the present invention relate to balls for a sports game, in particular to balls comprising one or more coils in order to utilize an electromagnetic field to detect the transit of the ball through an area of interest.

Background

For example, in soccer games systems have recently been proposed which utilize an electromagnetic field within a goal of a soccer field in order to detect the transit of a ball through the goal plane, i.e. into the goal. To this end, the soccer balls may be equipped with one or more coils such as to couple to the electromagnetic field or to at least its magnetic component and to, for example, use the voltage induced in a coil to power further electronics present within the ball itself. That is, the energy provided by the electromagnetic field is used in order to energize electronic components within the ball.

Other approaches use no active electronics but utilize resonant circuits comprising the coils within the ball so as to back-scatter the magnetic field, that is to generate or send out a signal allowing to conclude about the position of the ball. In particular, the resonance frequency of the resonant circuit comprising the coils is tuned to the frequency of the electromagnetic field as present in the goal plane or in the area of the goal. The resonant circuit is, in the area of the goal, excited by the electromagnetic field. Due to the characteristics of a resonant excitation, the coils then also serve as sending antennas of a magnetic field having a phase shift of 90° with respect to the magnetic component of the exciting electromagnetic field. The so back-scattered signal can be sensed and by the evaluation of the so sensed signal the transit of the ball through an area of interest, i.e. into the goal can be determined.

Independent from the particular implementation, the application of coils into a ball or, more general, into an elastic or inelastic moving object used in sports games imposes major problems when one aims at constant characteristics, irrespective of the particular

orientation of the moving object or irrespective of possible elastic deformations of the ball or the object. For example, the inductance of a coil depends on the coil area enclosed by the conductors of the coil, the longitudinal extension of the coil and the number of loops of the conductors of the coil. Integrating a coil into a ball, therefore, is rather challenging. On the one hand, the inductance of the coils of a resonant circuit in the ball should be independent from the manufacturing process so that a resonant circuit remains at any time tuned to a frequency of an exciting electromagnetic field. This normally requires the application of the circuit inside the ball before the resonant circuit is tuned to the desired resonance frequency when the coil is already in place. This, however, results in a time-consuming and rather expensive production of individual balls, since these can be only partly finished and closed, before the tuning is performed. After the tuning, the surface of the ball has to be closed, for example by stitching a final segment of the ball to the rest so as to provide a fully closed sphere of the ball. Moreover, loops fully encircling the sphere of the ball are sensitive to elastic deformations of the ball which, therefore, alter the inductance of the coils which in turn decreases the detection accuracy relying on a constant resonance frequency of the resonant circuit.

Therefore, the desire exists to provide for balls or sports equipment being more easy to produce and more insensitive to changes of the condition of the ball during its lifetime or during a game.

Summary

Embodiments of the present invention achieve this by providing a ball for a sports game which comprises a plurality of coils formed by conductors enclosing a corresponding coil area. In particular, balls according to some embodiments are provided such that the sum over projected coil areas of all coils of the ball differs by a maximum of 30 % between any possible pair of projections along different chosen directions. That is, regardless of the direction from which an electromagnetic field crosses the ball, an effective coil area, which is the coil area contributing to the generation of a back-scatter signal or to the extraction of field energy from the powering electromagnetic field is essentially similar. To this end, a projected coil area is understood as an area obtained by a projection of a coil

area onto a plane, wherein the projection is being performed in parallel to the chosen direction. That is, the projection may be performed perpendicular to the plane. In other words, embodiments of the present invention may be based on the finding that multiple beneficial geometries can be chosen, once it is established that the sum over the projected coil areas is mainly independent from the chosen direction from which the projection is performed. In particular, also geometries become feasible that allow for a cost-effective and efficient production of the ball and its associated coils.

According to some embodiments, the coils are arranged such within the ball that the conductors of different coils do not intersect each other. This may, for example, avoid mechanical instabilities due to intersecting conductors of the coils. When the coils intersect with each other, weight may be concentrated at the point of the intersection, thus causing an increased mechanical load on the remaining components of the ball at the point of the intersection. This, in turn, may lead to an increased abrasive wear of the ball. Furthermore, concentration of weight at particular positions in the ball may lead to a deterioration of the kinematic properties of the ball. For example, a ball may deviate significantly from a straight line of flight when the weight is distributed unequally within the ball.

Other embodiments achieve the above objective by providing a ball for a sports game, the ball comprising a plurality of coils (4a-h; 20a-h; 24a-d) formed by conductors, the conductors of each coil enclosing a coil area (15a, 15b), wherein all coils are arranged within the ball such that the conductive wires of different coils do not intersect each other.

According to some further embodiments of the present invention, the conductors of all coils are arranged at a spherical surface of the ball. Arranging the conductors of all coils at a spherical surface of the ball may provide for the advantage that the coil area remains stable over the lifetime of the ball and hence also the resonance frequency of a resonant circuit comprising the particular coil. According to some embodiments, the conductors of the coils are particularly arranged at or fixed to the spherical surface of a bladder of the ball or to the inner side of an outer hull of the ball. In this respect, a bladder shall be understood as a spherical component which is essentially airtight such as to provide for the

possibility to pressurize the ball. While the bladder is used to enclose the air, the outer hull as understood herein is used to define the outer shape of the ball and to provide a robust hull which withstands the pressure of the air contained inside the bladder. However, apart from those two particular examples, further embodiments of balls may have coils having their conductors arranged at arbitrary other spherical surfaces or spherical layers of the ball, such as for example intermediate layers of material between the bladder and the outer hull or the like.

According to some embodiments, the ball utilizes eight coils which are arranged at a spherical surface of the ball, for example between the bladder and the outer hull, wherein each coil covers a spherical angle of $\pi/2$. By utilizing eight equal coils distributed on the spherical surface such that each coil covers a spherical angle of $\pi/2$ provides an efficient arrangement according to which the sum over all projected coil areas is essentially equal for all possible chosen directions while at the same time using only a minor amount of coils such as to be able to manufacture the ball efficiently at considerable costs.

According to further embodiments of the present invention, balls are provided with multiple coils, wherein the distribution of the coils within the ball is symmetric about the center of the ball. This provides for an electromagnetic behavior of the ball which is essentially independent of the orientation of the ball by simply distributing individual coils symmetric with respect to the center.

