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(54) **EVENT SENSOR**

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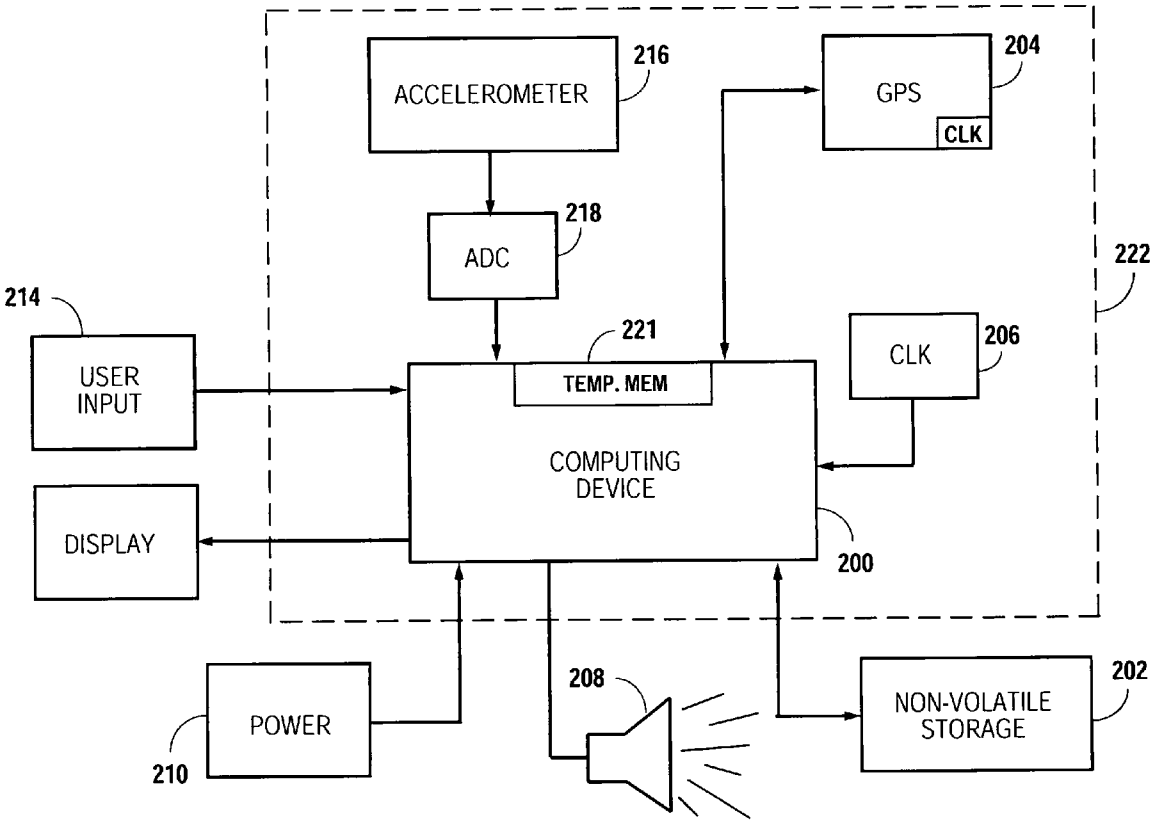
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(57) **ABSTRACT**

An automatic timing measurement system that provides a measure of time of passage of a watercraft through a prescribed course. Algorithms based on inertial or other estimates augmented by GPS speed/position measurements are used to track position of a watercraft. Said position estimates are used to allow the locations of prescribed courses to be mapped and memorized. Algorithms are then used to allow the apparatus to automatically detect passage of a watercraft through mapped courses for the purpose of measuring and reporting time of passage of said watercraft past key points in said course, and for modifying the behavior of the speed control portion of the apparatus if necessary at certain points in the mapped course. A measure of accuracy of driver steering can be provided along with the ability to automatically steer the watercraft through the course if "steer-by-wire" mechanism is available. GPS speed control is augmented with a secondary velocity measurement device that measures speed over water resulting in an optional user selectable real-time compensation for water current. Furthermore, GPS is used as the key input to produce boat speed-based pull-up profiles.



