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Bianco et al.

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(54) **MEMORY FOR GPS-BASED GOLF DISTANCING SYSTEM**

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(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

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(63) Continuation of application No. 08/447,617, filed on May 23, 1995, now Pat. No. 5,904,726, which is a continuation of application No. 08/183,594, filed on Jan. 19, 1994, now Pat. No. 5,438,518.

(51) **Int. Cl.**[7] **G01S 5/14**

(52) **U.S. Cl.** **701/213**; 701/208; 342/357.08

(58) **Field of Search** 701/213, 300, 701/208, 214; 340/995; 364/410.1; 342/357.08, 357.13

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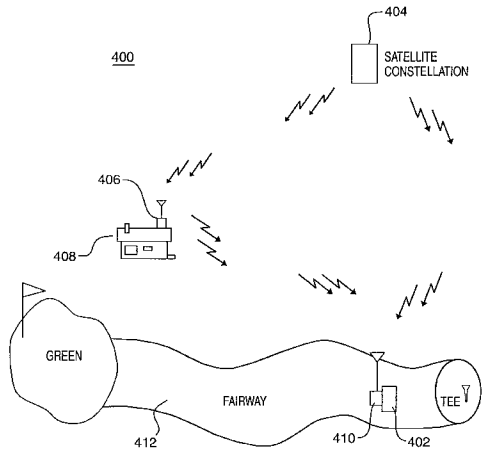
(57) **ABSTRACT**

A portable distance tracking system for use by a player on a playing field wherein the playing field includes at least a first landmark and wherein the system comprises at least one mobile interface unit. The mobile interface unit includes a memory element, position interface electronics, a data processor, and a player interface. The memory element stores digitized map representations of playing fields. The position interface electronics receive position indicative signals from and external source, wherein the position indicative signals are representative of a geographical location of the mobile interface unit. The data processor couples to the memory element and to the position interface electronics and correlates the geographical location to a field location of said mobile interface unit on said playing field. The processor also determines the distance from the mobile interface unit to the first landmark. The player interface is coupled to the data process and communicates the distance between the mobile interface unit and the first landmark to the player. According to a preferred embodiment, the playing field is a golf course and the first landmark is a flag location at a select hole on the golf course.

3 Claims, 11 Drawing Sheets



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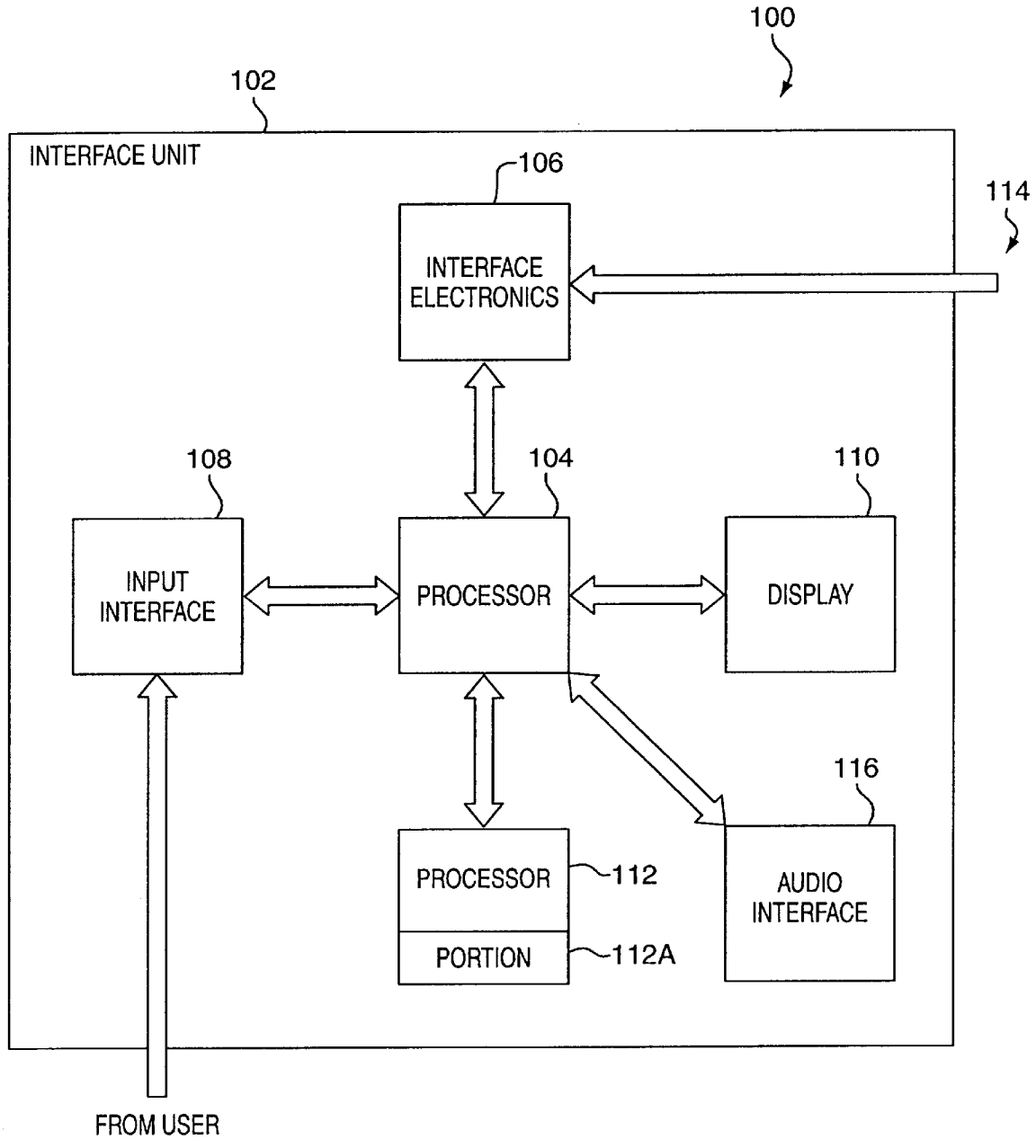
100
102
INTERFACE UNIT
106
114
INTERFACE ELECTRONICS
108
104
110
INPUT INTERFACE
PROCESSOR
DISPLAY
116
PROCESSOR
112
PORTION
112A
AUDIO INTERFACE
FROM USER

FIG. 1

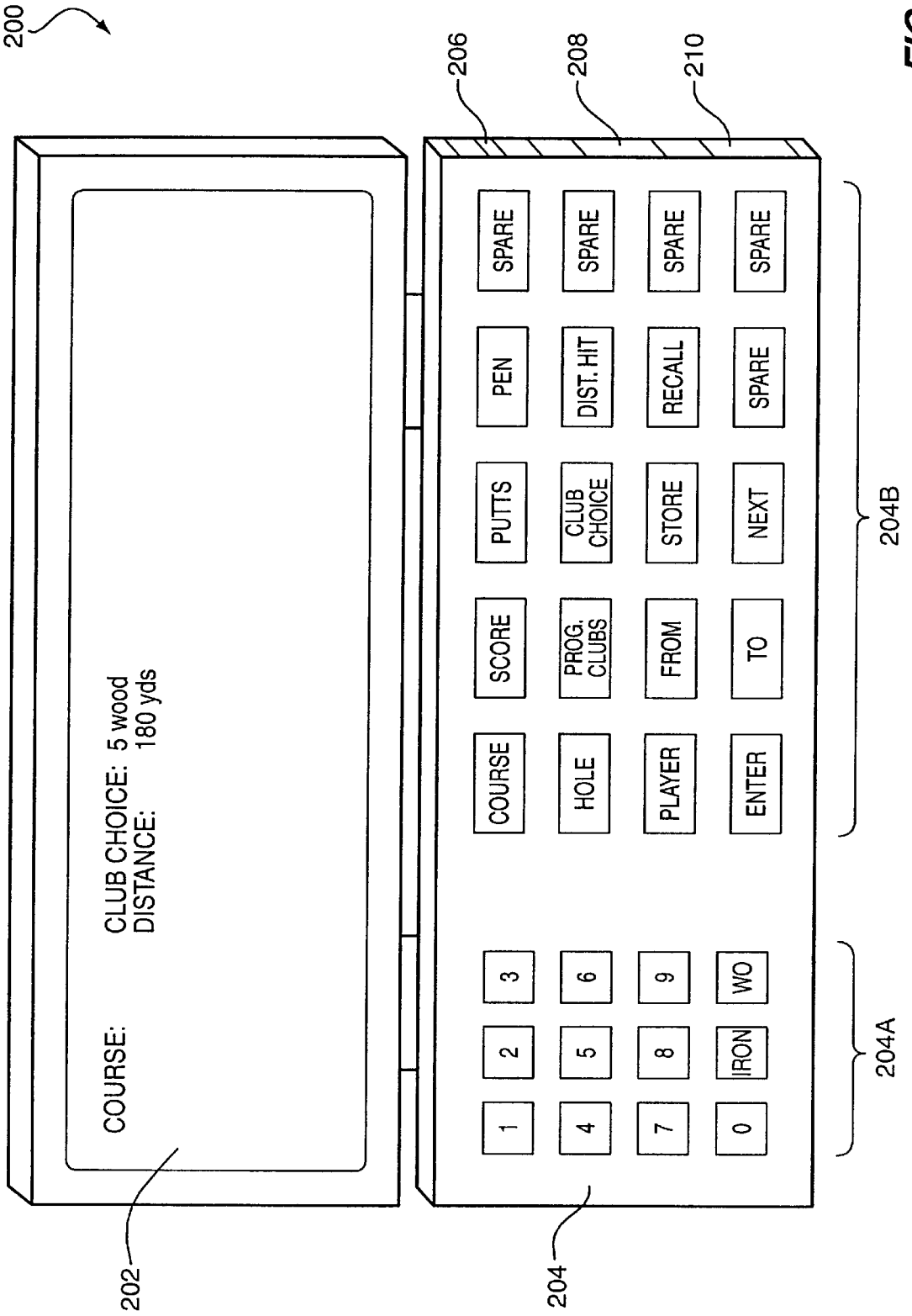
200
206
208
210
COURSE:
CLUB CHOICE: 5 wood
DISTANCE: 180 yds
SPARE
SPARE
SPARE
SPARE
PEN
DIST. HIT
RECALL
SPARE
PUTTS
CLUB CHOICE
STORE
NEXT
SCORE
PROG. CLUBS
FROM
TO
COURSE
HOLE
PLAYER
ENTER
204B
3
6
9
WO
2
5
8
IRON
1
4
7
0
204A
202
204