According to further embodiments, however, not all coils enclose the same coil areas. That is, further embodiments comprise coils of a first group, the first group having only coils enclosing a coil area of an identical first size, as well as coils of a second group, the second group having only coils enclosing a coil area of a different second size. In order to provide for appropriate electromagnetic characteristics of the ball, a distribution of all coils of the first group is symmetric about the center of the ball and, also, the distribution of all coils of the second group is symmetric about the center of the ball. That is, both groups of coils are distributed independently from one another. However, each group is, on its own, distributed symmetrically about the center of the ball.

According to some embodiments, a spherical surface of the ball, such as for example the outer hull, consists of at least two monolithic surface segments which are fixed or stitched together along a border between the two surface segments, wherein the coils are arranged within the ball such that the conductors of the individual coils do not intersect the border between the surface segments. This may increase long term stability of the ball, since the borders and their associated seams form areas where the conductors may potentially be destroyed. According to further embodiments, this may also provide for the possibility to efficiently manufacture a ball according to the invention in that individual coils are arranged or fixed to the monolithic surface segments before the same are fixed together. To this end, a time-consuming insertion of coils into an outer hull of the ball which is mostly completed may be avoided. To the contrary, according to some embodiments, the coils may be attached to the surface segments prior to their stitching or fixing together according to standard processes.

In particular, this may allow to attach a single coil to each of multiple surface segments of a ball prior to fixing the surface segments together at their borders in order to form a spherical surface of the ball. To this end, the coils may be attached to any surface segment of the ball, such as, for example, a segment of the outer hull of the ball, a segment of an intermediate layer of the ball or a segment of a bladder of the ball prior to their connection to form the spherical surface. Particularly, standardized pentagonal and/or hexagonal surface segments may be equipped with a single coil prior to stitching the segments together to form a spherical outer hull according to a standard process.

According to further embodiments, the coils are provided such that they comprise first segments where the conductors of the coils are arranged at a spherical surface of the ball as well as second segments, where the conductors extend radially inwards in the direction of the center of the ball. This may allow for a convenient interconnection of the individual coils, while the same are at the same time easy to implement and provide for electromagnetic characteristics of the ball which are mainly independent from the orientation of the ball. In particular, a reinforcement structure within the ball may be utilized, which has the form of a tetrahedron in order to support electric circuitry or the like in the center of

the ball in order to direct the conductor of the coils in the second segment radially inwards.

According to some embodiments of the present invention, all coils of the plurality of coils are part of a resonant circuit, wherein all resonant circuits of the ball are tuned to essentially the same resonance frequency in order to provide for direction independent electromagnetic characteristics of the ball.

According to some embodiments, the frequency to which the resonant circuit is tuned is within the interval between 9 kHz and 30 MHz, preferably between 9 kHz and 150 kHz. This may allow for a stable detection of the passage of the ball through an area of interest or a goal while at the same time avoiding disturbance of the electromagnetic field due to the presence of players in the field or close to the goal.

According to some embodiments of the present invention, a ball for a sports game comprising a plurality of coils may be assembled such that a plurality of coils formed by conductors is provided at the beginning. The plurality of coils is then distributed such within the ball that a sum over projected coil areas of all coils of the ball differs by a maximum of 30 % between any possible pair of projections along different chosen directions.

According to further embodiments of the present invention the method for assembling a ball furthermore comprises fixing the plurality of coils to at least two monolithic surface segments; and attaching the monolithic surface segments to each other so that a spherical surface of the ball is formed. That is, the fixation of the coils to the ball may take place before the ball is finally assembled, so reducing the production costs and time by a considerable amount.

According to a further embodiment of a method for assembling a ball, the plurality of coils is integrated into at least one resonant circuit and the circuit is tuned to a resonance frequency before the monolithic surface segments are attached to each other, so that previously provided surface segments may be fixed together utilizing standard production processes without the need for further optimizations later on.

To this end, the electrically active components and/or coils may be assembled to surface segments by a first manufacturer, delivering the so prepared surface segments to a second manufacturer, specialized in producing balls.

In other words, embodiments of the present invention comprise a ball or an item of sports equipment, for example a ball for a ball game, for example for handball, football or American football, which comprises a plurality of coils, wherein the coils of the plurality of coils are arranged in such a way that at least two coils of the plurality of coils are arranged at an angle with respect to one another which differs from 0° and an integral multiple of 180°, and wherein the coils of the plurality of coils are free of overlap. According to some embodiments, the coils of the plurality of coils are arranged at least partially or completely edge to edge, wherein these coils of the plurality of coils can be at a distance from one another or can touch one another.

With respect to the term ball, it should be noted, that balls in the sense of this document shall be any sports objects, flying or being moved around in a sports game, irrespective of their particular form or material composition. That is, balls in that sense may be flexible balls, deformable under the influence of force or also solid objects, like golf- or billiard-balls or the like. Furthermore, a ball with this respect does not necessarily have to have a spherical outer shape. On the contrary, balls or objects of different shapes are understood as balls herein, such as for example also American footballs or rugby balls or pucks of an ice hockey game or the like.

Brief description of the Figures

Some embodiments of apparatuses and/or methods will be described in the following by way of example only, and with reference to the accompanying figures, in which

Fig. 1 shows a perspective illustration of an embodiment of a ball;

Fig. 2 shows a projection of the embodiment of Fig. 1;

Fig. 3 shows a three-dimensional illustration of a further embodiment of a ball;

Fig. 4 shows an illustration of an outer hull of a ball according to an embodiment of the present invention;

Fig. 5 shows an illustration of multiple coils within a ball as distributed around a circumference of the ball;

Fig. 6 shows a further embodiment of a ball according to the present invention; and

Fig. 7 shows a block diagram of an embodiment of a method according to the present invention.

Description of Embodiments

Various embodiments will now be described with reference to the accompanying figures in which only some exemplary embodiments are illustrated. For the sake of clarity, individual components, lines, layers and/or regions within the figures may not be drawn to scale.