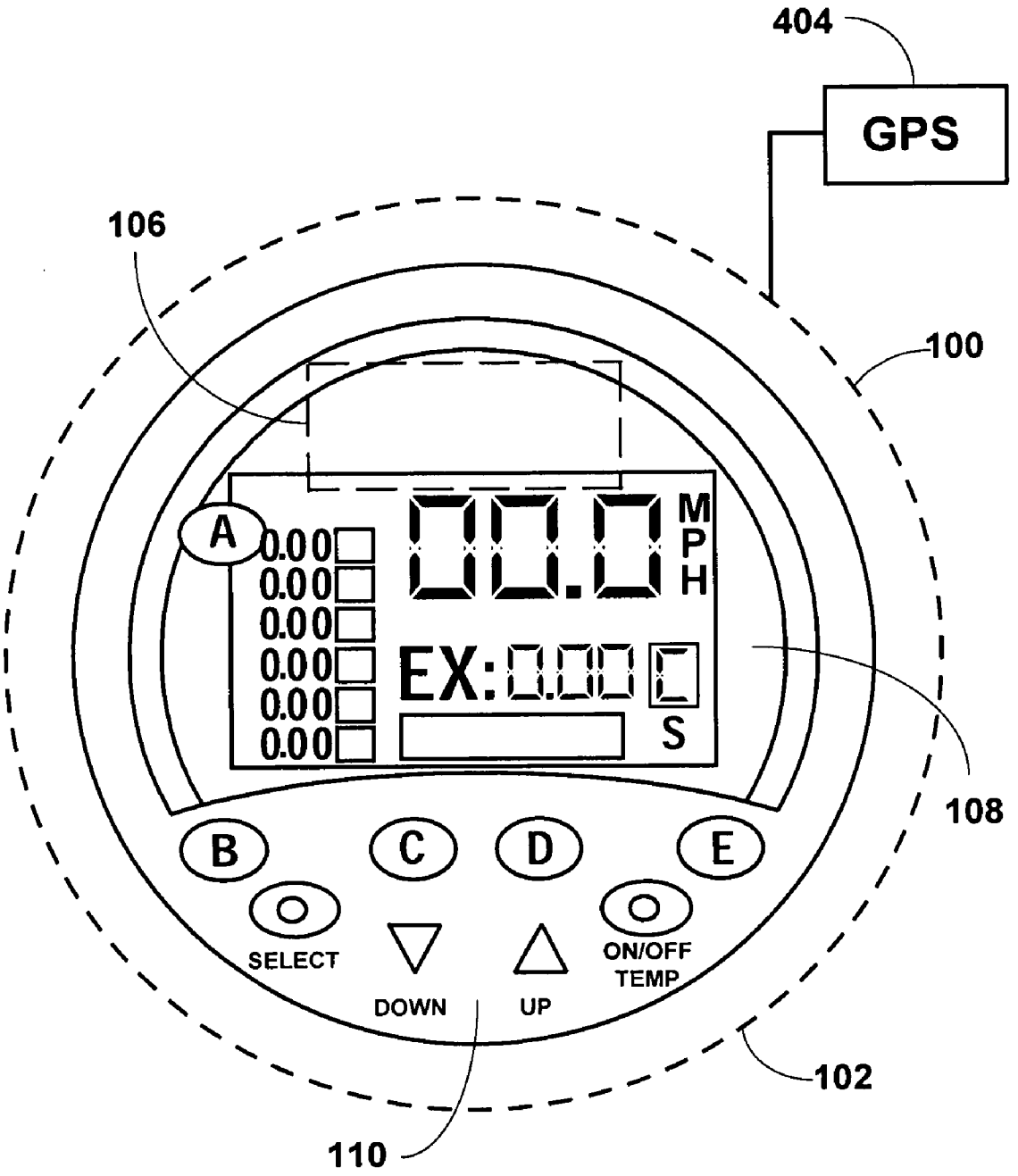

404
GPS
106
100
A
0.00
0.00
0.00
0.00
0.00
0.00
00.0
MPH
EX: 0.00
C
S
108
B
C
D
E
SELECT
DOWN
UP
ON/OFF
TEMP
102
110

Fig. 1

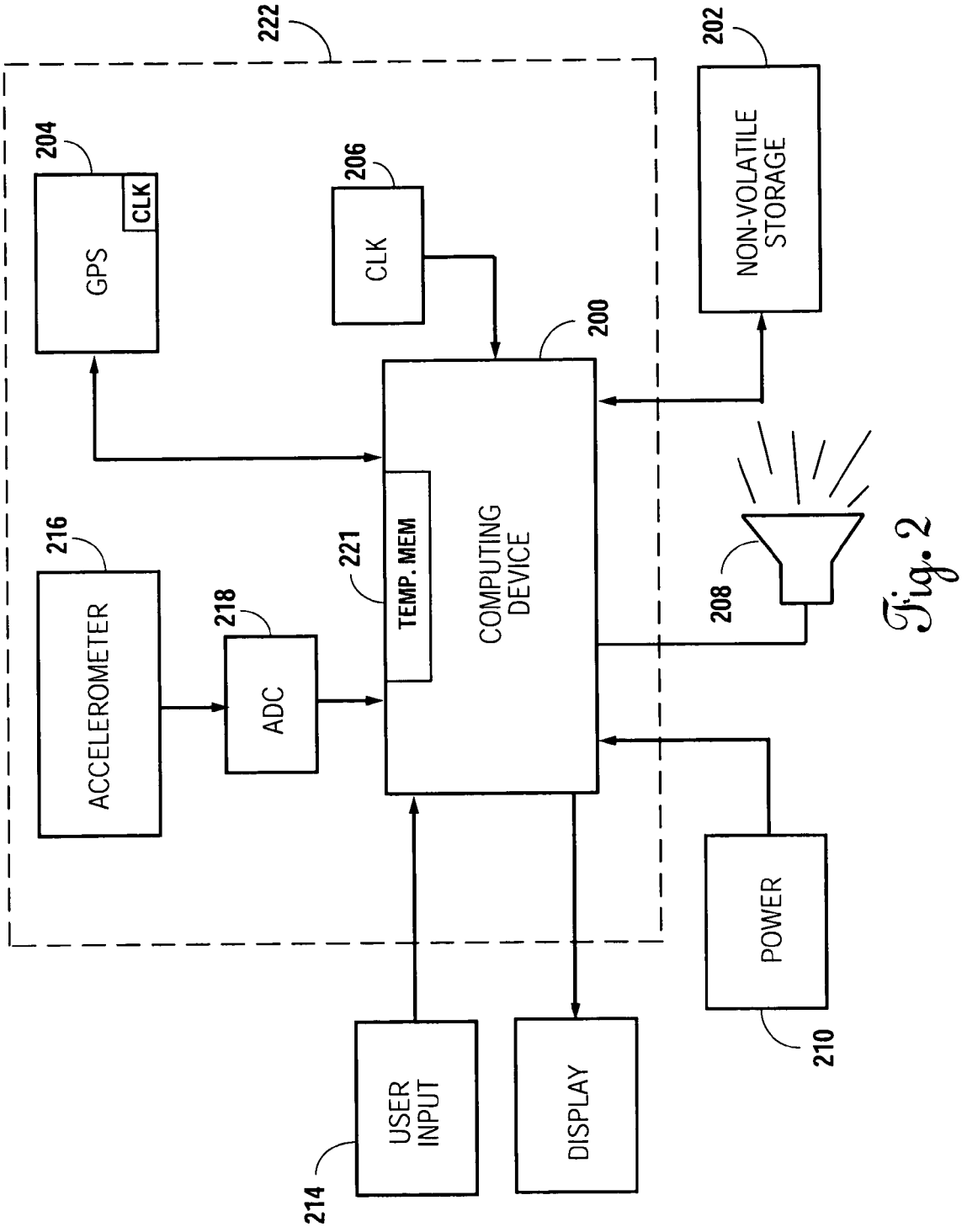

222
202
NON-VOLATILE STORAGE
204
GPS
CLK
206
CLK
200
COMPUTING DEVICE
TEMP. MEM
221
216
ACCELEROMETER
218
ADC
208
POWER
210
USER INPUT
214
DISPLAY

Fig. 2

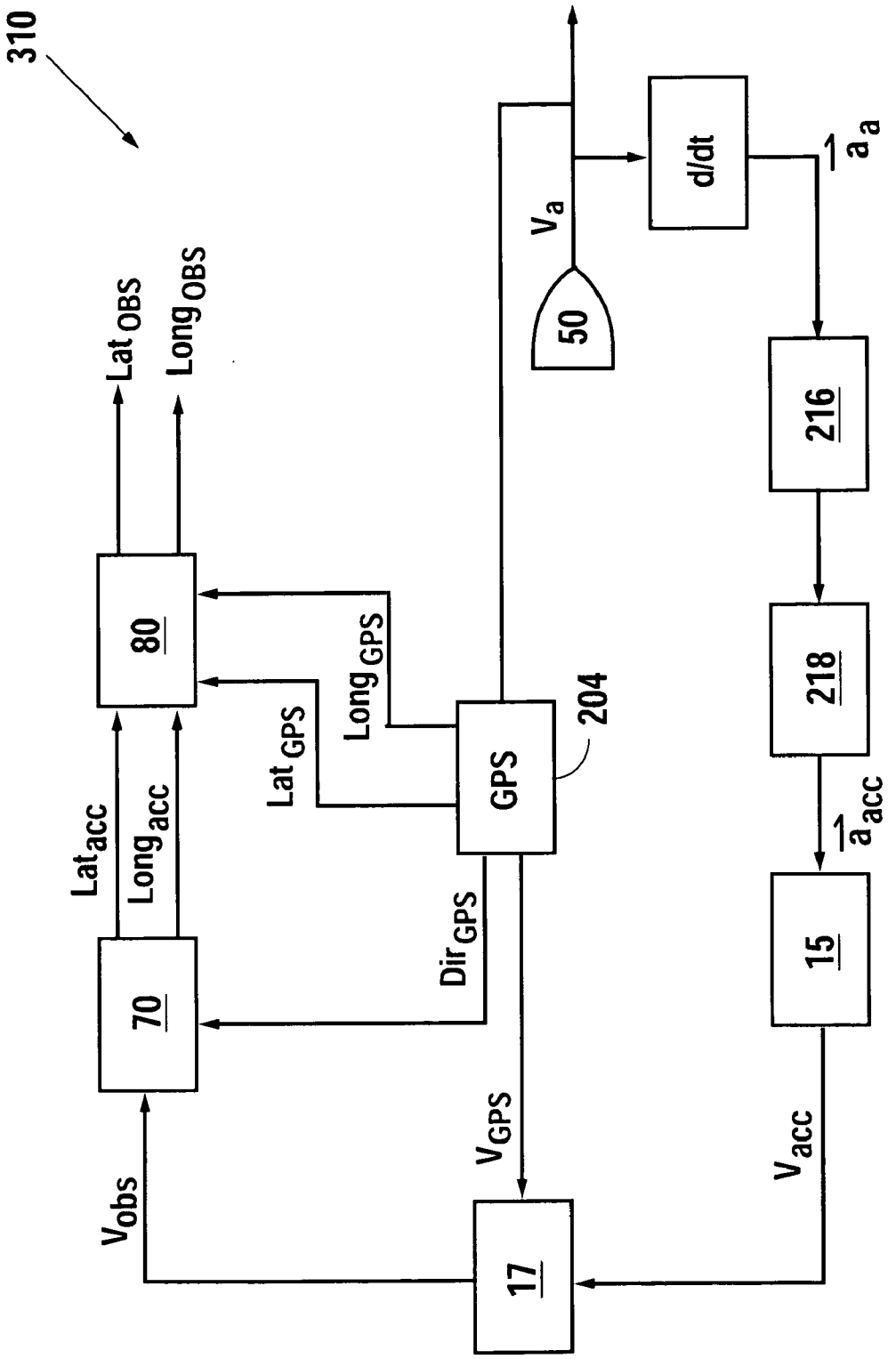

310
Lat OBS
Long OBS
80
Lat acc
Long acc
70
Lat GPS
Long GPS
GPS
204
Dir GPS
V GPS
V obs
17
V a
50
d/dt
a a
216
218
a acc
15
V acc