FIG. 2

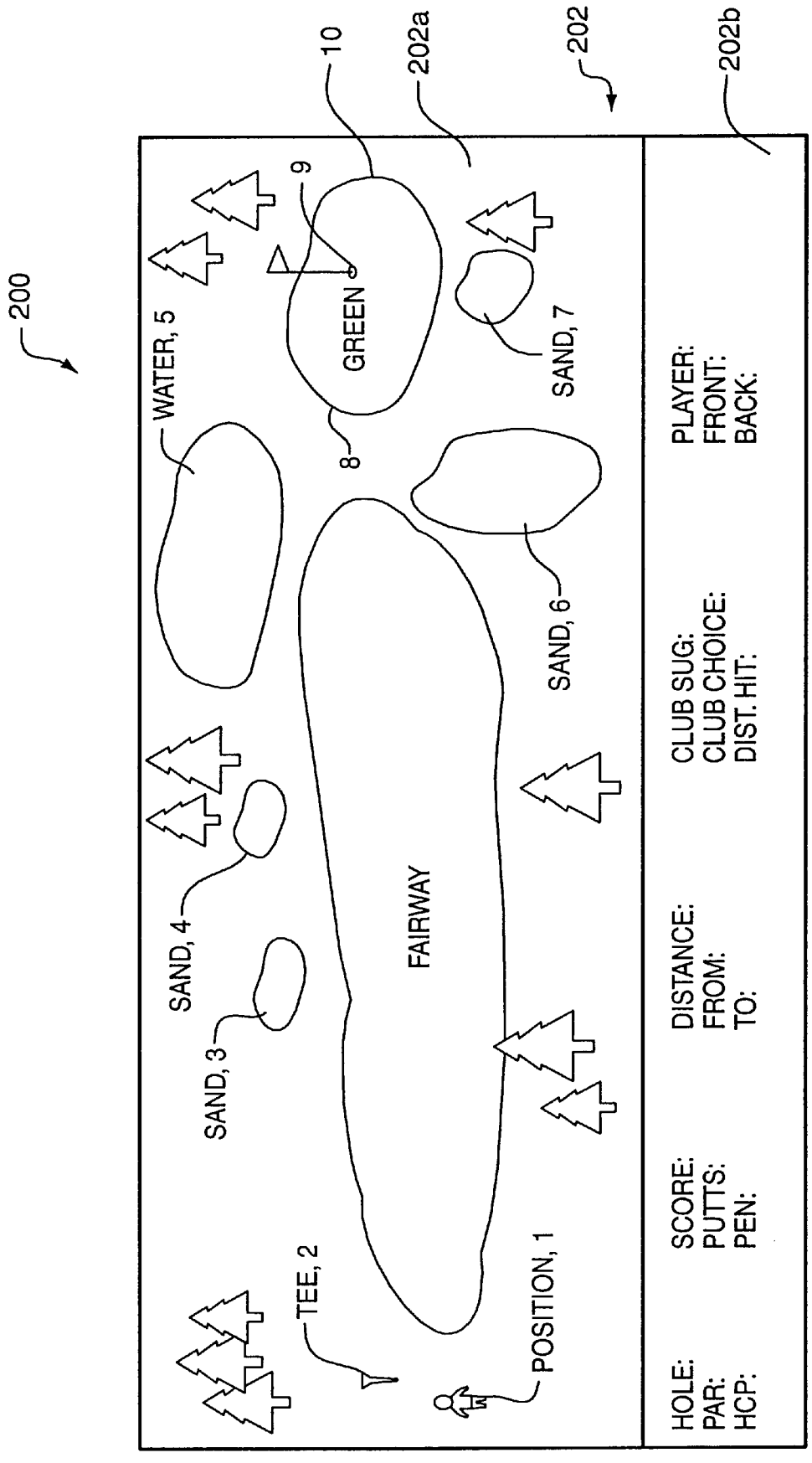
200
202
202a
202b
10
9
8
GREEN
WATER, 5
SAND, 7
SAND, 6
SAND, 4
SAND, 3
FAIRWAY
TEE, 2
POSITION, 1
HOLE:
PAR:
HCP:
SCORE:
PUTTS:
PEN:
DISTANCE:
FROM:
TO:
CLUB SUG:
CLUB CHOICE:
DIST. HIT:
PLAYER:
FRONT:
BACK:

FIG. 3

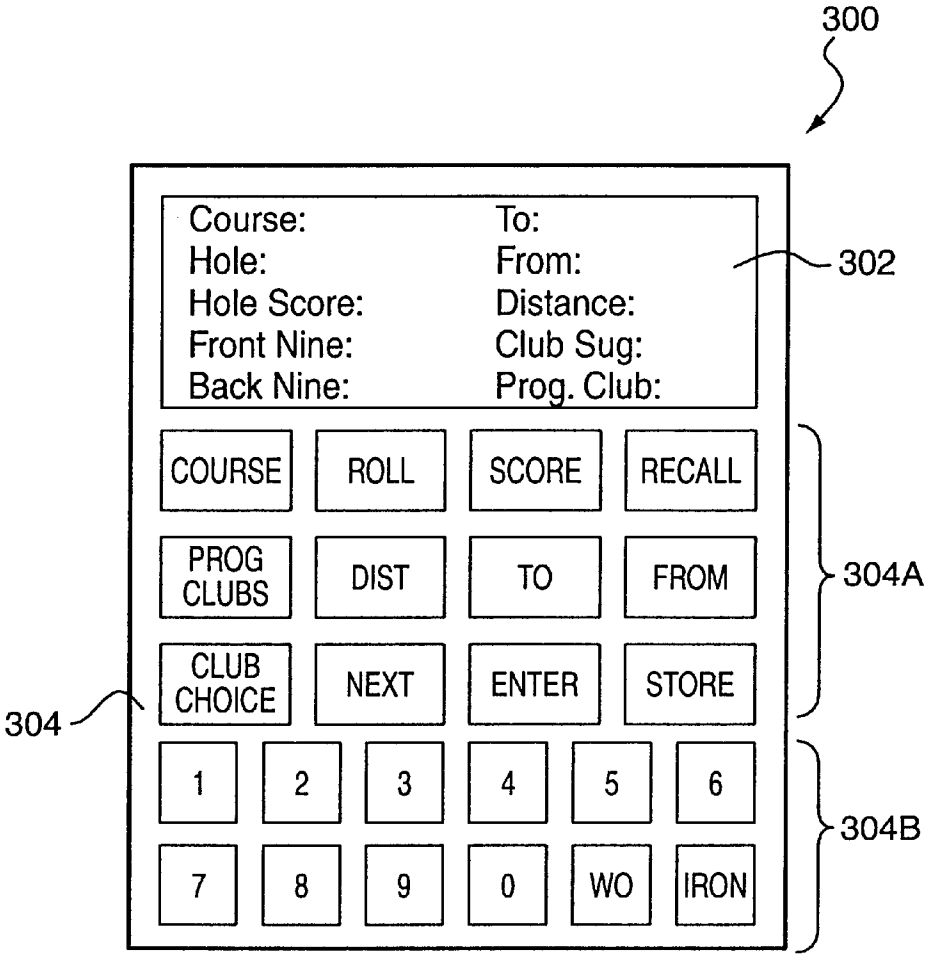
300
Course:
Hole:
Hole Score:
Front Nine:
Back Nine:
To:
From:
Distance:
Club Sug:
Prog. Club:
302
COURSE
ROLL
SCORE
RECALL
PROG CLUBS
DIST
TO
FROM
304A
CLUB CHOICE
NEXT
ENTER
STORE
304
1
2
3
4
5
6
7
8
9
0
WO
IRON
304B