It should be understood, however, that there is no intent to limit further embodiments to the particular implementations disclosed in the following figures. To the contrary, it is pointed out that further embodiments may use alternative implementations or modifications and equivalents of the implementations disclosed in the figures which fall within the scope of the invention. In particular, the fact that individual functionalities are described with respect to different entities, functional blocks or devices shall not be construed to mean that those entities are physically separated in all possible further embodiments of the present invention. Further embodiments may also unite several functionalities in a single entity, functional block or device. Also, multiple functionalities described

with respect to one single entity, functional block or device may be distributed over multiple physically separated components in further embodiments or implementations.

It will be understood that when an element is referred to as being "connected" or "coupled" to another element, it can be directly connected or coupled to the other element or intervening elements may be present. In contrast, when an element is referred to as being "directly connected" or "directly coupled" to another element, there are no intervening elements present. Other words used to describe the relationship between elements should be interpreted in a like fashion (*e.g.*, "between" versus "directly between," "adjacent" versus "directly adjacent," etc.).

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting further embodiments. As used herein, the singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises," "comprising," "includes" and/or "including," when used herein, specify the presence of stated features, integers, steps, operations, elements and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components and/or groups thereof.

Unless otherwise defined, all terms (including technical and scientific terms) used herein shall have the same meaning as commonly understood by one of ordinary skill in the particular art.

Like reference numbers refer to like or similar elements throughout the following description of the figures.

Fig. 1 shows an embodiment of a ball for a sports game, in particular an illustration where the distribution of eight individual coils within the ball becomes apparent. The outer hull 2 of the ball is only schematically illustrated by means of an enclosing spherical surface.

According to the embodiment illustrated in Fig. 1, eight coils 4a to 4h are distributed equally within the ball at a spherical surface thereof. The spherical surface may, for example, be formed by a bladder of the ball or, by the inner surface of the hull 2. The coils 4a to 4h are distributed within the ball such that each coil covers a spherical angle of $\pi/2$. That is, a coil covers an angle of 90° in two perpendicular directions with respect to the center 6 of the ball. As explained in more detail with respect to Fig. 2, which shows a projection of the coils 4a to 4h of the ball in parallel to a chosen direction 8, the distribution of the coils within the ball of Fig. 1 is such that the sum over all projected coil areas is essentially equal for all possible chosen directions. For the sake of simplicity, only the coils 4a, 4b, 4e and 4f are illustrated in Fig. 2. A current induced in the coils 4a, 4b, 4e and 4f by an exciting electromagnetic field is denoted Ia, Ib, Ie and If, respectively. For the sake of simplicity, it is furthermore assumed that the field vector of the exciting magnetic field H used to excite resonant circuits comprising the coils 4a-h and to detect the presence of the ball is in parallel to the chosen direction 8 so that the field vector of the backscattered magnetic field points into the opposite direction 9. The currents illustrated in Fig. 2 correspond to those generating the backscattered field.

The particular configuration of coils 4a-h as illustrated in Figs. 1 and 2 behaves as if a single coil was present which extends around the ball within plane 10 illustrated in Fig. 1, as the following considerations will show. The coils are distributed on the surface of the ball such that the conductors of neighboring coils extend in parallel to each other along the different segments of 90° each. Under the simplifying assumption that the exciting magnetic field H is parallel to the chosen direction 8, the currents induced in the coils 4a, 4b, 4e and 4f are equal. Although only coils 4a, 4b, 4f and 4e are visible in the projection of Fig. 2, it is apparent that an identical current is also induced in coils 4c, 4d, 4g and 4h, That is, an identical current is induced in all eight coils, Ia = Ib = Ic = Id = Ie = If = Ig = Ih. Assuming that the coils are part of a resonant circuit tuned to the frequency of the exciting electromagnetic field, each of the coils 4a-h also generates a magnetic field of identical strength, due to the identical currents induced in the individual coils. Hence, the coils 4a-h do also generate an (electro-) magnetic field. However, the phase of the so-called back-scattered signal is shifted by 90° with respect to the exciting electromagnetic field H.

As apparent from the illustration in Fig. 2, the projected currents Ia, Ib, Ie and If run in opposite directions within the segments of the coils that extend radially inwards in the projection of Fig. 2. Those parts of the currents cancel each other so that the remaining effective currents contributing to the generation of the back-scatter field are the ones running at the circumference of the spherical surface of the ball. These, however, correspond to the currents induced in a hypothetical coil running around the spherical surface in plane 10 of Fig. 2. That is, the configurations of Figs. 1 and 2 has the same effect than a configuration where three coils are formed around the circumference of the ball, which are perpendicular with respect to each other in a pairwise manner and which would, therefore, intersect each other at six positions.

This is because the coils 4a-h as distributed within the ball of Fig. 1 and Fig. 2 are distributed such that the sum over all projected coil areas is essentially equal for all possible chosen directions. Geometries different than the ones chosen in Fig. 1 and Fig. 2 may also fulfill this criterion, as simple geometric considerations show. Also, the particular orientation of the exciting magnetic field H with respect to the orientation of the coils 4a-f as chosen in Figs. 1 and 2 only serves to illustrate the basic principle without any unnecessary complication. Other orientations of the H field will end up with the same results.

The conductors of the individual coils of the embodiments of Figs. 1 and 2 do not intersect at a single location, avoiding problems with the stability of the ball, problems arising from the intersection of conductors, problems occurring during the production of the balls and the like.

Fig. 3 shows a further embodiment of the present invention, wherein multiple coils are arranged within the ball such that the conductors or the conductive wires of different coils do not intersect each other. The conductors of the individual coils are arranged at a spherical surface of the ball so as to enable an easy production and to furthermore provide for a reliable and mechanically stable configuration of the coils within the ball. As an example for the multiple coils illustrated in the three-dimensional sketch of the distri-

bution of the coils within the ball, the following consideration will focus on coils 12a and 12b as an example. Also in the embodiment of Fig. 3, the plurality of coils is distributed within the ball, in particular at a spherical surface of the ball such that the sum over all projected coil areas of all coils of the ball is essentially equal for any possible chosen direction 8 used to perform the projection.