Fig. 3

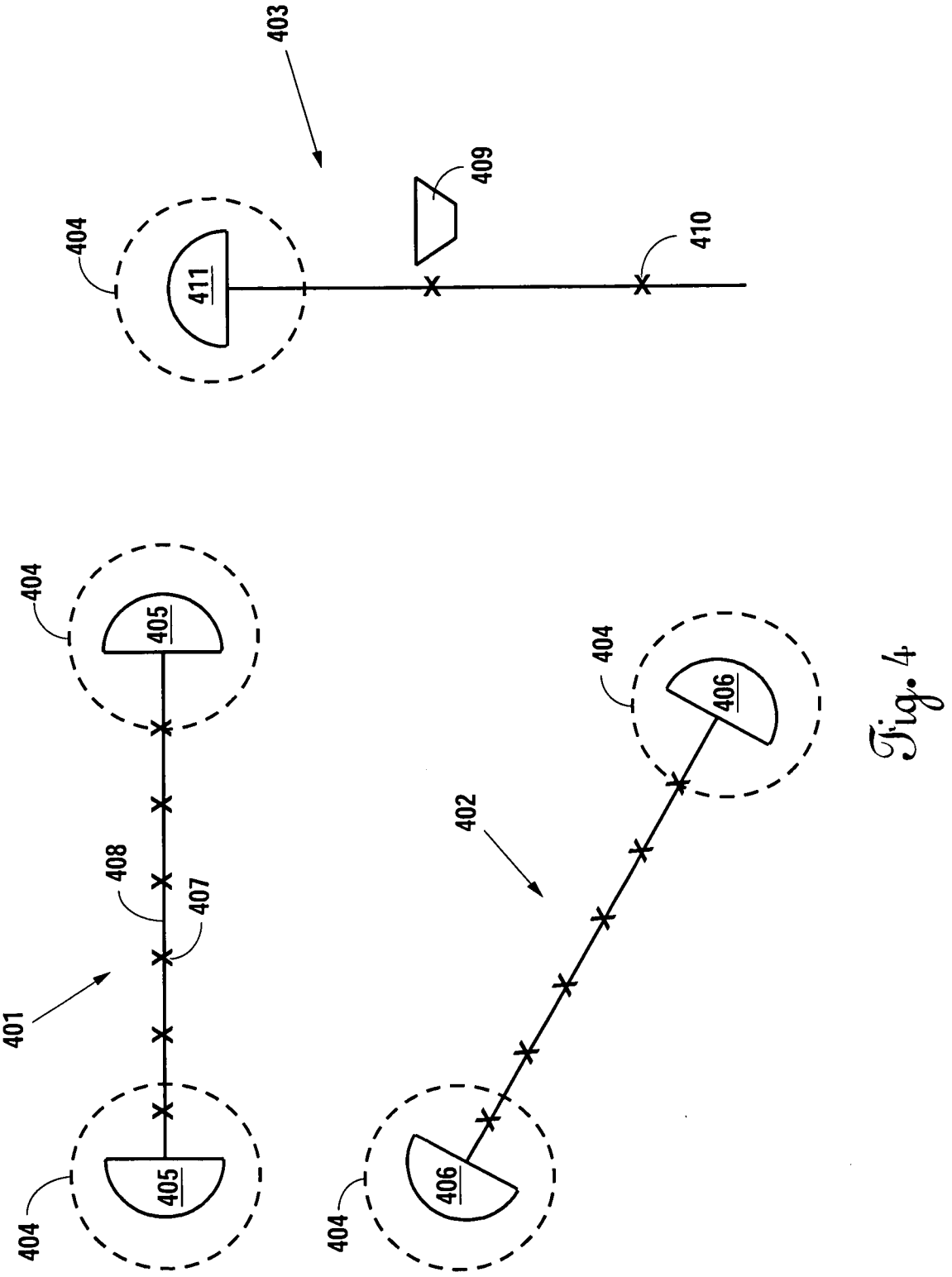

403
409
404
411
410
404
405
408
407
401
405
404
404
406
402
406
404

Fig. 4

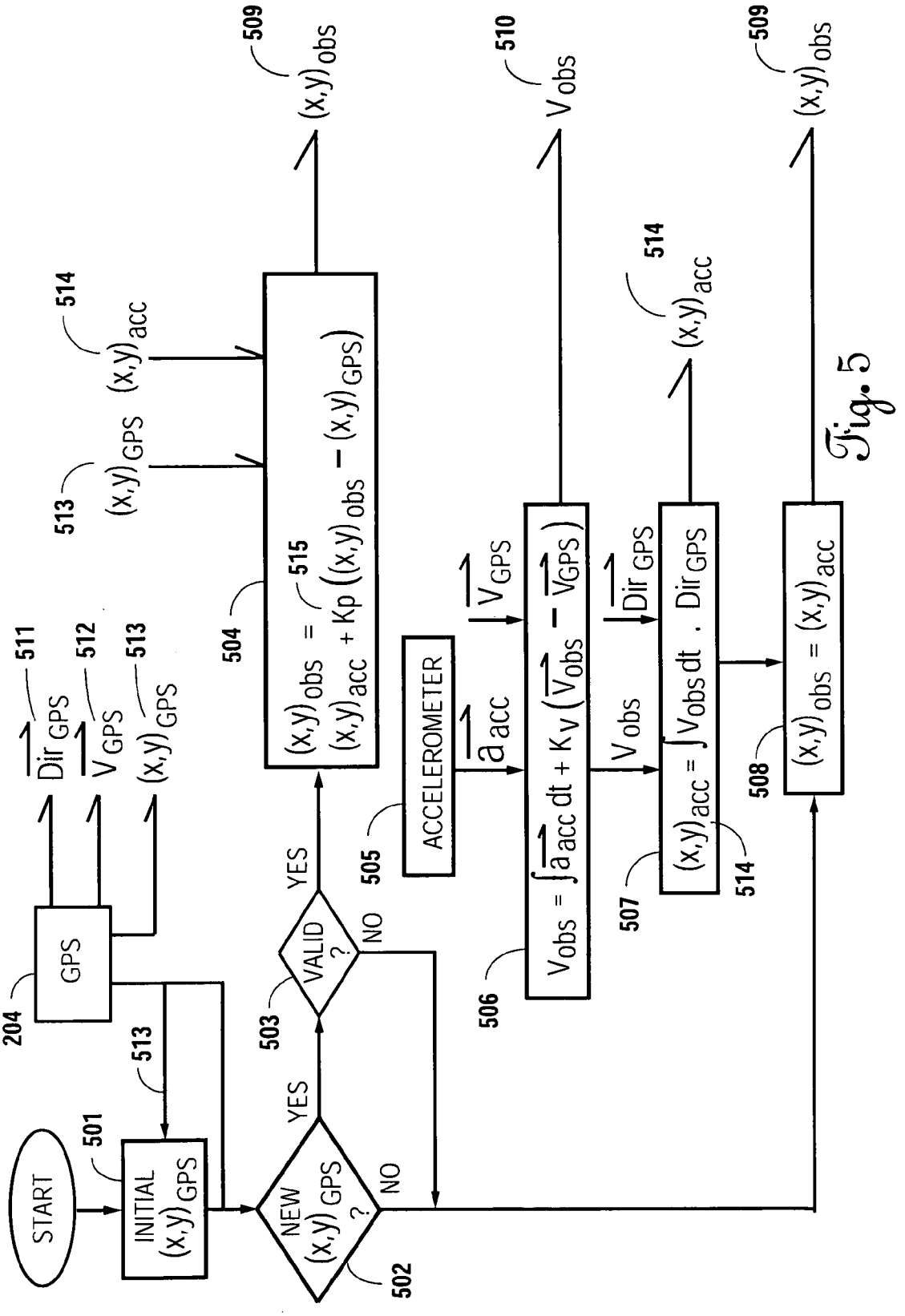

START
501
INITIAL $(x,y)_{GPS}$
513
204
GPS
$\overrightarrow{Dir}_{GPS}$
511
$\overrightarrow{V}_{GPS}$
512
$(x,y)_{GPS}$
513
503
VALID ?
YES
NO
502
NEW $(x,y)_{GPS}$?
YES
NO
504
$(x,y)_{obs} = (x,y)_{acc} + Kp\,((x,y)_{obs} - (x,y)_{GPS})$
515
513
$(x,y)_{GPS}$
514
$(x,y)_{acc}$
509
$(x,y)_{obs}$
505
ACCELEROMETER
$\overrightarrow{a}_{acc}$
$\overrightarrow{V}_{GPS}$
506
$V_{obs} = \int \overrightarrow{a}_{acc}\,dt + K_V(\overrightarrow{V}_{obs} - \overrightarrow{V}_{GPS})$