FIG. 4

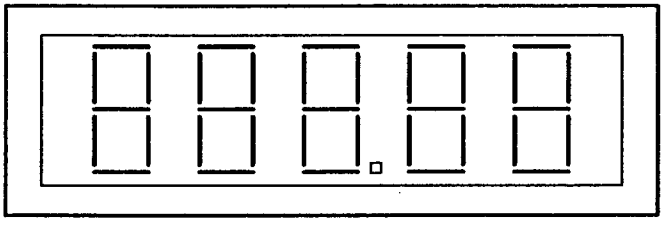

FIG. 4A

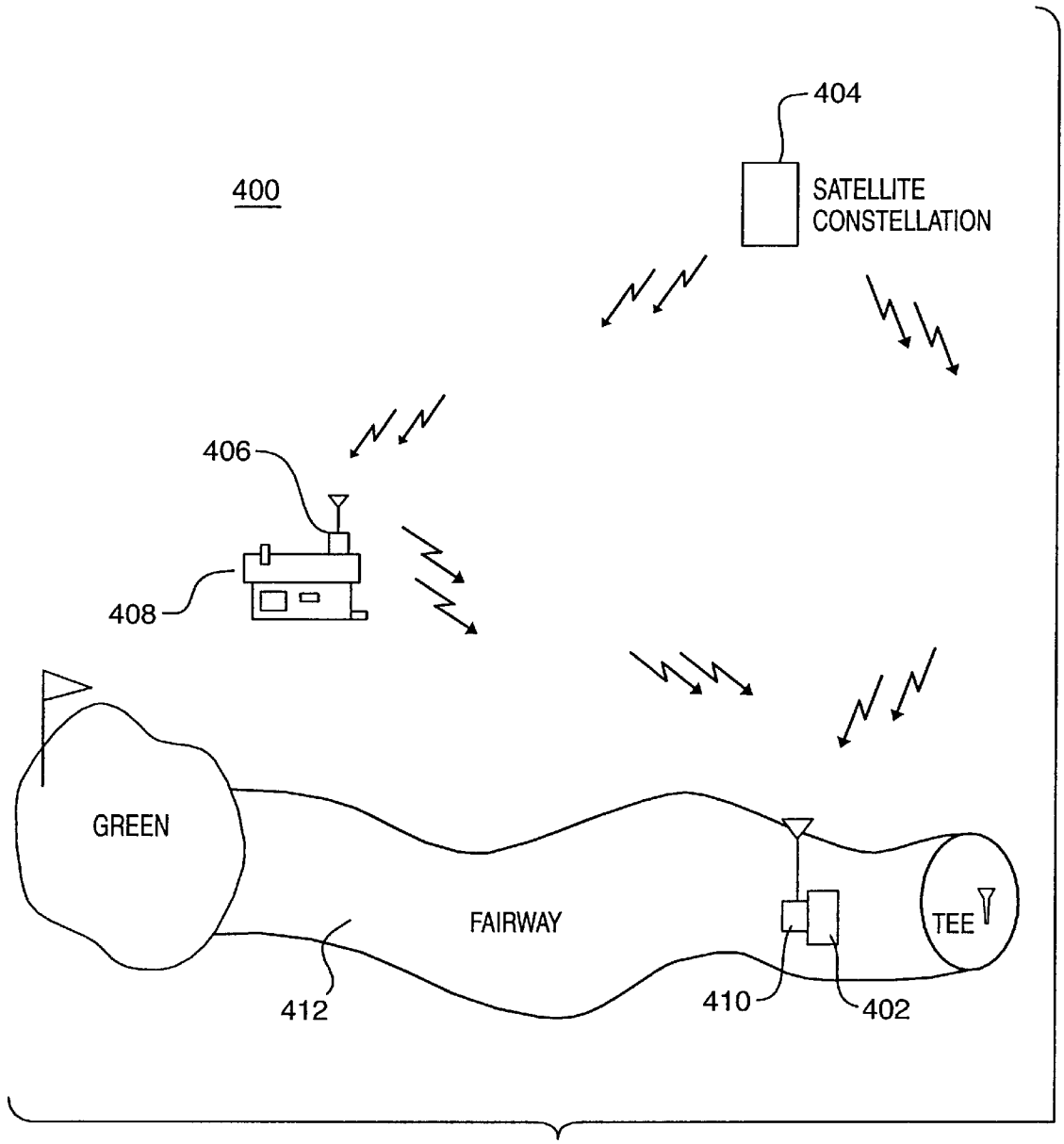
400
404
SATELLITE CONSTELLATION
406
408
GREEN
FAIRWAY
TEE
412
410
402

FIG. 5

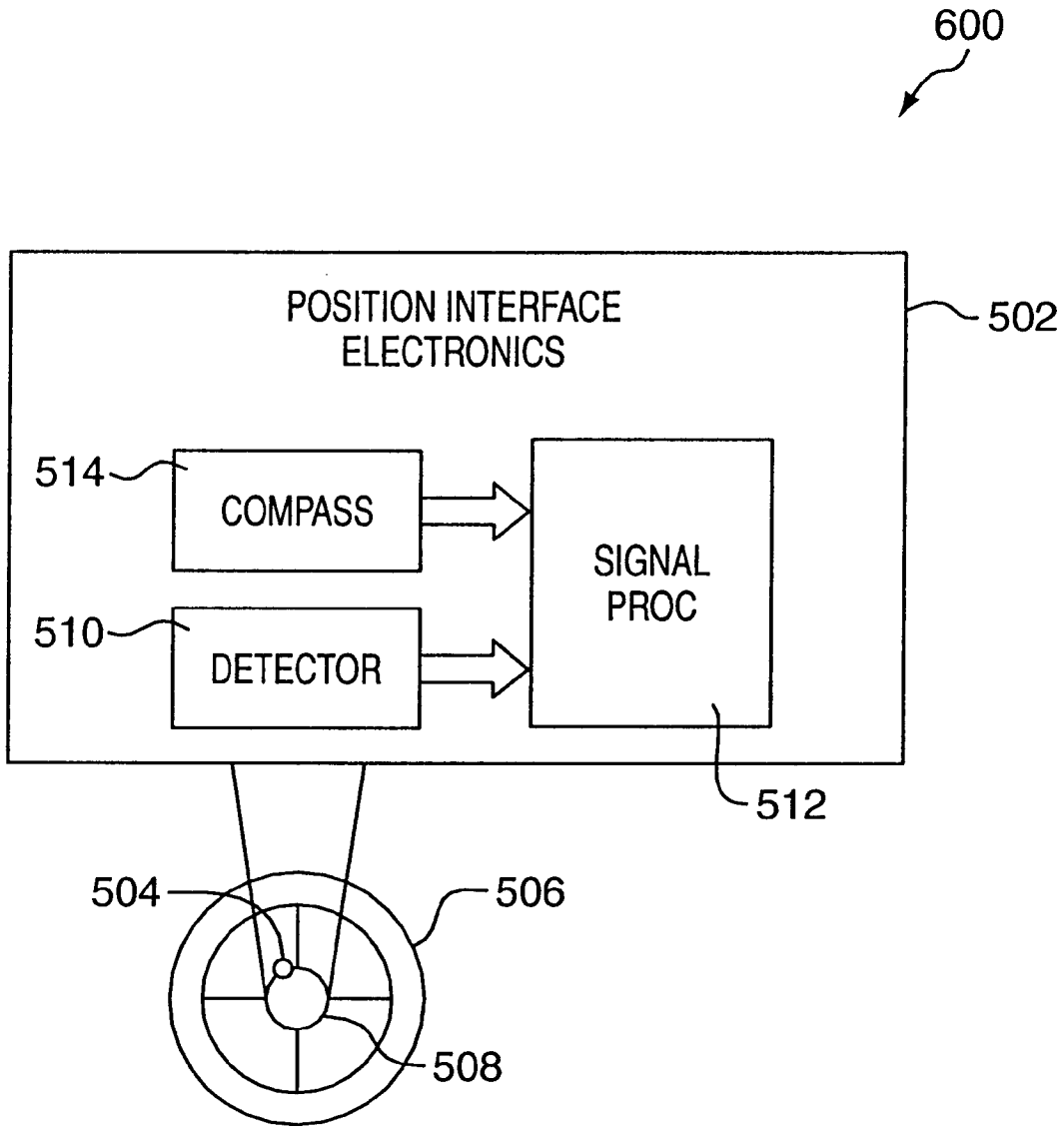
600
POSITION INTERFACE ELECTRONICS
502
514
COMPASS
510
DETECTOR
SIGNAL PROC
512
504
506
508

FIG. 6

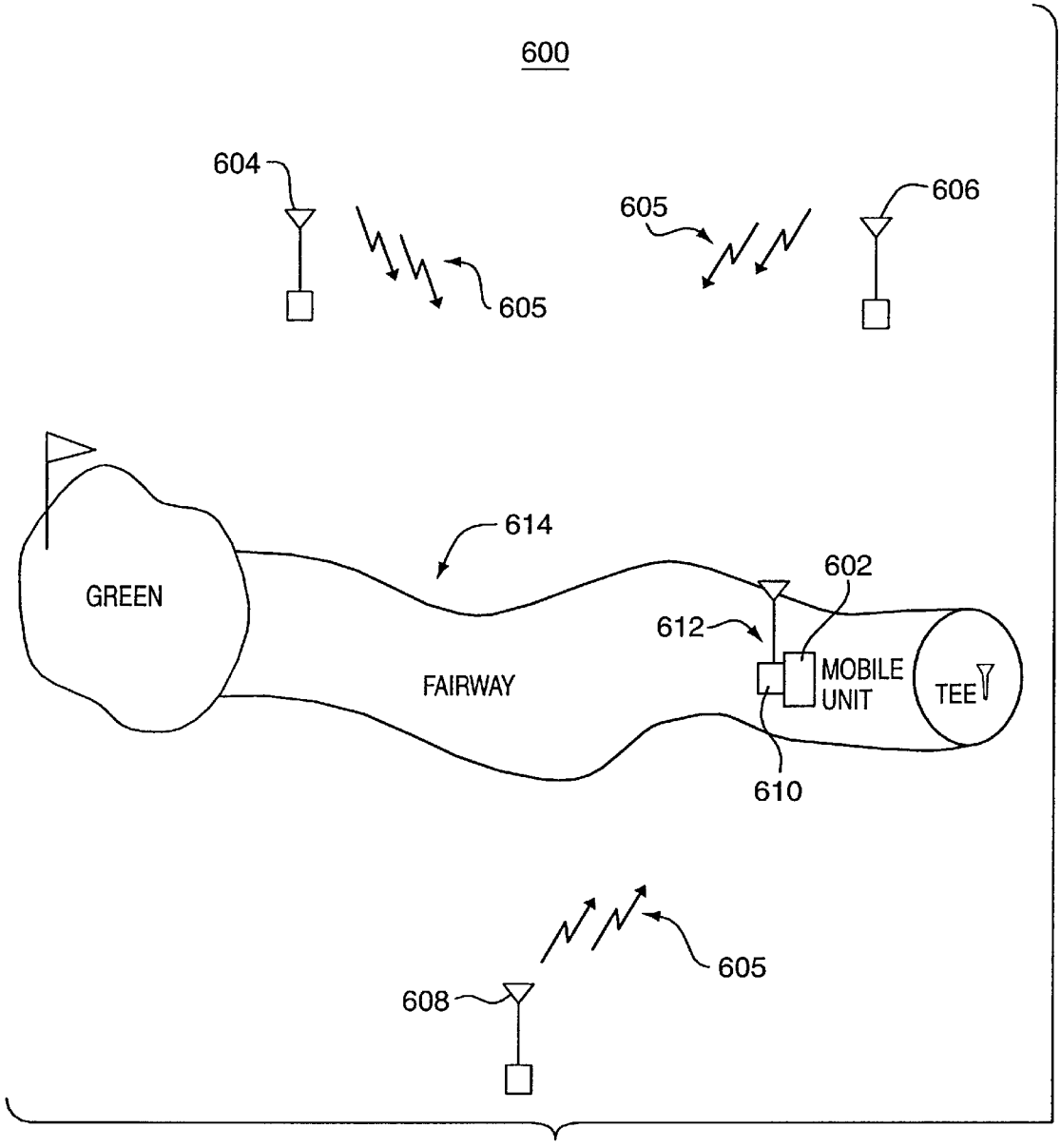
600
604
605
605
606
GREEN
614
602
612
FAIRWAY
MOBILE UNIT
TEE
610
605
608