Fig. 3 illustrates an embodiment where multiple coils are distributed on a spherical surface of the ball while the coils are not even of the same geometrical shape. A first group of coils comprising coil 12a has only coils enclosing a coil area of a first smaller size wherein a second group of coils comprising coil 12b has only coils with a greater coil area. It goes without saying that herein the term coil area does not necessarily imply that the area is within a plane. As already illustrated in Fig. 1, the area can be of any geometrical shape, as for example an area on a spherical surface or the like.

As illustrated in Fig. 3, the coils are distributed such within the ball, that the sum over all projected coil areas 16a and 16b is essentially equal for all possible chosen directions 8. For this evaluation, a projection of the coil areas 15a and 15b onto plane 14 is illustrated, plane 14 extending perpendicular to the surface of the drawing in this particular example. The projection to be performed is a plane projection, that is, the projection is performed in parallel to the chosen direction 8 for each individual coil. As illustrated in Fig. 3, the first coil 12a having an associated coil area 15a is projected onto a projected coil area 16a on plane 14. In particular, the projected coil area 16a is rather small as compared to the projected coil area 16b associated to coil 12b. This is due to the cause that the coil 12a is placed on the spherical surface of the ball in an orientation nearly in parallel to the chosen direction 8. However, due to the particular distribution of the coils on the spherical surface, the sum over all projected coil areas is essentially equal for all possible chosen directions 8. One particular way to achieve this is to distribute the coils within the ball symmetrically about the center of the ball. When coils of different sizes, that is, coils with different associated coil areas are used, as in the example of Fig. 3, one particular way to achieve the above criterion to distribute the coils of the first group symmetrical about the center of the ball and to simultaneously distribute the coils of the second group symmetrically about the center of the ball.

One particular attractive way to distribute the coils becomes apparent when looking at a particular way as to how to form a spherical surface of an outer hull 2 of a ball by means of multiple pentagonal and hexagonal monolithic segments 18a and 18b during the production of the ball. The distribution of the coils of Fig. 3 corresponds to the distribution of the pentagonal segments of the outer hull so that each coil is associated to a single segment of the outer hull 2. That is, during the production of the ball, a plurality of monolithic segments of the outer hull may be provided and a single coil may be attached to each of the segments of the outer hull. According to some embodiments, it may even be possible to tune a resonance frequency of a resonant circuit attached to each coil to the frequency of the exciting electromagnetic field before the final assembly of the ball. Apart from the pentagonal/hexagonal segments 18a and 18b, it goes without saying that further embodiments may utilize different shapes of the monolithic surface segments. In this respect, the term monolithic describes that the particular segment is made of one piece, that is, the segment is made of a single sheet of material or component which is later on stitched together or glued together or by some other means attached to a further monolithic segment in order to provide a closed surface of a ball.

By attaching a single coil to each of the hexagonal/pentagonal surface segments, an equal distribution of the coils on the spherical outer surface of the ball is achieved, so that the electromagnetic properties of the ball remain constant at any possible orientation of the ball with respect to the exciting electromagnetic field. Furthermore, the conductors of the individual coils do not have to intersect the stitches or the connections between the individual surface segments, which experience a high mechanical load. Therefore, a danger to destroy the conductors at those particular locations may be minimized. According to some embodiments, each of the individual coils has associated thereto an individual resonant circuit tuned to the desired resonance frequency. That is, possible further circuitry of a resonant circuit, such as for example capacitors or the like, may be attached to the individual surface segments prior to their stitching together. That is, conventional manufacturing processes can be maintained, whereas according to some production methods according to the present invention, pre-equipped surface segments already including attached coils/resonant circuits may be provided to a manufacturer.

Apart from the advantages in the production mechanism, embodiments of the present invention provide balls with resonant circuits that may withstand higher mechanical loads and that may experience a longer lifetime, as for example, systems having single coils extending circumferentially around the ball and intersecting each other. Consider, for example, an elastic ball, as for example a football. With respect to Fig. 5, a configuration of multiple coils 20a to 20 h which are distributed around a circumference of a spherical surface of the ball are illustrated so as to compare this particular configuration with a configuration employing a single coil extending circumferentially around the surface. Such a coil is, for illustrative purposes only, also illustrated as comparative coil 22 in Fig. 5. When, for example, the ball or the shape of the ball is deformed due to the force of a shot, the shape of the ball is altered to become more elliptical. That is, the area as enclosed by the comparative coil 22 changes significantly and, as a consequence, the resonant circuit is becoming mistuned. According to the embodiment of the present invention, where the multiple coils are distributed around the circumference of the ball, those effects can be mostly disregarded. The effects on different coils around the circumference may eventually even cancel out.

In other words, a deformation of the ball leads to an increase of the pressure on the inside of the ball. This increase may, at least partially, lead to an increase of the diameter of the ball. While there is no conductive or direct mechanical connection between the coils 20a to 20h of an embodiment of the present invention, the absolute diameter of the ball may vary without causing a significant variation of the length of the conductors of the individual coils. This, however, is not possible according to comparative embodiments employing a comparative coil 22 where a change in diameter of the ball may eventually result in a loss of the coil due to mechanical failure or the like. That is, embodiments of the present invention do not only provide for ways to simplify the production of the balls but also provide for balls experiencing a better long-term stability, since a mechanical force on the ball, causing a deformation of the same, has fewer impact on the individual subsystems, that is the individual coils and the associated resonant circuits.

Apart from that, embodiments of the present invention allow a simplified production method, since the individual coils or subsystems comprising resonant circuitry electronics may be attached to the surface segments already prior to the final assembly and stitching of the same together. According to some embodiments, it is furthermore possible to tune the individual coils and associated resonant circuits before the final stitching of the surface segments, since a change of the circumference of the ball during production or during a game play does not impact the resonance frequency of the associated resonant circuits.