510
V_{obs}
$\overrightarrow{Dir}_{GPS}$
507
$(x,y)_{acc} = \int V_{obs}\,dt \;.\; Dir_{GPS}$
514
$(x,y)_{acc}$
508
$(x,y)_{obs} = (x,y)_{acc}$
509
$(x,y)_{obs}$

Fig. 5

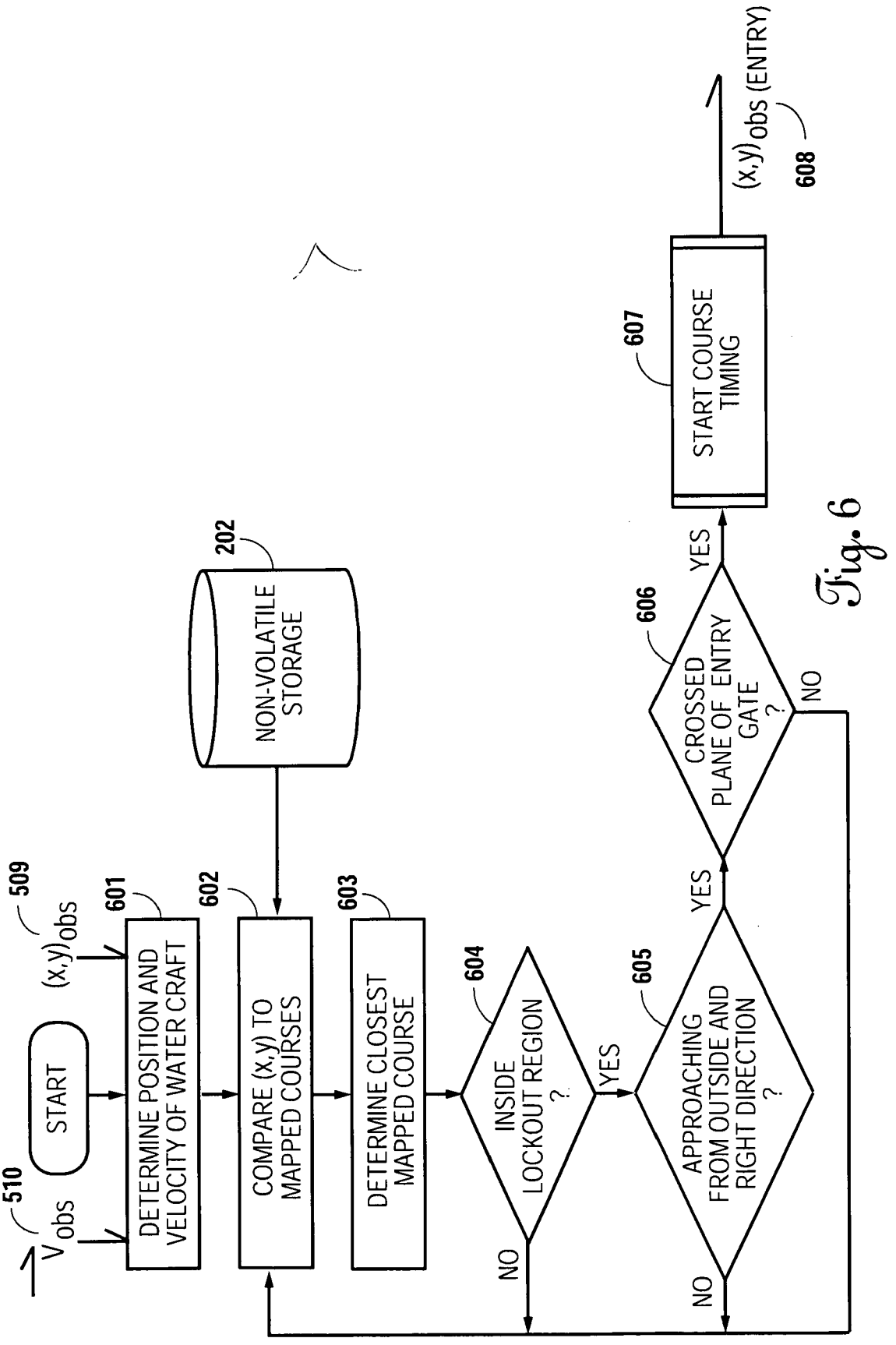

START
510
V_{obs}
509
$(x,y)_{obs}$
601
DETERMINE POSITION AND VELOCITY OF WATER CRAFT
602
COMPARE (x,y) TO MAPPED COURSES
603
DETERMINE CLOSEST MAPPED COURSE
604
INSIDE LOCKOUT REGION ?
NO
YES
605
APPROACHING FROM OUTSIDE AND RIGHT DIRECTION ?
NO
YES
606
CROSSED PLANE OF ENTRY GATE ?
NO
YES
607
START COURSE TIMING
608
$(x,y)_{obs}$ (ENTRY)
202
NON-VOLATILE STORAGE