FIG. 7

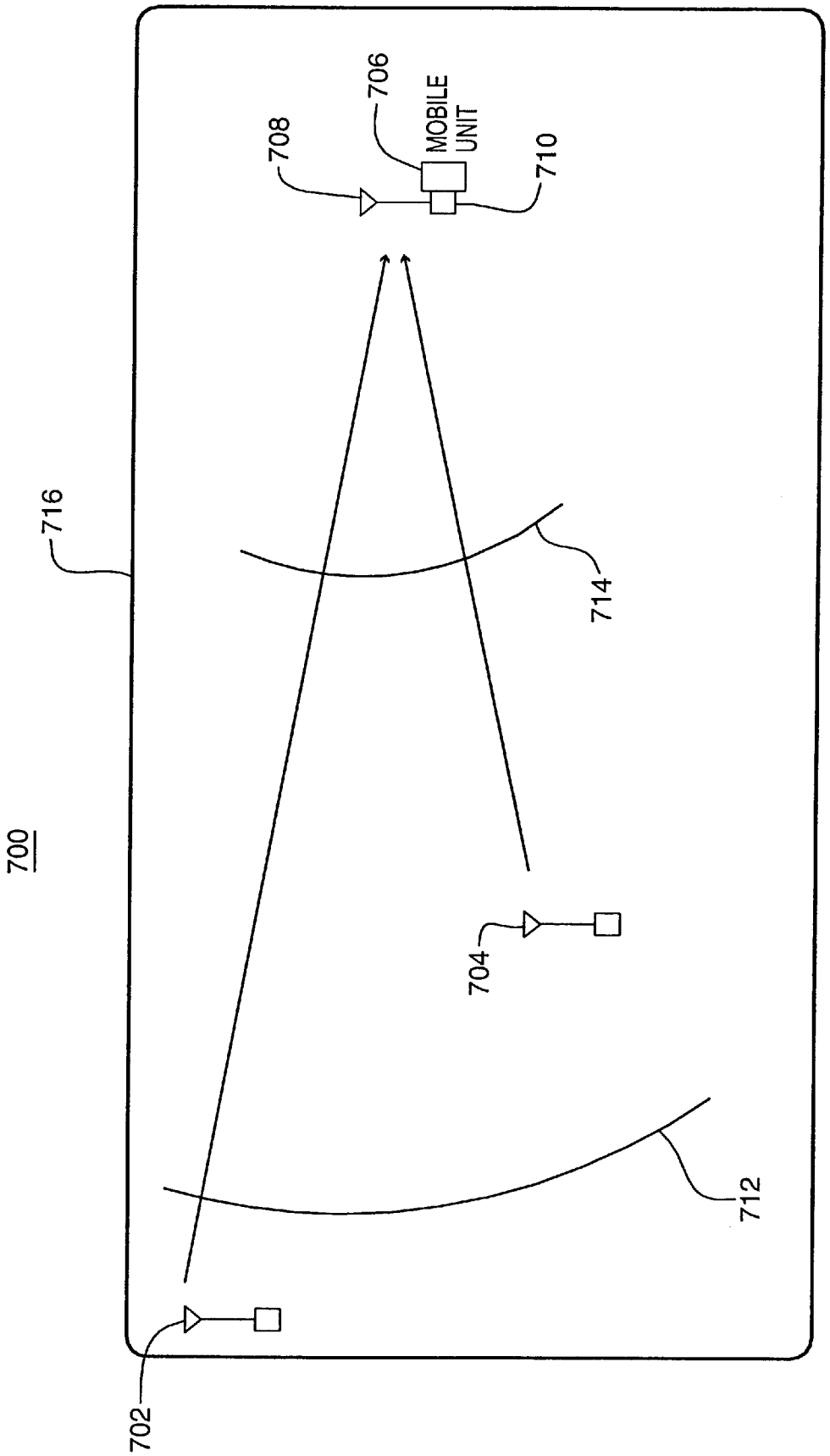

FIG. 8

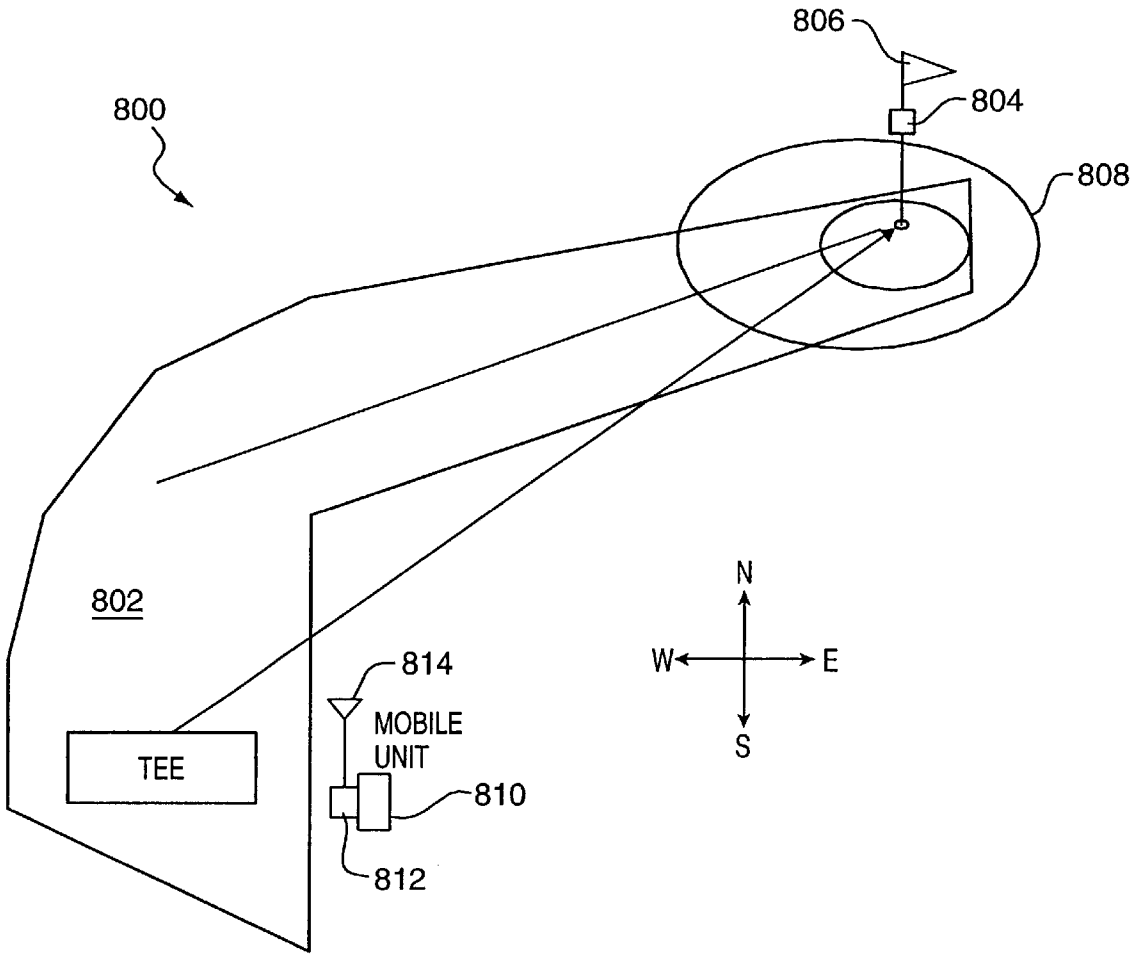

FIG. 9

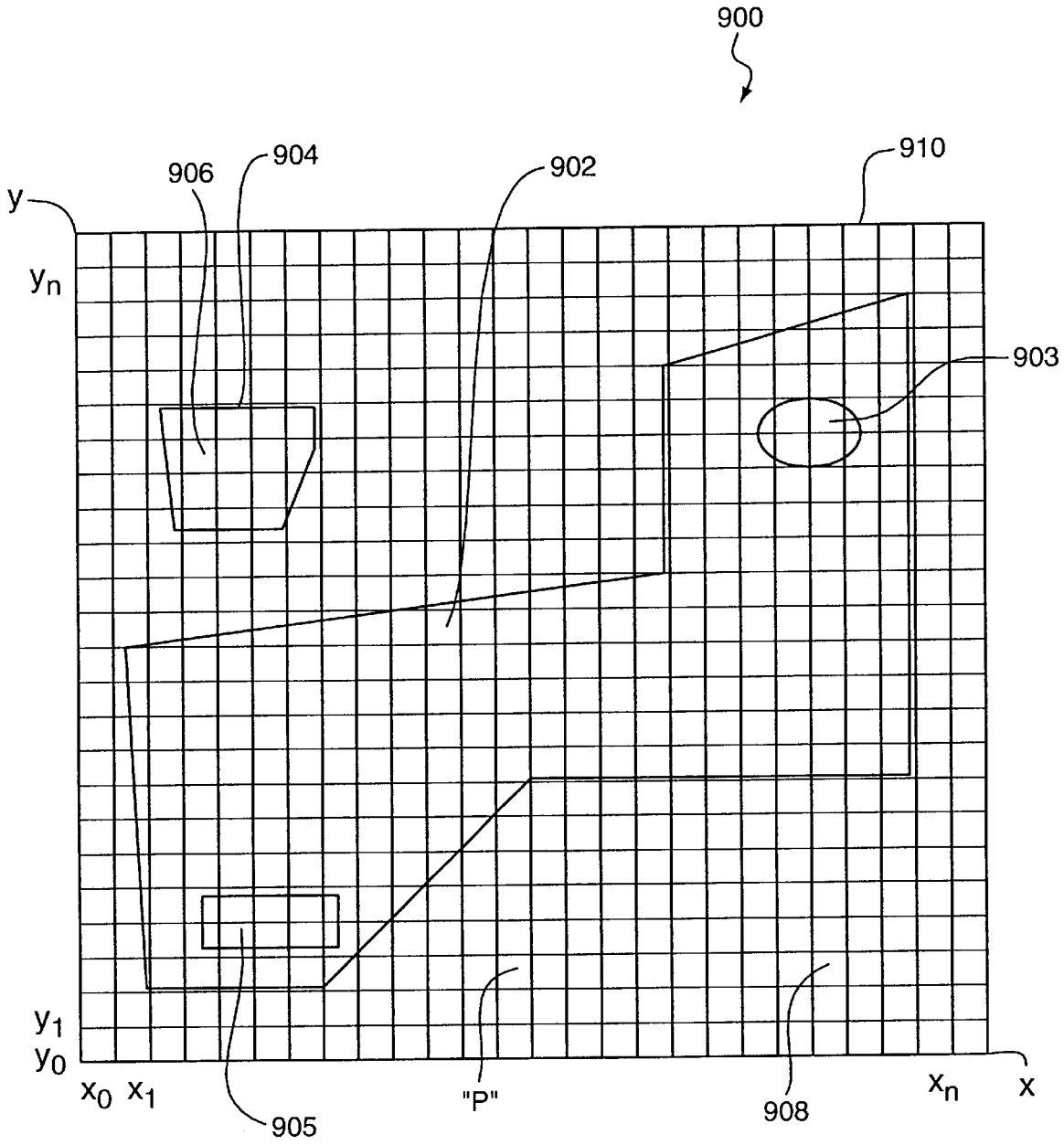

FIG. 10

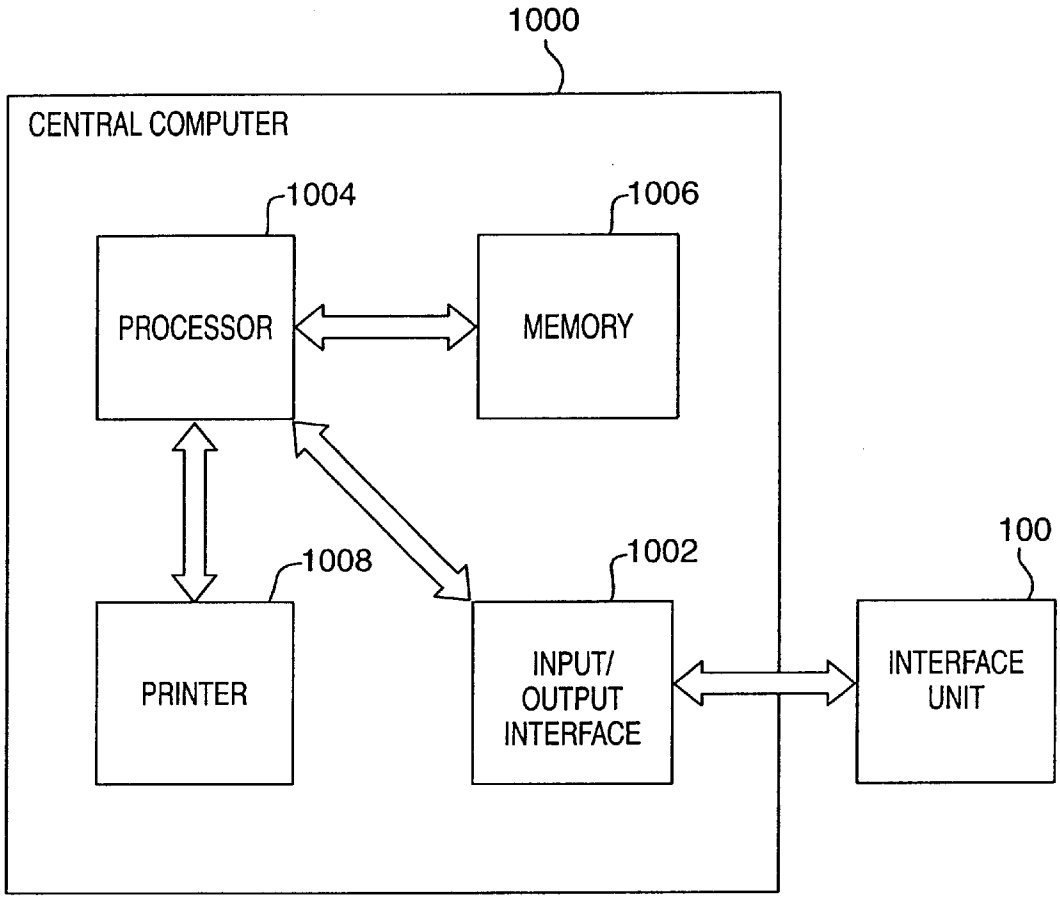
1000
CENTRAL COMPUTER
1004
1006
PROCESSOR
MEMORY
1008
1002
100
PRINTER
INPUT/
OUTPUT
INTERFACE
INTERFACE
UNIT

FIG. 11

MEMORY FOR GPS-BASED GOLF DISTANCING SYSTEM

This application is a continuing application of U.S. patent application Ser. No. 08/447,617, filed May 23, 1995, and now U.S. Pat. No. 5,904,726, which is a continuing application of U.S. application Ser. No. 08/183,594, filed Jan. 19, 1994 and now U.S. Pat. No. 5,438,518, U.S. patent application Ser. No. 08/447,617 incorporating U.S. application Ser. No. 08/183,594 by reference.

BACKGROUND OF THE INVENTION

This invention relates generally to an electronic system for providing information to players on a playing field. More particularly, it relates to a system for determining the position of a golfer on a golf course and for communicating that position along with other relevant information to the golfer.

There are many thousands of golf courses in the United States and abroad, and tens of millions of people who play golf. Some people who play golf regularly do so at the same course. However, quite often golfers playing at a course are unfamiliar with the course topography. To accommodate these players, course operators provide maps, usually as part of a score card, which illustrate the layout of the course and which indicates the distance from the tee to the flag for each hole. Additionally, the courses usually include distance markers placed at various locations along the course. By way of example, at golf courses located in the United States, each hole typically includes a distance marker located along the fairway to indicate when a golfer is 150 yards from the flag.

In addition to such aids provided by golf courses, there are also a variety of prior art distancing and ranging devices. These devices can include systems for assisting a golfer's performance. They can also include some mechanism for attempting to measure distances between a golfer and a variety of landmarks on a golf course. Such prior art devices employ a variety of methods to perform distance measurements. Some rely on visually siting the flag, while others require the flag to act as a receiver or transmitter of some sort. Other prior art systems rely on developing a coordinate system for the golf course and use linear accelerometers to track a golfer's movement along the course. Yet other systems require the golf course to install tracking sensors below the fairway turf.

There are several drawbacks with regard to the prior art systems for informing golfers as to their position on a golf course. One drawback is that the maps provided are usually very small; typically all eighteen holes are contained on a card that is approximately 3"×5" in size, thus lacking sufficient detail. By way of example, the maps often provide the distance from the tee to the flag and the general shape of the fairway, but fail to indicate the location of hazards such as accumulations of water and sand traps. Even when a course map depicts hazards, it virtually never provides distances to those hazards, nor does it typically provide other important distances, such as to the front of the green or to the back of the green. Another drawback is that the maps and markers which the course operators provide are often not up to date. As a golf season progresses, courses can become worn from over-use. Consequently, course operators periodically relocate the tees and the flags. As a result, the distance information provided by the maps and the markers is often inaccurate. A further drawback of the prior art systems is that the distance markers positioned on the course are sometimes difficult to locate. Often, for example, common looking shrubs are used as distance markers. At other golf courses, small stakes are located along the edge of the fairway. Still other courses place small metal or cement plates in the ground.