Fig. 6 shows a further embodiment of the present invention where the coils, that is the conductors, also have segments where the conductor extends radially inwards in the direction to the center 6 of the ball. In the particular embodiment of Fig. 6, four coils 24a to 24d out of six overall coils are illustrated. These are arranged in associated coil planes 26a to 26d such that each pair of planes of the coil planes encloses an identical angle, in particular an angle of 120° of a tetrahedron. In the particular embodiment of Fig. 6, a tetrahedron support structure may be utilized to additionally support electronics at the position of the center 6 of the ball. These electronics may be utilized to further track the ball during the game play by means of actively sending electronics or the like. A reinforcement structure of Fig. 6 is known to be beneficial for the dynamics of the ball in that the dynamics of the ball are disturbed to a lower extent than if orthogonal support structures were used. That is, the borders of the coils 24a-d may be defined by the support structures of the tetrahedron whereas further segments of the conductors of the coils 24a-d may extend along the inner surface of the bladder of the ball. The conductors of the individual coils may be connected to resonant circuit electronics in the middle or the center 6 of the ball. Furthermore, other electronic components may be supported in the center of the ball by means of the tetrahedron, e.g. matching circuitry or semiconductor chips or the like. These may, alternatively or additionally, also comprise active or semi-active back-scatter electronics or electronics sending particular tracking signals or the like.

Finally, Fig. 7 schematically illustrates a method for assembling a ball of a sports game having a plurality of coils.

In a providing step 30, a plurality of coils formed by conductors is provided, wherein the conductors of each coil enclose a coil area of predetermined size.

In a distribution step 32, the plurality of coils is distributed such within the ball, that a sum over projected coil areas of all coils of the ball differs by a maximum of 30% between any possible pair of projections along different chosen directions.

The method may furthermore comprise an optional pre-preparation step 34, where the plurality of coils are fixed to at least two monolithic surface segments. According to a further embodiment of the present invention, the also illustrated optional integration step 36 of integrating all coils of the plurality of coils into at least one resonant circuit may be part of the method.

According to a further optional tuning step 38, all resonance frequencies of all resonant circuits may be tuned to essentially the same resonance frequency before the monolithic surface segments are attached to each other.

Finally, a hull of the ball may be finished by attaching the surface segments together in an optional completion step 40.

It goes without saying that conductors used to form coils according to the present invention may be any type of conductive material or separately pre-produced conductors or the like. This includes isolated or non- isolated wires, conductive or semi-conductive material as sputtered on a substrate, printed on a flexible substrate of the like. Generally, conductors in the terms of the present invention comprise any material that has, as compared to its surrounding material, a higher conductivity for electric currents than the surrounding material.

The description and drawings merely illustrate the principles of the invention. It will thus be appreciated that those skilled in the art will be able to devise various arrangements that, although not explicitly described or shown herein, embody the principles of the in-

vention and are included within its spirit and scope. Furthermore, all examples recited herein are principally intended expressly to be only for pedagogical purposes to aid the reader in understanding the principles of the invention and the concepts contributed by the inventor(s) to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions. Moreover, all statements herein reciting principles, aspects, and embodiments of the invention, as well as specific examples thereof, are intended to encompass equivalents thereof.

Functional blocks denoted as "means for ..." (performing a certain function) shall be understood as functional blocks comprising circuitry that is adapted for performing a certain function, respectively. Hence, a "means for s.th." may as well be understood as a "means being adapted or suited for s.th.". A means being adapted for performing a certain function does, hence, not imply that such means necessarily is performing said function (at a given time instant).

Functions of various elements shown in the figures, including any functional blocks may be provided through the use of dedicated hardware, as e.g. a processor, as well as hardware capable of executing software in association with appropriate software. When provided by a processor, the functions may be provided by a single dedicated processor, by a single shared processor, or by a plurality of individual processors, some of which may be shared. Moreover, explicit use of the term "processor" or "controller" should not be construed to refer exclusively to hardware capable of executing software, and may implicitly include, without limitation, digital signal processor (DSP) hardware, network processor, application specific integrated circuit (ASIC), field programmable gate array (FPGA), read only memory (ROM) for storing software, random access memory (RAM), and non-volatile storage. Other hardware, conventional and/or custom, may also be included.

It should be appreciated by those skilled in the art that any block diagrams herein represent conceptual views of illustrative circuitry embodying the principles of the invention. Similarly, it will be appreciated that any flow charts, flow diagrams, state transition diagrams, pseudo code, and the like represent various processes which may be substantially

represented in computer readable medium and so executed by a computer or processor, whether or not such computer or processor is explicitly shown.

Furthermore, the following claims are hereby incorporated into the Detailed Description, where each claim may stand on its own as a separate embodiment. While each claim may stand on its own as a separate embodiment, it is to be noted that - although a dependent claim may refer in the claims to a specific combination with one or more other claims - other embodiments may also include a combination of the dependent claim with the subject matter of each other dependent claim. Such combinations are proposed herein unless it is stated that a specific combination is not intended. Furthermore, it is intended to include also features of a claim to any other independent claim even if this claim is not directly made dependent to the independent claim.

It is further to be noted that methods disclosed in the specification or in the claims may be implemented by a device having means for performing each of the respective steps of these methods.

Further, it is to be understood that the disclosure of multiple steps or functions disclosed in the specification or claims may not be construed as to be within the specific order. Therefore, the disclosure of multiple steps or functions will not limit these to a particular order unless such steps or functions are not interchangeable for technical reasons. Furthermore, in some embodiments a single step may include or may be broken into multiple sub steps. Such sub steps may be included and part of the disclosure of this single step unless explicitly excluded.

Claims

1. Ball for a sports game, the ball comprising:

a plurality of coils (4a-h; 20a-h; 24a-d) formed by conductors, the conductors of each coil enclosing a coil area (15a, 15b), wherein

a sum over projected coil areas of all coils of the ball differs by a maximum of 30% between any possible pair of projections along different chosen directions (8), wherein a projected coil area (16a, 16b) is obtained by a projection of a coil area (15a, 15b) onto a plane (10, 14), the projection being performed in parallel to the chosen direction (8).

2. The ball of claim 1, wherein the sum over all projected coil areas (16a, 16b) is essentially equal for all possible chosen directions (8).

3. The ball of claim 1 or 2, wherein all coils (4a-h; 20a-h; 24a-d) are arranged within the ball such that the conductors of different coils (4a-h; 20a-h; 24a-d) do not intersect each other.

4. The ball of any of the preceding claims, wherein the distribution of the coils (4a-h; 20a-h; 24a-d) within the ball is symmetric about the center (6) of the ball.