Fig. 6

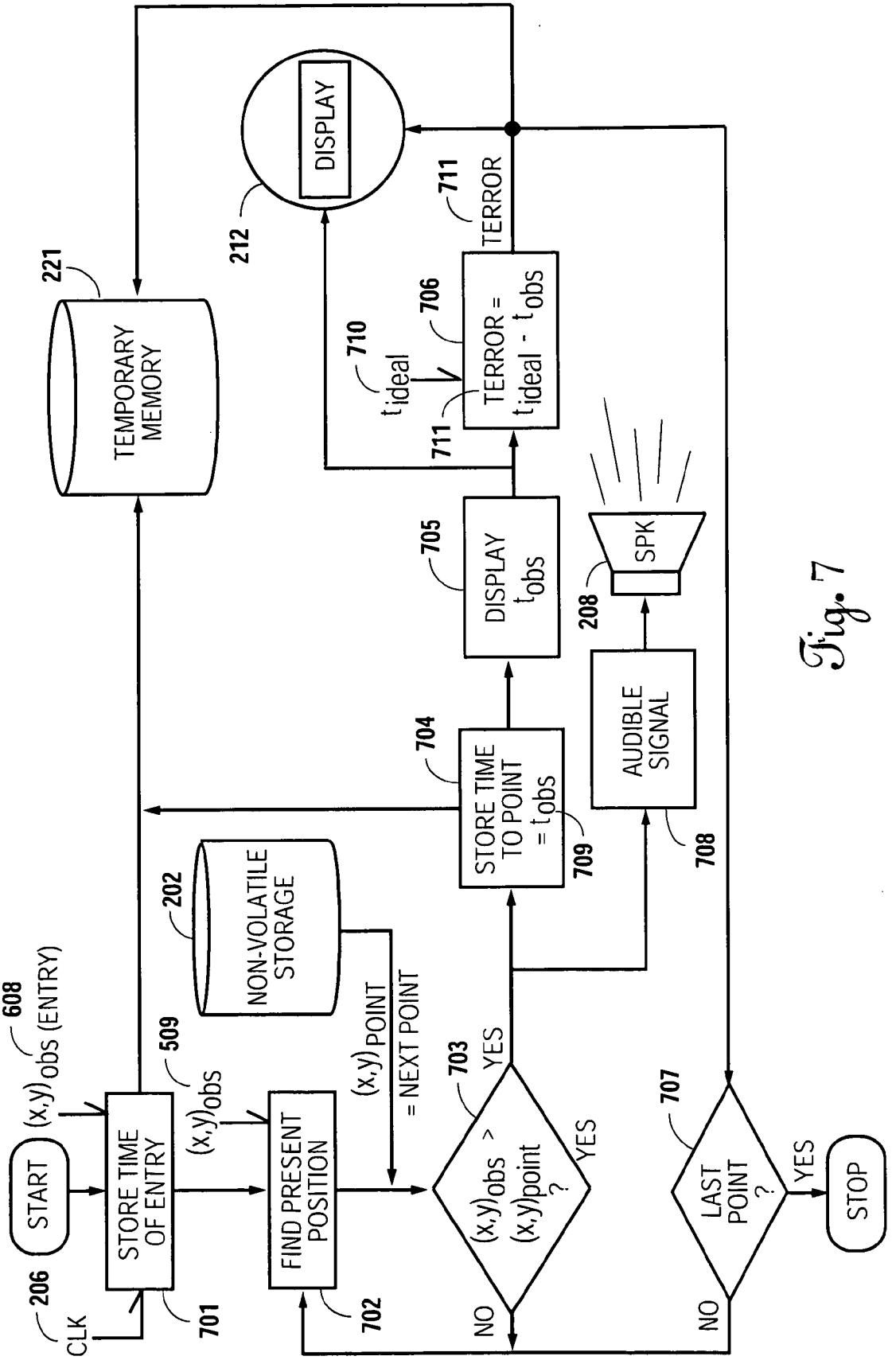

START
206
CLK
701
STORE TIME OF ENTRY
509
$(x,y)_{obs}$
608
$(x,y)_{obs}$ (ENTRY)
FIND PRESENT POSITION
702
$(x,y)_{POINT}$ = NEXT POINT
202
NON-VOLATILE STORAGE
703
$(x,y)_{obs}$ > $(x,y)_{point}$?
YES
NO
704
STORE TIME TO POINT = t_{obs}
709
DISPLAY t_{obs}
705
AUDIBLE SIGNAL
708
SPK
208
LAST POINT ?
707
YES
NO
STOP
221
TEMPORARY MEMORY
212
DISPLAY
711
TERROR
706
TERROR = t_{ideal} - t_{obs}
710
t_{ideal}
711

Fig. 7

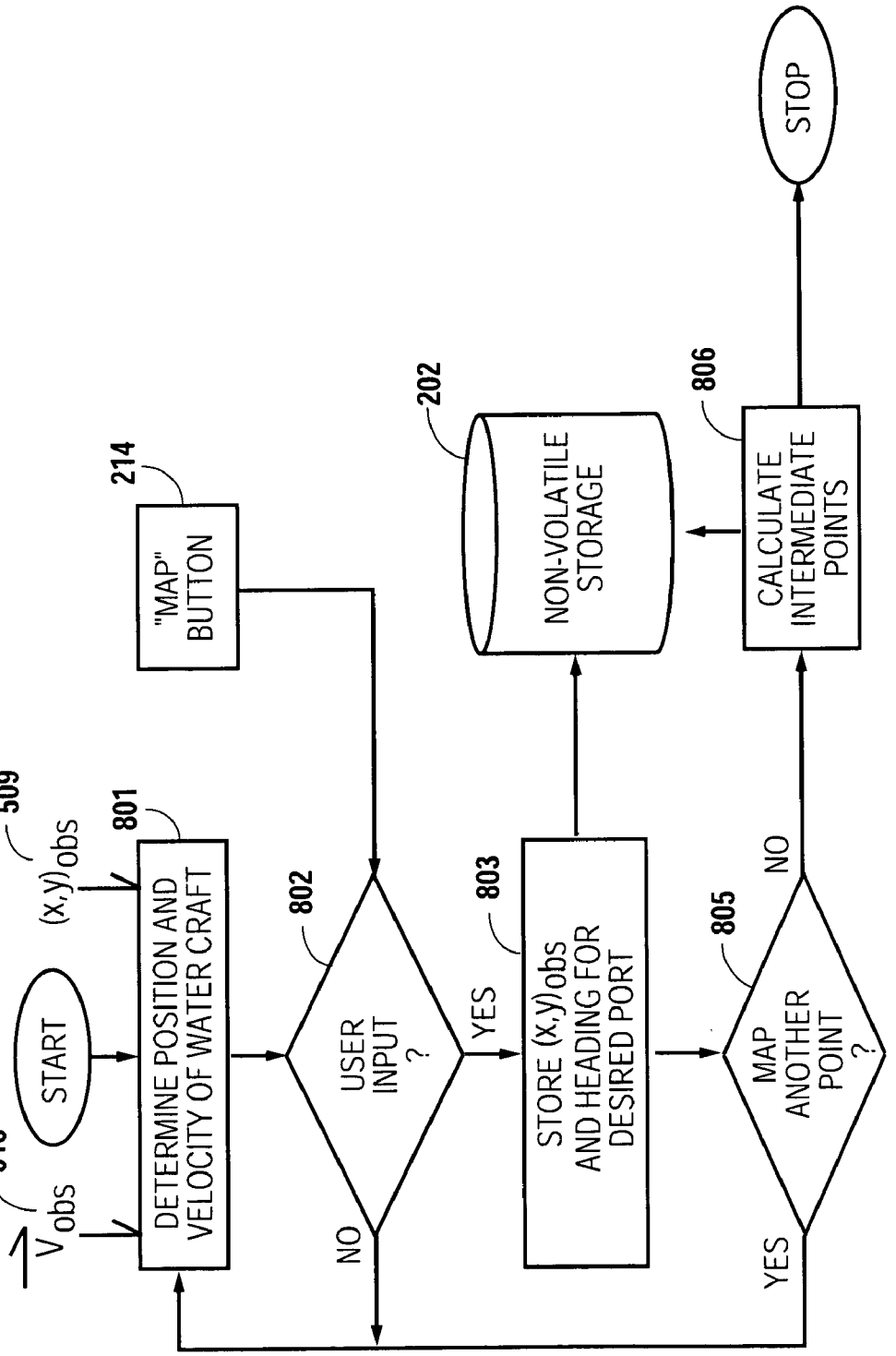
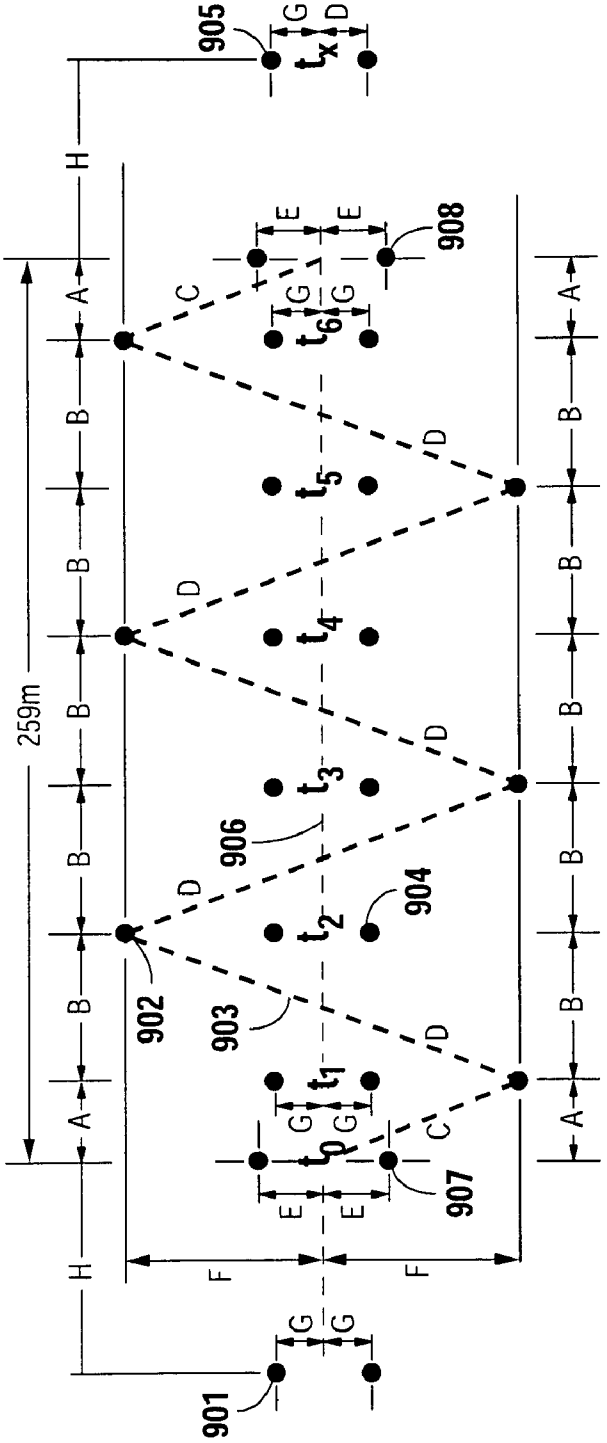