Because these distance markers are difficult to locate, and because the maps are very small, their usefulness is impeded for those who need them most: golfers who have never played the course and those golfers who are visually impaired.

Another significant drawback in prior art golf location systems that utilize a score card and accompanying map is that it is difficult for a golfer to track historical information with regard to play at a particular course. Accordingly, unless a golfer takes notes and saves old score cards, it is virtually impossible for the golfer to recollect performance on a given hole, particularly if the golfer only plays a course a few times each year. Consequently, no effective learning occurs, even if the golfer encounters the same situation more than one time.

Other more automated prior art systems also suffer from several disadvantages. Certain of those systems require siting the flag to operate continuously. Consequently, if a player cannot see the flag, that player cannot use the system to determine distance. This situation can be exacerbated by players forgetting to replace the flag. Another disadvantage to some prior art golf location systems is that they require special tracking sensors to be installed. Such installation can be labor intensive and also disruptive to play. Additionally, maintenance of the tracking systems can be costly. Furthermore, other prior art electronic systems are typically complex and expensive in the methods employed to acquire positional information.

Accordingly, one object of the invention is to provide golfers with information regarding their position on a golf course.

Another object of the invention is to provide golfers with information regarding their distance to the flag.

An additional object of the present invention is to provide golfers with information regarding distances to hazards on a golf course.

A further object of the invention is to provide golfers with accurate distance information on a golf course, regardless of the movement of the tees and the flags.

Another object of the present invention is to provide golfers with adaptive information regarding proper club selection.

An additional object of the present invention is to provide visually impaired golfers with positional, distance, and other related information in a conveniently usable format.

Other general and specific objects of the invention will in part be obvious and will in part appear hereinafter.

SUMMARY OF THE INVENTION

The invention relates generally to an electronic system for providing information to players on a playing field. More particularly, the invention provides a portable distance tracking system for determining the position of a player and for communicating that position, along with other relevant information to the player.

According to one embodiment of the invention, the playing field includes at least a first landmark and the tracking system comprises at least on mobile interface unit. The mobile interface unit includes a memory element, position interface electronics, a data processor, and a player interface. The memory element stores digitized map representations of

at least one playing field. In one preferred embodiment, the playing field is a golf course and the map representations are digitally scanned arial photographs of the golf course. As those skilled in the art will appreciate, any number of conventional methods of digitizing map information can be employed to store a representation of the playing field in the memory element. According to a further embodiment, the memory element is replaceable. In this way, different memory elements containing different playing fields can be swapped in and out of the mobile interface unit. Thus, in the case of the playing field being a golf course, a golfer can insert a particular memory element, which is dependent upon which golf course is to be played. Alternatively, a single memory element can contain map representations for a plurality of playing fields, thereby reducing the frequency with which the memory element need be replaced. Alternatively, the memory element is updateable and is overwritten with new golf course information via a data link interface.