5. The ball of any of the preceding claims, wherein the coils (4a-h; 20a-h; 24a-d) comprise coils of at least a first group and a second group, the first group having only coils (12a) enclosing a coil area (15a) of an identical first size and the second group having only coils (12b) enclosing a coil area (15b) of a different second size, wherein the distribution of all coils (12a) of the first group is symmetric about the center (6) of the ball and wherein the distribution of all coils (12b) of the second group is symmetric about the center (6) of the ball.

6. The ball of any of the preceding claims, wherein the ball is a soccer ball, an American football ball, a Rugby ball, a basketball, a handball, a volleyball, a tennis ball, a bowling ball, a billiard ball, a golf ball, or a puck.

7. The ball of any of the preceding claims, wherein the conductors of all coils (4a-h; 12a, b; 20a-h) are arranged at a spherical surface of the ball.

8. The ball of claim 7, wherein the ball has eight coils (4a-h) arranged at the spherical surface of the ball such that each coil (4a-h) covers a spherical angle of $\pi/2$.

9. The ball of any of the preceding claims, wherein a spherical surface of the ball consists of at least two monolithic surface segments (18a, 18b) fixed together at a border, wherein the coils (12a, b) are arranged within the ball such that the conductors of the individual coils (12a, b) do not intersect the border between the surface segments.

10. The ball of any of the preceding claims, wherein a spherical surface of the ball consists of multiple monolithic surface segments (18a, 18b) fixed to each other, wherein each of the surface segments (18a, b) has a single coil (12a, b) is attached thereto.

11. The ball of any of the preceding claims, wherein each of the monolithic surface segments (18a, 18b) is pentagonal or hexagonal.

12. The ball of any of the preceding claims, wherein the coils (24a-d) comprise first segments where the conductors of the coils are arranged at a spherical surface of the ball as well as second segments where the conductors extend radially inwards in the direction of the center (6) of the ball.

13. The ball of claim 12, comprising six coils (24a-d) neighboring each other, the coils being arranged such that the coil areas of all coils lie within coil planes, wherein each pair of plains of the coil planes encloses an identical angle.

14. The ball of any of the preceding claims, wherein all coils (4a-h; 20a-h; 24a-d) of the plurality of coils are part of a resonant circuit, all resonant circuits being tuned to essentially the same resonance frequency.

15. The ball of claim 14, wherein the frequency is between 9kHz to 30MHz, preferably between 9kHz and 150kHz.

16. The ball of claim any of the preceding claims, wherein all coils (4a-h; 20a-h; 24a-d) are arranged within the ball such that intersecting conductors of different coils (4a-h; 20a-h; 24a-d) intersect each other at angles different than 90 degrees, preferably enclosing an angle smaller than 85 degrees with respect to each other.

17. The ball of any of the preceding claims, wherein the conductors of all coils (4a-h; 20a-h; 24a-d) are at least partially arranged at a spherical surface of the ball.

18. A method for assembling a ball of a sports game having a plurality of coils (4a-h; 20a-h; 24a-d), the method comprising:

providing (30) a plurality of coils formed by conductors, the conductors of each coil enclosing a coil area, wherein

distributing (32) the plurality of coils within the ball such that a sum over projected coil areas of all coils of the ball differs by a maximum of 30% between any possible pair of projections along different chosen directions, wherein a projected coil area is obtained by a projection of a coil area onto a plane, the projection being performed in parallel to the chosen direction.

19. The method of claim 18, the method further comprising:

fixing (34) the plurality of coils to at least two monolithic surface segments; and

attaching the monolithic surface segments to each other so that a spherical surface of the ball is formed.

20. The method of claims 18 or 19, further comprising:

integrating (36) all coils of the plurality of coils into at least one resonant circuit; and

tuning (38) all resonance frequencies of all coils or resonant circuits to essentially the same resonance frequency before the monolithic surface segments are attached to each other.

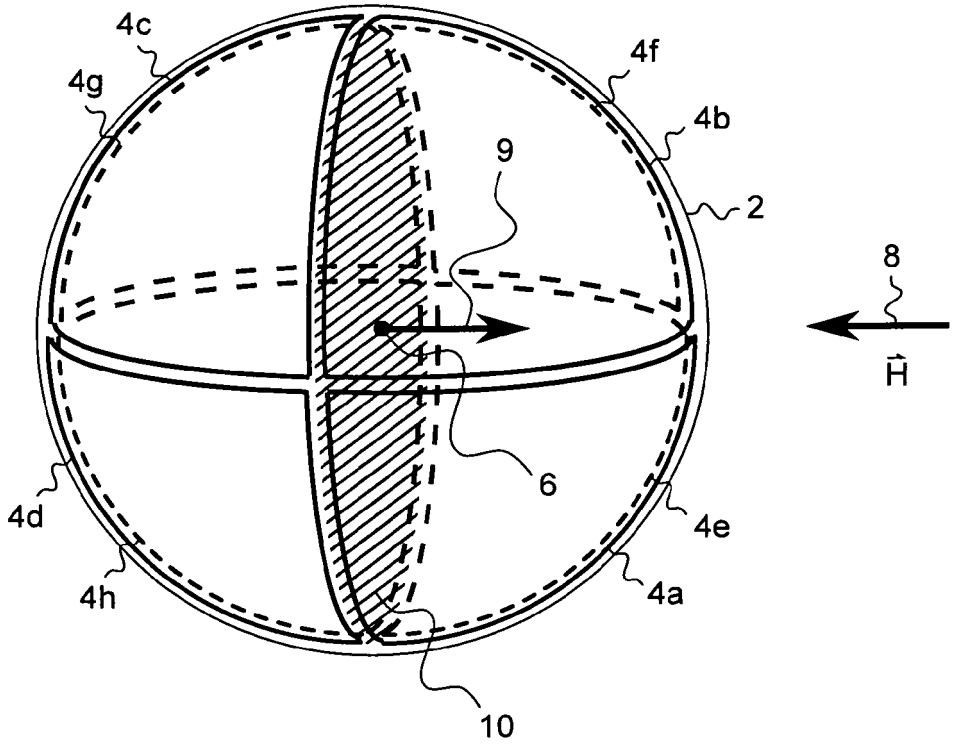
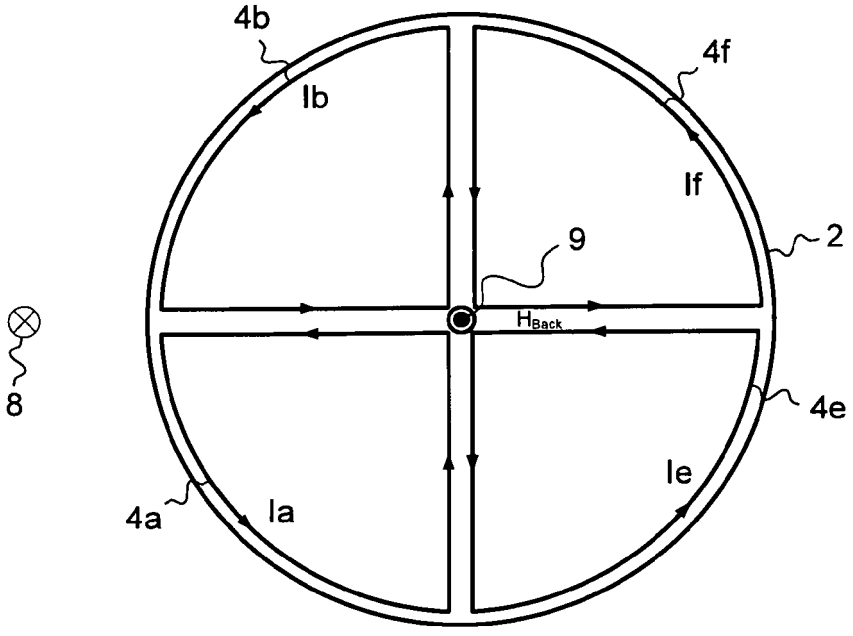