START
510
V_{obs}
509
$(x,y)_{obs}$
801
DETERMINE POSITION AND VELOCITY OF WATER CRAFT
802
USER INPUT ?
NO
YES
803
STORE $(x,y)_{obs}$ AND HEADING FOR DESIRED PORT
805
MAP ANOTHER POINT ?
NO
YES
806
CALCULATE INTERMEDIATE POINTS
202
NON-VOLATILE STORAGE
214
"MAP" BUTTON
STOP

Fig. 8



BOAT SPEED		SCORE	0-0.5	1-1.5	2-2.5	3-3.5	4-4.5	5-5.5	ALL 6
KPH	MPH	DISPLAY	0	1	2	3	4	5	6
58	36.0	FAST	1.64	4.15	6.67	9.20	11.73	14.25	15.92
		IDEAL	**1.68**	**4.22**	**6.77**	**9.31**	**11.86**	**14.40**	**16.08**
		SLOW	1.71	4.28	6.84	9.41	11.97	14.53	16.22

A = 27 meters, B = 41 meters
F = ~ 38'
Total Course Length = 259 meters

Fig. 9

EVENT SENSOR

[0001] This patent is a continuation-in-part patent application that claims priority and incorporates herein by reference U.S. patent application Ser. No. 11/056,848, now issued as U.S. Pat. No. 7,229,330; U.S. patent application Ser. No. 11/811,616, filed Jun. 11, 2007; U.S. patent application Ser. No. 11/811,605 filed Jun. 11, 2007; U.S. patent application Ser. No. 11/611,606, filed Jun. 11, 2007; U.S. patent application Ser. No. 11/811,604, filed Jun. 11, 2007; and U.S. patent application Ser. No. 11/811,617. filed Jun. 11, 2007.

FIELD OF THE INVENTION

[0002] The present invention pertains to the field of water sports and boating and more specifically to electronic devices for use in water sports.

BACKGROUND OF THE INVENTION

[0003] Competitors in trick, jump, and slalom ski and wakeboard events require tow boats capable of consistent and accurate speed control. Successful completion of slalom and jump runs require passes through a competition water course at a precise specific speed. Competition rules usually require that said speed requirements be confirmed by use of a speed measurement system. For example, American Water Ski Association Three-Event Slalom and Jump competitions specify a required time window for completion of all segments of the course to confirm that speed was maintained adequately throughout the pass. These times have historically been measured either using manual stopwatch measurements or, more recently, using magnetic sensors which are triggered by the presence of magnets attached to buoys in the water in close proximity to the path of the tow boat at the required timing measurement points in the course. Course times have to be reported and logged for every individual pass in competition. Reliability of triggering the magnetic sensor, as well as maintenance of the magnets attached to the buoys has consistently caused major difficulties in running competitive 3-event competitions.

SUMMARY OF THE INVENTION

[0004] The present invention provides a consistent, maintenance free and accurate method of measuring time of passage of a tow boat and skier through courses such as those used for slalom and jump competitions without the need for magnets or other physical attachments to the course infrastructure. Global Positioning System (GPS) satellite technology is used to map and memorize the location of courses in a permanent memory within a computer system. The system is then able to recognize every time the tow boat passes through the course using continuously updated GPS position estimates. By interpolating between periodic position updates, the system can accurately estimate time of closest approach to the entry gate to the course, and subsequently track time to all points of interest down the course using either the same GPS position measurement technique, or by tracking displacement of the tow boat down the line of the course using other techniques such as integration of velocity to derive position displacement.

[0005] An automatic timing measurement system that provides a measure of time of passage of a watercraft through a prescribed course. Algorithms based on inertial or other estimates augmented by GPS speed/position measurements are used to track position of a watercraft. Said position estimates are used to allow the locations of prescribed courses to be mapped and memorized. Algorithms are then used to allow the apparatus to automatically detect passage of a watercraft through mapped courses for the purpose of measuring and reporting time of passage of said watercraft past key points in said course, and for modifying the behavior of the speed control portion of the apparatus if necessary at certain points in the mapped course. A measure of accuracy of driver steering can be provided along with the ability to automatically steer the watercraft through the course if "steer-by-wire" mechanism is available. GPS speed control is augmented with a secondary velocity measurement device that measures speed over water resulting in an optional user selectable real-time compensation for water current. Furthermore, GPS is used as the key input to produce boat speed-based pull-up profiles.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. **1** is a perspective view of an embodiment of external housing of the device of the instant invention.

[0007] FIG. **2** is a block diagram of the electronics contained within the housing of FIG. **1**.

[0008] FIG. **3** is a feedback control loop diagram demonstrating the operation of an observer in accordance with a preferred embodiment of the present invention.

[0009] FIG. **4** is a diagram of an example water body including three ski courses.

[0010] FIG. **5** is a flow diagram disclosing a method that an observer in accordance with a preferred embodiment of the present invention may use to determine observed velocity and observed position.

[0011] FIG. **6** is a flow diagram disclosing a method for automatically detecting a previously-mapped course.

[0012] FIG. **7** is a flow diagram disclosing a method of detecting and reporting the time at which a plurality of events is detected.

[0013] FIG. **8** is a flow diagram disclosing a method by which a user interactively "maps" a desired water course, and by which the present invention stores the mapped water course into non-volatile memory.

[0014] FIG. **9** is an example of a competitive slalom ski course.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0015] The present invention relates generally to electronic event detectors and more specifically to electronic event detectors for use with power boats.