The position interface electronics receive position indicative signals from an external source. The position indicative signals are representative of a location of the mobile interface unit. According, to one embodiment, the position interface electronics receives the position indicative signals from a global positioning system satellite constellation located in orbit around the Earth. In this case, the signals from the constellation provide the position interface electronics with the geographical position of the mobile interface unit.

The invention can also employ a differential global positioning system. According to the differential system, a master global positioning system unit is located at a fixed location having a known longitude and latitude. The master unit receives the position indicative signals from the satellite constellation, calculates its longitude and latitude, and transmits an error correction signal to the mobile interface unit, wherein the error correction signal is based at least in part on a difference between said known longitude and latitude and the calculated longitude and latitude. The mobile interface unit receives the error correction signal from the global positioning system master unit, and processes the error correction signal with the position indicative signals to determine a corrected geographical position of said mobile interface unit.

The data processor couples to the memory element and to the position interface electronics and correlates the geographical location of the mobile interface unit with the digitized map representation of the playing field to determine a field location of the mobile interface unit on the playing field. The data processor also determines the distance between the mobile interface unit and the first landmark. The player interface, couples to the data processor and communicates at least the distance between the mobile interface unit and the landmark to the player.

In the case where the playing field is a golf course, the first landmark can be the flag location of a particular hole on the course. According to further embodiments, the player interface includes a keyboard interface and a visual display. The visual display can automatically provide a graphical display of a hole being played on the golf course. The display can show various landmarks, as trees, water hazards, boundary markers, sand traps, distance markers, the green location. In other aspects, the display also provides distances from the mobile interface unit to the displayed landmarks and also the distances between selected landmarks.

The keyboard enables the golfer to set certain initialization parameters and also to request various relevant information while playing a round of golf. By way of example, a golfer can set the distance that he or she expects to hit each golf club. According to one embodiment, during play the mobile interface unit displays club suggestions based in part on the golfer's distance from a particular landmark and in part on the club distances previously set. According to a further embodiment, the mobile interface unit automatically revises the club distances previously set in response to a golfer's actual performance. The keyboard also enables the golfer to enter for storage and/or display various information while playing a round of golf. For example, according to further embodiments of the invention, a golfer can enter the score on a particular hole, the number of penalty shots taken, and the number of putts taken. The memory element can store this information for later recall by the golfer.

According to another embodiment of the invention, the system includes a central computer. The central computer includes a communications link for interfacing with the mobile interface unit. The central computer can provide the mobile interface unit with such information as updated course information. Additionally, following a round of golf, the mobile interface unit can download such information as scores on each hole, number of putts on each hole, number penalty strokes, distances of particular shots and other like information. The central computer can then process, store and if requested print out reports in various formats concerning the downloaded information.

In still other aspects of the invention, the invention provides for a system which determines the distance to a hole on a golf course. A GPS receiver is arranged to receive a global earth position, and a processor subsystem communicates with the GPS receiver to correlate the GPS signals into a local position on the golf course. A memory element is also included to store locations on the golf course which include at least one hole of the golf course. The golf course locations are representations of the local coordinates wherein the processor correlates the GPS signals into the coordinates representing the golf course. The processing subsystem thus correlates the global earth position to the location on the golf course wherein the distance from the global earth position to the desired location is determined.

Preferably, the invention thus includes indication element, e.g., an LED or LCD display, for indicating the distance to a user of said system.

The invention also preferably incorporates a stationary differential GPS receiver/transmitter and a GPS receiver which is a differential GPS receiver. Such a differential GPS receiver receives and applies a correction signal from the stationary differential GPS receiver/transmitter which is arranged at a known global earth location geographically located with the golf course. The stationary GPS receiver/transmitter means operates in conjunction with the differential GPS receiver means and transmits the correction signal to the GPS receiver.

In certain aspects, the memory element also stores a second location of at least one object, e.g., a known hazard, on the golf course. The processor subsystem thus includes circuitry and programming to correlate the global earth position to the second location such that the distance between the global earth position and the second location is determined.

In another aspect of the invention, the processor subsystem includes a memory load subsystem which communicates coordinates representative of at least one location of the golf course to the memory element.

In still another aspect of the invention, a local memory storage element is included which stores coordinates repre-

sentative of the golf course. The local memory storage element is generally provided at a stationary location, e.g., at the club house, so that users can load the coordinates of the current golf course into the inventive system. The memory load subsystem thus is adapted for selective communication with the local memory storage element wherein the memory load subsystem communicates the coordinates representative of the golf course to the memory element for storage in the memory element.

In yet another aspect according to the invention, there is provided a system for determining the distance to a hole on a golf course. The system includes (i) a GPS receiver arranged to receive a global earth position; and (ii) a processing subsystem, i.e., including a microprocessor, in communication with the GPS receiver. The processing subsystem includes a memory element for storing a location of at least one hole of the golf course, and a correlation processor for correlating the global earth position to the location, such that the distance from the global earth position to the location is determined.

In this way it can be seen that the invention provides golfers with a portable system for tracking position on a golf course. It also provides golfers with a convenient mechanism for logging relevant performance information while playing a round of golf and for reviewing that information at a later time. Furthermore, the invention provides golfers with accurate distance measurements to landmarks on a golf course.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the nature and objects of the invention, reference should be made to the following detailed description and the accompanying drawings, in which:

FIG. **1** shows a block diagram of a player positioning system according to one embodiment of the invention;

FIG. **2** depicts a mobile interface unit particularly adapted for operation on a golf course;

FIG. **3** shows one preferred embodiment of the display portion of the mobile interface unit of FIG. **2**;

FIG. **4** shows an alternate embodiment of the mobile interface unit of FIG. **2**;

FIG. **4A** shows an alternate embodiment of the display portion of the mobile interface unit of FIG. **4**;

FIG. **5** is a schematic illustration depicting one embodiment of the positioning system of FIG. **1**, adapted for receiving positional information from Global Positioning System satellites;

FIG. **6** is a diagram depicting one embodiment of the position interface electronics of FIG. **1**, adapted for receiving positional information from a sensor mounted to the wheel of a golf cart;

FIG. **7** is a diagram illustrating one embodiment of the positioning system of FIG. **1**, adapted for receiving positional information from a plurality of ground based transmitters;

FIG. **8** is a diagram illustrating one embodiment of the positioning system of FIG. **1**, adapted for receiving positional information from two ground based transmitters;

FIG. **9** is a diagram illustrating one embodiment of the positioning system of FIG. **1**, adapted for receiving positional information from a plurality of ground based acoustic transducers;

FIG. **10** illustrates one method of digitizing a playing field for storage in the memory unit of FIG. **1**. and,

FIG. **11** shows a schematic block diagram of a central computer interfacing with the mobile interface unit of FIG. **1**, in accord with the invention.

DETAILED DESCRIPTION

FIG. **1** shows a block diagram of a player positioning system **100** according to one embodiment of the invention. The illustrated embodiment **100** includes a mobile interface unit **102** that determines a player's position on a playing field from externally provided signals **114**, and relays that positional information, along with other relevant information, to the player. According to a preferred embodiment, the unit **102** is kept in close proximity to the player, and includes a processor **104**, position interface electronics **106**, a user input interface **108**, a display **110**, and memory **112**. The unit **102** can also optionally include an audio interface **116**.

The position interface electronics **106** receives externally generated positional information signals **114**. The signals **114** can come from a variety of sources, such as, for example, the Global Positioning System (GPS) satellite constellation, ground based microwave transmitters, electromechanical sensors, or ground based acoustic transducers, all of which are discussed in further detail below. Following initial processing of the signals **114**, the interface electronics **106** then couples information gleaned from those signals to the processor **104**.

The memory **112** can store, among other information, digitally encoded positional information, such as digitized maps, for one or more particular playing fields. According to one embodiment, a portion **112***a* of the memory **112** can be removed and replaced with digitized maps of a plurality of playing fields. In this way, the system can be easily adapted for use at a variety of locals. The processor **104** determines a player's position on the playing field by correlating the positional information signals provided by the interface electronics **106** with the digitized map information stored in the memory **112**. Once the processor **104** determines the players position, it conveys that information to the player by way of the display **110**, or optionally by way of the audio interface **116**.

Quite often players desire additional information besides their position. One sport where players desire such additional information is golf. The user interface **108**, which by way of example can be a keyboard, enables golfers to query the processor **104** as to distance and performance related information. For instance, according to one embodiment, a golfer can request the distance to a particular flag, or to a hazard, such as sand trap, pond or tree. According to a further embodiment, golfers can request information regarding the distance between any two of a plurality of landmarks, such as between the tee and the flag of a particular hole or the distance to the club house. The unit **102** provides the requested information by way of the display **110** or the audio interface **116**.

FIG. **2**, depicts a mobile interface unit **200** of the type shown in FIG. **1**, but particularly adapted for operation on a golf course. The unit **200** includes a display **202** and keyboard interface **204**. The display **202** can display both graphics and alphanumeric characters. The keyboard **204** includes keys that can be generally grouped as numerical keys **204***a* and keys that can be grouped as command keys **204***b*. The unit **200** also includes an on/off switch **206**, a digital input/output interface **208** and a removable memory module **210**.

During operation, a player can perform a variety of initialization procedures. First, the player can enter a

numerical code which designates the particular golf course to be played. The golfer accomplishes this by actuating the "COURSE" command key followed by actuating the numerical keys corresponding to the desired course, followed by actuating the "ENTER" command key. In response, the processor **104** accesses the map for the selected course from the memory **112**, and the display **200** shows the selected course code in the "COURSE:" field. According to alternative embodiments, the golfer can change memory the module **210** to provide the appropriate course map or can receive, through the interface **208**, a signal from the club house that automatically sets the appropriate course selection code. According to a further embodiment, particular golf courses can provide mobile interface units **200** to the golfers, in which case the course can program the appropriate course map into the memory **112** before time. Where the golf course provides either the memory modules or the entire unit **200**, up to date topography changes in the course can be incorporated into the digitized memory map. This can be easily accomplished via a central base computer located in the club house. Accordingly, in one embodiment, the invention provides a centralized computer, typically at the club house, for storing day-to-day course data.