4c
4g
4f
4b
9
2
8
$\vec{H}$
6
4d
4e
4h
4a
10

Fig. 1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4f
If
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2
H_{Back}
8
4e
Ie
4a
Ia

Fig. 2

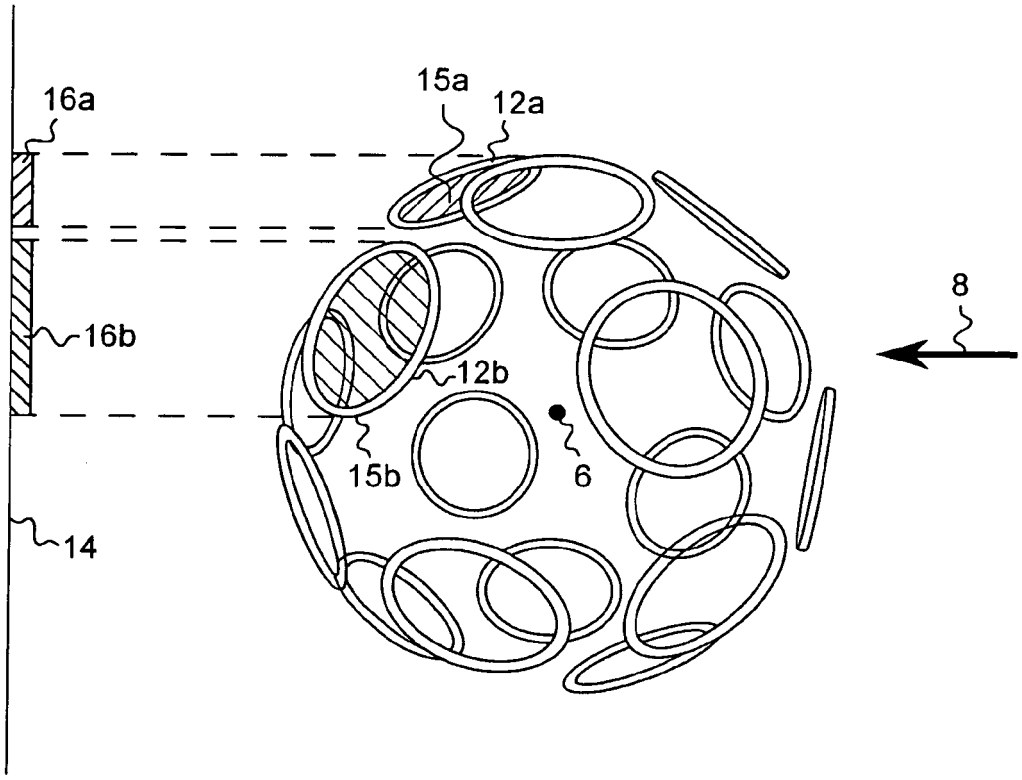


Fig. 3

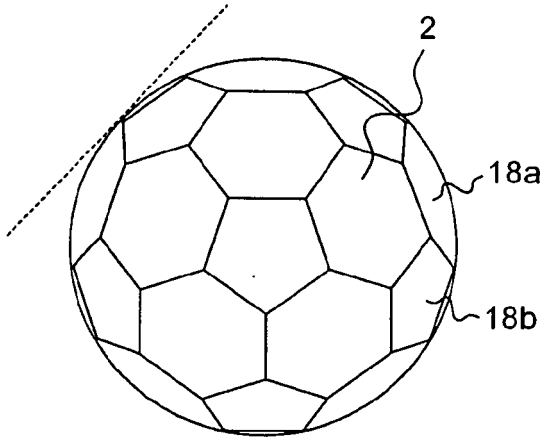
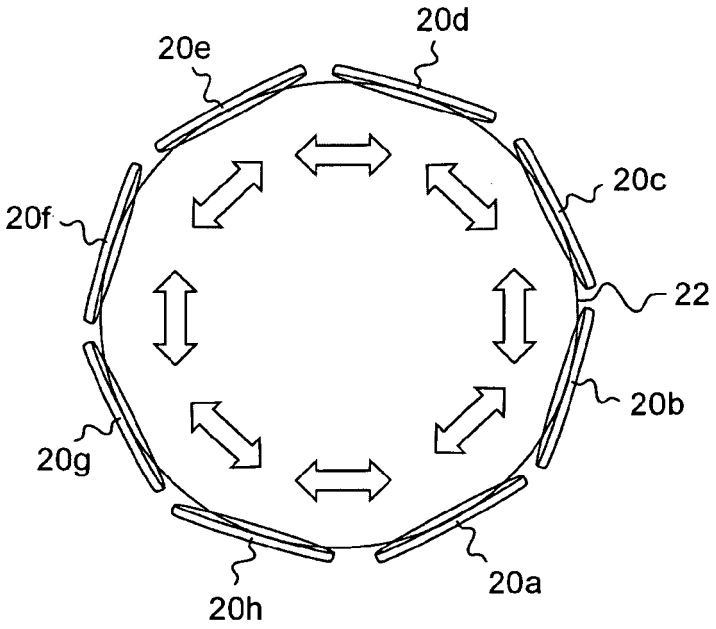