[0016] As show in FIG. **1**, the event detector **100** of the present invention includes a housing **102** for housing the electronics of the invent detector an accelerometer **106** and a GPS **104**. GPS **104** is preferably a unit separate from housing **102**, e.g. a GARMIN® GPS18-5 Hz.

[0017] Electronic housing **102** includes a display **108** and interface buttons **110**. As will be appreciated by one skilled in the art the display **108** is preferably made out of moldable materials such as plastic, aluminum, glass, and the like, with a clear glass or plastic cover. Importantly, the housing is adapted to be waterproof to prevent damage to the electronics when in use. The display **108** may be a commercially available LCD display that is capable of displaying numbers or

letters and information related to the event. User interface buttons **110** are actuators attached to the electronics covered in a rubberized membrane that allows buttons to remain waterproof during their actuation. The LCD display interface buttons **110** and glass cover are attached to an insulated housing **102** via e.g., screws, friction fit, adhesive, or the like inside the housing **102** are electronics, to be described below, that perform the functions of the device.

[0018] The electronics will now be described with reference to FIG. **2**. In general, the electronics of the event locator device **100** includes microprocessor **200**, non-volatile storage **202**, GPS interface **204**, Clock **206**, speaker **208**, power device **210**, user input interface **214**, accelerometer **216**, and analog-to-digital converter **218**.

[0019] Microprocessor **200** is the "brains" of the invention and performs location calculations and timing data for output to a user. Preferably microprocessor **200** is capable of being externally programmed. Volatile storage **202** is connected to microprocessor **200** and stores event data such as map information, location information, and timing information for the microprocessor's calculations. Clock device **206** provides time data to the microprocessor **200** which can be displayed to a user. GPS interface **204** interfaces with the GPS system which provides location data to the microprocessor **200**. Accelerometer **216** generates an acceleration signal and provides the same to the microprocessor **2000**. AC/DC converter converts the signal from the accelerometer to a digital signal for input into the microcontroller **200**. User input interface **214** is connected to the microprocessor and allows the user to program certain device settings into the non-volatile storage **202** such as map information, desired speed, and the like. Display **212** interacts with microprocessor to display event data speed, location and time information. Power supply **210** provides power to microcontroller and all of the associated electronics.

[0020] The general operation of microprocessor **200** will now be described in more detail with reference to FIG. **3**. Note FIG. **3** contemplates a scenario where course mapping information is already saved in memory and accessible by the microprocessor. As is shown, the accelerometer receives a signal from the boat indicative of the boat's acceleration and inputs this signal to a microprocessor. The microprocessor converts the acceleration value into a velocity value in step **15** and in step **16** receives both the velocity information from the accelerometer and the velocity data from the GPS. As one skilled in the art will appreciate the velocity from a GPS is not updated continuously, and the velocity information from the accelerometer is used to provide resolution to the velocity information from the GPS system in step **17**. An observed velocity is output at step **17**, and in step **70** the velocity information and direction information obtained from the GPS system is used to calculate a latitude and longitude value for the accelerometer. In step **80**, latitude and longitude information from the GPS system is compared to latitude and longitude information from the accelerometer. Much like step **17**, the latitude and longitude information from the accelerometer is then used to attenuate the GPS signal. The microprocessor then outputs a latitude and longitude observed signal, which is used in reference to map data input by the user at the start of the process. When a preselected event occurs, as calculated by the comparison observed latitude/longitude signals the microprocessor outputs a sound signal to speaker **208** and a display signal to user display **108**.

[0021] Collectively, the accelerometer **216**, analog-to-digital converter **218**, computing device **200**, GPS unit **204**, memory **221** and clock **206** comprise the elements of an observer **222**. The observer **222** is adapted to act both as a velocity observer (in which it outputs an observed velocity) and as a position observer (in which it outputs an observed position). In the preferred embodiment of the present invention, an accelerometer acts as the primary source of data for computing displacements over time, with periodic updates from the GPS provided to account for drift in the accelerometer. But it will be appreciated by those skilled in the art that there are many other methods available for performing this task. For example, over-water velocity may be measured directly by means of a transducer such as a paddle wheel or a pitot tube, and those measurements may or may not be corrected with GPS inputs. In the case of direct velocity measurement, only a single integration with respect to time is needed to compute a new position. And, as GPS technology becomes more accurate and as new data are available at a higher frequency, it is conceivable that a GPS unit will provide the sole velocity and position inputs. Other configurations for measuring velocity and position will be apparent to those of ordinary skill in the art, and it is intended for this patent to encompass such additional configurations.

[0022] The specific software flow of the microprocessor programming will be described with reference to FIGS. **5** through **8**.

[0023] FIG. **5** discloses the functioning of a preferred embodiment of an observer **222**. In step **501**, a GPS signal is received from the GPS device **204**. GPS device **204** provides a GPS position **513**, a GPS velocity **512**, and a GPS direction **511**. Step **501** uses the GPS position as its initial starting position. In Step **502**, there is a check to see if a new GPS position has been received. If a new GPS position has been received, in Step **503** it is checked to see if the GPS position is a valid GPS position. Step **503** compensates for the potential of invalid GPS signals such as occasionally occur in GPS devices known in the art. If the new GPS signal is a valid signal, then the observed position **509** is set to a value of the accelerometer corrected by the difference between the last observed position and the GPS position **513**. A constant **515** is provided such as is calculated to provide the appropriate weight to the GPS measurement. For example, if constant **515** is set to one, then the GPS position is afforded its full weight. If constant **515** is set to a value less than one, the GPS is provided less weight, and it if it set to a value greater than one, the GPS is provided more weight. This constant is selected in accordance with the relative accuracies of the GPS and accelerometer such that for a more accurate GPS device, greater weight can be given to the GPS value and for a less accurate GPS device, less weight can be given to the GPS value. The result of this calculation is an observed position **509**.

[0024] It is necessary to compensate for the 5 Hz resolution of the GPS device. This resolution is insufficient for the preferred embodiment of the present invention. So there is provided an alternative device, starting at step **505**, which includes an accelerometer **316**. The accelerometer provides a measured acceleration which is converted to a binary value in analog-to-digital converter **218**. It is then useful for being compared to digital values provided by the GPS device **204**. In step **506**, an observed velocity is computed. The velocity is computed by first taking the last observed velocity **510** and the velocity provided by the GPS **512**. This difference is adjusted by a velocity constant **517**. As with position constant

515, velocity constant **517** is selected to compensate for the relative accuracy of the GPS device. The weighted difference is then added to the velocity computed by taking the first integral of the acceleration with respect to time, thereby providing a correction factor. In step **507**, an accelerometer-computed position **514** is calculated. This position is computed by taking the integral of the velocity vector with respect to time. The displacement calculated thereby is adjusted to the direction signal provided by the GPS. This GPS correction step is used in the preferred embodiment because, in the interest of simplicity, the three-accelerometer is used only to compute acceleration along the single axis of the length of the boat. The result is accelerometer-computed position **514**. The usefulness of accelerometer-computed position **514** is that it can be calculated at a frequency of approximately 1,000 hertz. So returning to step **502**, if no new GPS signal has been provided, then the observed position is provided by the change in position as calculated by the accelerometer with no further input from the GPS device. Thus, there is provided from the observer an observed position **509** as well as an observed velocity **510**.

[0025] FIG. **8** discloses a method of using a watercraft equipped with a position and velocity observer, such as is described in FIG. **5**, to map a competitive water course. In step **801**, there is initial determination of the position and velocity of the watercraft as provided by the observed velocity **510** and the observed position **509**. In step **802**, there is a check to see whether there has been a user input from a map button **214**. If no user input is provided, then the position observer continuously updates the position and velocity of the watercraft. Once there has been a user input at step **803**, the current observed position **509** and the current heading are stored in non-volatile storage **202**. In step **805**, there is provided a step of checking to see if it is desired to map another point. If another point is to be mapped, then there is a return to step **801** and the method is repeated until, at step **805**, there is no further point to mapped. When there is no further point to be mapped, at step **806**, the device may calculate a number of predetermined intermediate points in between the points mapped and stored in step **803**. These intermediate points are also stored in non-volatile storage **202**.