The mobile unit **200** can accommodate a plurality of golfers (typically four in one preferred embodiment). Consequently, according to one embodiment, whenever taking advantage of any of the programming features of the unit **200**, the golfer first actuates the "PLAYER" command key followed by a player code, e.g., 1, 2, 3, 4, etc.

One feature that the golfer can program into the memory **112** is the distance that he or she normally hits a golf ball with each club or with any subset of clubs. To enter the program clubs mode, the golfer actuates the "PROG. CLUBS" command key. Next, the golfer actuates the "CLUB CHOICE" command key, followed by the numerical designation of the club to be set. followed by the "ENTER" command key. By way of example, to select the five wood, the golfer actuates the "WOOD" key, followed by the "5" key, followed by the "ENTER" key. In response, the display **202** indicates a "5 wood" in the "CLUB CHOICE:" field. Next, the golfer actuates the "DIST. HIT" command key followed by the numerical keys corresponding to the desired distance, followed by the "ENTER" key. The display **202** then shows the selected distance (e.g., 180 yds.) in the "DISTANCE:" field. To program distances for additional clubs, the golfer repeats the above sequence of commands, or alternatively, to program the next club in sequence, the golfer can actuate the "NEXT" command key. To exit this mode of operation, the golfer simply actuates the "PROG. CLUBS" command key a second time. If a golfer chooses not to program club distances, the unit **200** can use a default set of parameters, e.g., a five iron for a 150 yard shot etc. Using the above described procedure, a golfer can alter any or all of the default distance parameters.

FIG. **3** shows the display **202**, according to one embodiment of the invention and for one exemplary hole. As can be seen, the display **202** includes a graphical display portion **202***a* and an alphanumeric display portion **202***b*. Once the course selection has been programmed and any desired initialization has been performed, the unit **200** is ready for use. Prior to teeing off, the golfer can select the hole to be played. This is accomplished by actuating the "HOLE" command key followed by actuating the numerical designation for the hole (e.g., 01, 02, . . . , 18), followed by actuating the "ENTER" command key. In response, the display **202***b* indicates the designation for the selected hole in the "HOLE:" field. Alternatively, as a golfer approaches the tee for a particular hole, the unit **200** can receive a signal, via the interface **114**, that automatically programs the hole to be played. Additionally, in response to receiving the hole designation, the processor **104** accesses map information stored in memory **112** and transmits this information to the display **200**. The display **200** provides a graphical representation of the selected hole in field **202***a*. As can be seen from the illustrative hole shown in field **202***a*, all significant features of the hole being played, including the tee **2**, the green **8** and various landmarks and hazards **3** through **7** can be displayed. Additionally, the processor correlates the position information provided by the position interface electronics **106** with the map information provided by the memory **112** to determine the position of the mobile unit **200** on the golf course. The golfer's position is illustrated on the display **202***a* by the character at 1. The processor also accesses other relevant information regarding the hole being played from the memory **112** and automatically displays that information in the display portion **202***b*. Such information includes par, handicap, and distance from the tee to the flag for the hole. This information is displayed in the "PAR:", "HDCP:", AND "DISTANCE:" fields, respectively. Just prior to playing the hole, the golfers select which golfer is about to play. That golfer's code, e.g., 1, 2, 3, 4, etc. appears in the "PLAYER:" field.

As the golfer plays each hole, the mobile unit **200** can provide considerable information. For example, according to one preferred embodiment, the unit **200** automatically displays the distance from the mobile unit **200** to the flag. By request, the unit **200** can also provide a golfer with the distance from the mobile unit **200** to any of the landmarks shown in the graphical display **202***a*. To determine such distances, the golfer actuates the "TO" command key, followed by the numerical designation for the landmark. In response, the unit **200** displays the landmark designation in the "TO:" field and the requested distance in the "DISTANCE:" field of display **202***a*. According to a further embodiment, the unit **200** can also provide a golfer with the distance between any two of the landmarks shown in the graphical display **202***a*. To determine such distances, the golfer actuates the "FROM" command key, followed by the numerical reference designation of the first landmark of interest. In response, the display **202***b* indicates the selected reference designation in the "FROM:" field. Next, the golfer actuates the "TO" command key followed by the numerical reference designation for the second landmark of interest. In response, the display **202***b* shows that reference designation in the "TO:" field. The processor **104** then accesses the map information in the memory **112**, calculates the distance between the two selected reference designations, and couples the calculated distance to the display **202***b*. The display **202***b* then indicates this distance information to the golfer in the "DISTANCE:" field. To reenter the mode of automatically displaying the distance between the mobile unit **200** and the flag 9, the golfer simply actuates the "TO" command key, followed by the reference designation "1."

Alternative to the above description, the display **202***a* can show the distance to each hazard or other object automatically by overlying the distance information from the player to each reference on the display and at the location of each hazard or object.

The processor can also automatically accesses the club distance information (either the default parameters or those previously programmed by the golfer, as may be appropriate) and display a club suggestion for each shot. The display **202***b* indicates the club suggestion for each shot in

the "CLUB SUG:" field. The golfer can also enter his or her actual club choice by actuating the "CLUB CHOICE" command button, followed by the "ENTER BUTTON" followed by the "STORE" command key. The processor **104** displays the new club choice in the "CLUB CHOICE:" field in the display **202***b*. The golfer can also enter the distance that he or she hit the ball using that particular club choice. The distance hit is displayed in the "DIST. HIT" field. The processor automatically stores the displayed club choice, distance, course and hole information, and golfer position information for the particular hole. The processor **104** also uses this information to automatically update the golfers distance selection for the particular club selected. If the golfer repeats this procedure for each shot taken on the hole, a complete record of play on that hole will be stored. To recall this information at a later time, the golfer actuates the "RECALL" command key, and then specifies the course and hole of interest. To review successive shots, beginning at a particular hole, the golfer actuates the "NEXT" command key. In this way golfers can review their play on troublesome holes, and learn to avoid repeatedly making the same mistakes, such as incorrect club selection for particular shots.

As shown in FIG. **11**, optionally the golfer can down load information regarding the round of golf from interface unit **100**, FIG. **1**, to the central computer **1000** located in the club house. The central computer **1000** can include an input/output interface **1002**, a processor **1004**, memory **1006**, and a printer **1008**. To down load information regarding a round of golf, the golfer simply provides the golf course operator with his removable memory module **210** or alternatively attaches the unit **200** to the central computer **1000** by way of input/output interface **1002** and serial interface **208**. The central computer **1000** can access the memory module **210**, store the data, and process the data in processor **1004**, and print the data on printer **1008** in any number of formats, depending on the personal preferences of the golfer.

The mobile unit **200** can also provide the golfer with a convenient system for keeping score. Following the completion of a hole, the golfer can actuate the "SCORE" command key followed by the score for that hole. The processor **104** updates the golfer's score and transmits the updated score to the display **202***a*. The display **202***a* in turn displays the score for the hole just played in the "SCORE:" field and also displays the updated total score in either the "BACK NINE:" or "FRONT NINE:" fields, as appropriate. The golfer can also enter any penalties for the hole by actuating the "PENALTY" command key. This will signal the processor to update the score for the hole accordingly. Additionally, the golfer can track how many putts were taken by actuating the "PUTTS" command key.

While the above description addresses various features of the present invention, those skilled in the art will appreciate that the description of the particular implementation of those features, such as the particular command keys included and their arrangement, along with the particular layout of display is illustrative in nature. By way of example, the display **202***b* depicts various information being displayed simultaneously. However, according to other embodiments within the scope of the invention, information can be displayed as a sequence of user interface dialogs, employing a tool bar and various menus, and being initiated by a golfer actuating a particular command key. Additionally, command keys can share various functions. In this way, the display can be made smaller, and the number of command keys can be reduced. Alternatively, as the golfer moves to different positions along a fairway, the display can be automatically updated to provide a more detailed display of the relevant area of play. Also, the alphanumeric display **202***b* can be integrated with the graphical display **202***a*, to further conserve on display space.

As in any electronic system, the information that can be conveniently received from and conveyed to a user is at least in part dependent on the size of the system and the power consumed by the system. Consequently, as the unit **200** is made larger, more of the above described features can be included and the display can be more detailed. According to one preferred embodiment, the mobile unit **200** can be mounted to a drivable golf cart. According to a further embodiment, the drivable golf cart can provide the power required by the unit **200**, thus enabling the unit **200** to include a relatively detailed display **202** and a significant number of features such as described above. According to another embodiment, the unit **200** can be adapted to be either hand held or mounted to a pull-type golf cart. To provide for lower power consumption and convenience of size, the hand held and pull-type golf cart embodiments can be essentially paired down versions of the embodiment of FIG. **2**. In the most paired down version, the unit simply provides the golfer with the distance from the mobile unit to the flag of the hole being played.

For example, FIG. **4** shows a portable display unit **300**, particularly adapted for operation as a hand held unit or for mounting on a pull-type golf cart. As can be seen, the unit **300** includes a display **302** and a keypad interface **304**. Like the unit **200** of FIGS. **2** and **3**, the keypad interface **302** includes command keys **304***a* and numeric keys **304***b*. According to the depicted embodiment, the display **302** only includes alphanumeric capabilities. However, according to other embodiments, a small graphical display portion, such as those employed on hand held video games can be incorporated. In the case where a graphical display is used, the unit **300** operates essentially identically to unit **200** of FIGS. **2** and **3**. In the event that no graphics capability is included, a small map can be included to provide the reference designations for the landmarks that are located along the golf course. Alternatively, the unit **300** can be programmed to only provide the distance between the mobile unit **300** and the flag for the hole being played.

FIG. **3**A illustrates one such embodiment which only provides the distance between the mobile unit **300** and the flag. According to the depicted embodiment, the display **302** is an LED or LCD display, such as those well known in the art. LED and LCD displays can be advantageous due to their small size, low power consumption and low cost.