Fig. 4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20e
20c
20f
22
20b
20g
20h
20a

Fig. 5

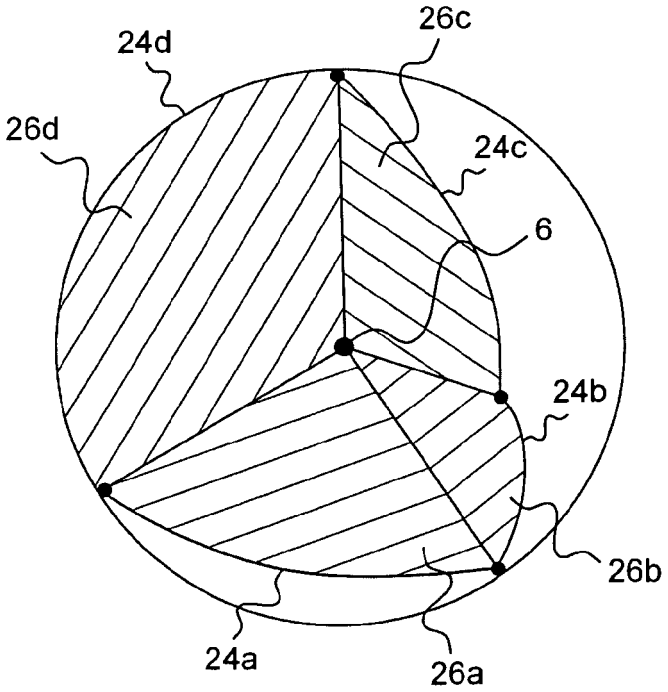
26c
24d
26d
24c
6
24b
26b
24a
26a

Fig. 6

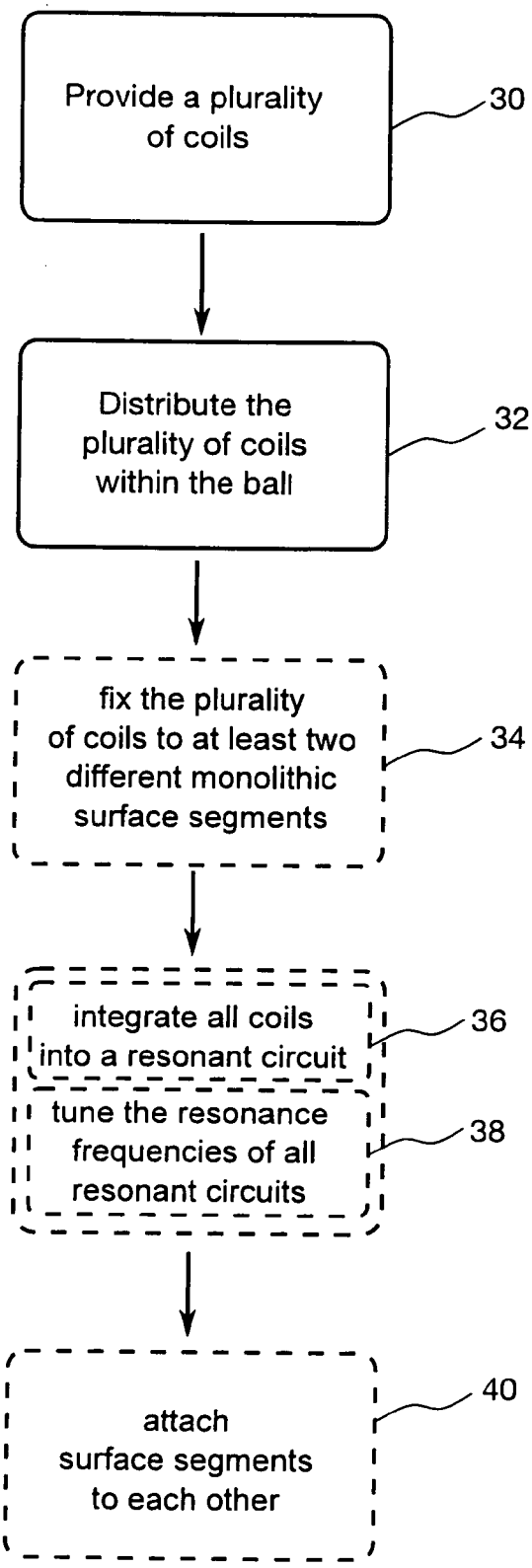
Provide a plurality of coils
30
Distribute the plurality of coils within the ball
32
fix the plurality of coils to at least two different monolithic surface segments
34
integrate all coils into a resonant circuit
36
tune the resonance frequencies of all resonant circuits
38
attach surface segments to each other
40

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/065299

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01Q7/00 H01Q21/28 H01Q1/22 G06K19/077
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01Q G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2011/316529 A1 (STANCIL DANIEL D [US] ET AL) 29 December 2011 (2011-12-29) the whole document	1-20
X	US 5 699 048 A (GALLOWAY GEORGE G [US]) 16 December 1997 (1997-12-16)	1-20
Y	the whole document	1-20
Y	US 2011/215808 A1 (CHOLAYIL SAMEER [US]) 8 September 2011 (2011-09-08) the whole document	1-20
A	JP 2004 086607 A (HITACHI CABLE) 18 March 2004 (2004-03-18) the whole document	1-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 August 2013	16/09/2013

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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