As mentioned above, the positional information that the mobile unit processes to provide distance and other related information to a player can be derived from a variety of sources. By way of example, such sources can include the Global Positioning System (GPS) satellite constellation, ground based microwave transmitters and receivers, electro-mechanical sensors operating in combination with a gyroscope, compass, and/or ground based acoustic transducers.

The GPS comprises a 21 NAVSTAR satellite constellation orbiting at 20,180 kilometers above the earth. These satellites provide real-time navigation and positioning information to anyone on earth with a GPS receiver. The operation of the GPS is conceptually straight forward. Each GPS satellite transmits a microwave radio signal that details the satellite identification number, its internal atomic clock, and the orbital location of the satellite (which is acquired through radar tracking). The elapsed time between the signal

transmission, which is calibrated to an on-board atomic clock (typically either rubidium or cesium frequency standards), and the receipt at the ground-based GPS receiver, which has its own internal clock and antenna, divided by the speed of light, is roughly, the distance to one satellite. By computing the distance from each of three satellites, a triangulation is effected which enables the ground-based GPS receiver to determine its own position on the earth's surface. By computing the distance to each of four or more satellites, the ground-based receiver can determine its position in three dimensions, including height.

GPS receivers are available from a variety of manufacturers. By way of example, the GPS NAV 100 and the TRAXXAR 6 channel GPS are available from Motorola and Magellan, respectively. Typically, these receivers have location accuracies in the range of 25 meters. However, for greater accuracy, users can turn to differential GPS, commonly denoted as DGPS. DGPS is widely used. For example, the US. Coast Guard has initiated several reference stations around US. Coastal waters to provide DGPS to U.S. harbors. Likewise, the Federal Aviation Administration has installed advanced DGPS equipment at some airports to replace the older radio beacons and to improve location accuracy to approximately one foot.

Operationally, DGPS requires a local "master" GPS receiver which is positioned at a known location and linked to a transmitter, and a "slave" GPS receiver, which can be mobile. The master and the slave are linked together, for example, by a local UHF or VHF radio link. The master GPS receiver determines its coordinates from the GPS constellation, calculates a correction factor, and then transmits the correction signal to any slave in an extended geographical region about the master via the local radio link. The slave processes the correction signal along with its own GPS-determined coordinates and determines the slave location at a significantly improved accuracy over normal GPS receivers. Ideally, the master GPS receiver/transmitter is located on slightly elevated ground relative to the slave units to reduce multipath interference. An example of a portable DGPS unit is the Motorola LGT 1000™ Lightweight GPS/GIS terminal which has a probable location accuracy of 1–5 meters. Conveniently, two LGT 1000™ systems operate to form a DGPS. One functions as the master and requires continuous operation power consumption at its external connector and one serves as the slave GPS and employs an internal battery. The accuracy of DGPS can be further improved by time integration. By way of example, to generate real-time information at approximately 1 Hz, the accuracy for present DGPS is approximately 1 meter.

FIG. **5** depicts a system **400** according to the invention which includes a mobile interface unit **402**, similar to the unit **102** of FIG. **1**, that is adapted for operation with the GPS satellite constellation **404**. Also shown is the master GPS **406**, which can be located at the clubhouse **408**. Thus, in this embodiment, the slave GPS unit **410** becomes the position interface electronics **106** of FIG. **1** for the mobile interface unit **402**. As the mobile interface unit **402** traverses the exemplary hole **412**, the slave unit **410** receives transmissions from the constellation **404** and the master unit **406** to provide the mobile unit **402** with real-time, high accuracy positional information.

FIG. **6** is a schematic block diagram **500** of an alternate embodiment of the invention, wherein the position interface electronics **502** is adapted to process a signal form an electro-mechanical sensor **504** coupled to a wheel **506** of either a drivable or pull-type golf cart. As shown, the sensor can be coupled to the shaft **508** of the wheel **506**. However, depending on the particular device employed, the sensor **504** can be coupled to the spokes or even the hub of wheel **506**. According to one preferred embodiment, the sensor **504** is a light emitting device which couples a beam of light to the detector **510** each time the wheel **506** rotates. According to another embodiment, the device **504** can be a shaft encoder or an automobile type odometer. The detector **510** couples a digital signal, representative of one wheel revolution to the processor **512**. Additionally, the compass **514** provides the processor **512** with information indicative of the direction of the golf cart or pull cart. The processor **512** uses the information from the compass **514** and the detector **510** to determine the distance traveled and the direction in which that distance has been traveled. As long as the mobile interface unit is reset, either manually or automatically, at each hole, i.e., a vector, the embodiment of FIG. **6** provides accurate positional information to the flag.

FIG. **7** depicts a system **600** according to the invention and including a mobile interface unit **602**, adapted for operation with a plurality of ground-based transmitters **604**, **606**, and **608**. The mobile interface unit **602** includes the position interface electronics **610**, which is similar to the electronics **106** of FIG. **1**. The position interface electronics **610** can receive and process signals **605** the antennas **604**, **606**, **608** as the mobile interface unit **602** traverses the hole **614**. According to one embodiment, antennas **604**, **606**, **608** are phased array microwave antennas and the interface electronics can measure the phase difference between signals received via antenna **612** to determine the position of the mobile unit **610**. According to a further embodiment of system **600**, the interface electronics **610** processes the amplitude differences between the signals received from antennas **604**, **606**, **608** to determine the position of the mobile unit **602**.

While the system of FIG. **7** is depicted with three transmitting antennas **604**, **606**, **608**, two transmitting antennas can be employed with virtually identical results. More particularly, FIG. **8** shows a diagram of a system **700** which illustrates the use of two transmitting antennas **702** and **704** to provide positional information to the position interface electronics **710** of the mobile interface unit **706**. The system is depicted on an exemplary golf course **716**. With only two antennas **702** and **704** to provide positional information, there are two possible solutions for the position of the mobile unit **706**. However, the antennas **702** and **704** can be arranged such that one solution typically will fall outside the boundary for the hole being played. As in the case of the system of FIG. **6**, the mobile unit **706** can process either phase or amplitude information from the antennas **702** and **704** to determine its position.

According to a further embodiment of the invention, the mobile interface unit can process acoustic data to determine its position on a playing field. Since sound travels at a known speed in atmosphere (340 meters/second), it can be used like any other ranging system. Additionally, since sound travels at a much slower rate than does radio frequency or microwave frequency signals, the complexity of the electronics is greatly reduced. The transmitted sound can be non-audible so as not to disturb the quiet at the golf course.

FIG. **9** shows a schematic diagram **800** of a representative hole **802** which illustrates the operation of a mobile interface unit **810** according to the invention and adapted for determining position from acoustic data. An acoustic sound generator **804** is located at the flag **806**. The generator **806** provides periodic acoustic energy pulses illustrated by sound waves **808**. The position interface electronics **812** receive the acoustic energy pulses by way of the acoustic transducer **814**, e.g. a microphone.

As discussed above, according to the invention, map information for various golf courses can be stored in the memory **112** of FIG. **1**. One method of storing of map information is to create a cartesian coordinate grid **910** of the golf course. The grid **910** has an x-coordinate and a y-coordinate. FIG. **10** exemplifies a Cartesian coordinate mapping according to one embodiment of the invention for a typical hole **900**. The hole **900** includes a fairway **902**, a green **903**, a clubhouse **904**, tee-off location **905**, and first and second reference locations **906** and **908**, respectively.

The hole **900** can be mapped into the coordinate grid **910** by any of a variety of methods. By way of example, the golf course can be arially scanned. According to one arial scanning method, an airplane flies over the golf course and employs a device such as a charge coupled device (CCD) scanner to scan the ground scene. The CCD scanner is comprised of an array of CCD elements. Typically, the CCD scanner extends transverse to the travel of the airplane. Thus, as the airplane travels along the direction of travel (e.g., along the "y" axis), an electronic slice of the course is created. Each CCD element acquires one pixel "P" image of the golf course. As shown in FIG. **10**, at y-coordinate y1 a first slice is taken traversing from x0 through xn. At y-coordinate y2 a second slice is taken, once again traversing from x0 through xn. This continues until similar scans are performed for coordinates y0 through yn. With the full image of the hole **900** electronically scanned, it can be stored in memory **112** and access by x- and y-coordinates. In an alternative embodiment, the hole **900** can be arially photographed and then the photograph can be digitally scanned into the memory **112**. Regardless of whether the hole **900** is scanned directly or a photograph or other rendition of the hole is scanned, the resolution of the stored image is directly proportional to the number of coordinate grids **908**. Thus, the more data points stored, the more precise the measurements which the positioning system **100** can perform.

As shown in FIG. **10**, two reference locations of known longitude and latitude can be selected on the golf course. For example, one know location can be location **906** at the clubhouse **904**. Another known location can be some other arbitrary point **908**. With the resolution of the grid **910** known, the known points **906** and **908** can be used to map all other x-and y-coordinate locations to longitude and latitude locations. In this way, when the position interface electronics receives longitude and latitude information from the GPS constellation, for example, the processor **104** can combine the received information with the coordinate information stored in the memory **112** to determine the position of the mobile interface unit **200** on the golf course **900**.

It is accordingly intended that all matter contained in the above description or shown in the accompanying drawings be interpreted as illustrative rather than in a limiting sense.

It is also intended that the following claims cover all of the generic and specific features of the invention as described herein, and all statements of the scope of the invention which, as a matter of language, might be said to fall there between.

Having described the invention, what is claimed as new and secured by Letters Patent is:

1. A GPS-based golf distancing system, comprising:

a GPS receiver for receiving GPS signals and for determining a current location of the system on a golf course;

a digital memory for storing a digital map representation of the golf course, the digital map representation defining at least one location;

a data processor for correlating the current location to the one location to determine distance between the current location and the one location; and

means for updating the digital memory with a new digital map representation, to compensate for physical movement of the one location, the physical movement being detectable through GPS location accuracy, in the determination of distance.

2. A GPS-based golf distancing system according to claim **1** wherein the means for updating comprises interface means for facilitating removal, and subsequently replacement, of the digital memory with the new digital map representation.

3. A GPS-based golf distancing system according to claim **1**, wherein the means for updating comprises means for updating the digital memory through electronic interface with a computer or data interface.

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