[0026] In FIG. **6**, there is disclosed a method of automatically detecting a course that has been mapped in accordance with the method of FIG. **8**. At step **601**, there is initial determination of position and velocity provided by observed position **509** and observed velocity **510**. In step **602**, compare the observed position **509** to a predetermined position as mapped in accordance with the method of FIG. **8**. This mapped position is provided from non-volatile storage **202**. In **603** there is a determination of which of a plurality of mapped courses as mapped in accordance with the method of FIG. **8** is the closest to the present observed position **509**. Once a closest course has been locked in, then, in step **604**, there is a check to see whether the watercraft is inside the lockout region of the closest water course. If the craft is within the lockout region, then there is also a check to see whether the craft is approaching from outside the course and is proceeding in the right direction along the center line of the course. If these criteria are not met, then continue looking for entrance into a course. If the criteria are met, then, in step **606**, check to see whether the craft has crossed the plane of the entry gate of the course. If it has not, then return to step **602**, continuing looking for entry to a course. If the criteria are met, then the craft has entered a mapped course and the course timing algorithm will automatically begin in step **607**. This provides an observed position at the entry point **608**.

[0027] In FIG. **7** there is disclosed a method for computing total time and intermediate times through a competitive water course. There is provided an observed position at the entry point **608** and there is also provided a clock signal **206**. In step **701**, the time at the entry point is recorded in temporary memory **221**. In step **702**, an observed position **509** is provided and this provides the present position of the watercraft. A plurality of points of interest are stored in non-volatile storage **202**. In step **703**, a point of interest is provided and there is a check to see if the current observed position **509** exceeds the position of the point of interest. If the present position **509** does not exceed the position of the point of interest, then the loop is continued until the present observed position exceeds the position of the point of interest. At this point, in step **704**, the present observed time **709** is recorded into temporary memory **221** and, in step **705**, the current observed time **709** is displayed on user display **212**. In step **706**, there is provided an ideal time **710**. An error time **711** is computed as the difference between the ideal time **710** and the observed time **709**. The error time **711** is also stored in temporary storage **221** and displayed on user display **212**.

[0028] In a parallel process to step **704**, when a point of interest is reached, there is also provided an audible signal through a speaker **208** to provide an audible indication to the user that this point has been passed. After steps **704**, **705**, **706** and **708** are completed, then in step **707** there is a check to see if this is the last point of interest. If it is not, then there is a return to step **702**. If this is the last point of interest, the process ends.

[0029] The use of the device will now be described with respect to FIGS. **3**, **4** and **9**.

[0030] As diagrammed in FIG. **3** showing feedback system **310**, the inertia measurement device (accelerometer) **216** measures the actual acceleration a_a of a watercraft **50** and the GPS device **204** measures the actual velocity v_a and position of the same watercraft **50**. The output from the accelerometer a_{Acc} is input into a first step **15** that coverts a_{Acc} to velocity v_{Acc}. The output from first step **15** v_{Acc} and the GPS output v_{GPS} are input to a second step **17**. The output from a second step **17** v_{OBS} and the output (Dir_{GPS}) indicating course or direction of travel from the GPS device **204** are input into a third step **70** to derive inertial-based estimates of the latitude (Lat_{Acc}) and longitude ($Long_{Acc}$) of the watercraft **50**. Direct GPS measurements of latitude (Lat_{GPS}) and longitude ($Long_{GPS}$) and the outputs from the third step **70** are input in a fourth step **80** to correct inertial-based estimates of the latitude (Lat_{Acc}) and longitude ($Long_{Acc}$) of the watercraft **50** to account for any inaccuracies due to drift or acceleration sensor inaccuracies. Lat_{OBS} and $Long_{OBS}$ can then be used to allow the boat driver to record via a user interface the absolute latitude and longitude position coordinates of a course to be saved into a permanent non-volatile memory. Coordinates can be recorded either by direct numerical entry of measured coordinates, or by snapshotting course coordinates as the boat is maneuvering through the course to be mapped. The driver can identify course reference points via a user interface (not shown) or button press as the boat passes the point to be mapped. Since all courses of interest are laid out in straight lines, mapping of two known points in a course is sufficient to fully define the locations of all points of interest in a course and it's direction relative to earth latitude and longitude coordinates. All future passages of the towboat within a specified

distance of selected course coordinates as measured by Lat_{OBS} and $Long_{OBS}$ can then be detected and used to initiate timing measurements of the towboat through the mapped course.

[0031] FIG. **9** discloses a competitive slalom ski course. This is the type of course on which an embodiment of the present invention may be used. There is shown an entry gate **901**, which can be characterized by a precise global coordinate specified in latitude and longitude. The opposite end point of the course is exit gate **905**, which may also be characterized as a latitude and longitude. Because the course lies along a substantially straight line, the locations of all points of interest along the course can be found given the positions of the two end points. A course centerline **906** lies along a substantially straight line and is slightly larger than the width of a water craft. The centerline is defined by boat buoys **904**, which the water craft must stay in between. There are also provided ski buoys **902**, which the skier must ski around during the passage of the course, in an alternating pattern as shown by the ski path **903**. The skier must pass between the buoys defining first break point **907** before proceeding along ski path **903**. At the end of the course is a second break point **908**. The skier must ski between the two buoys defining second break point **908** after passing around the last buoy **902**. In between these points are six intermediate points **904**, each defined by a pair of buoys, which are positioned to be substantially collinear with the ski buoys **902**.

[0032] The entry gate **901**, exit gate **905**, break points **907** and **908** and intermediate buoys **904** are all points of interest whose passage may need to be detected. The time at which the boat **50** passes these points may be used to determine whether a run is valid, according to whether the time is within an allowable margin of error. Because these points are defined according to precisely-surveyed distances, their locations can be detected by a substantially accurate observer (such as is provided by the preferred embodiment of the present invention) given only the location of the two end points. So the mapping course-mapping method described in FIG. **8** provides the observer with sufficient information to determine when a point of interest has been passed in accordance with the method of FIG. **7**.

[0033] Once a course has been mapped, the location of the course can be stored in a permanent storage medium **202** such as a disk drive or flash memory. Further qualification of valid entry to a course can then be carried out based on GPS direction measurements so that timing measurements are only made when the towboat enters a mapped course while traveling along the known direction of the course centerline. Further, any deviations of the tow boat from the center line of the course can be detected and factored geometrically into the measurement of displacement down the centerline of the course so that errors in timing measurement due to driver steering error can be compensated for.

[0034] FIG. **4** discloses a water course with a plurality of competitive ski courses. There is disclosed a first slalom course **401**, a second slalom course **402** and a jump course **403**. First slalom course **401** has entry and exit thresholds **405**. Second slalom course **402** has entry and exit thresholds **406**. The slalom courses may be traversed in either direction through entry and exit thresholds **405** and **406**. A jump course **403** may be entered only through entry threshold **411** because ski jump **409** is unidirectional.

[0035] According to a preferred embodiment of the present invention, a user may approach a course, for example first slalom course **401**. Upon entering the entry threshold **405** in the direction of the course centerline **408**, the user will press a button whereby the computing device is alerted of the location of the entry/exit threshold. The user then proceeds along course centerline **408** and presses a button again at the opposite entry/exit threshold **405**.

[0036] The computing device also interfaces with a permanent storage medium. This storage medium contains the desired locations of intermediate buoys **407**, which are located at pre-determined distances from the entry/exit buoys. "This process" allows the computing device to learn the exact location of first slalom course **401**. "The process" can then be repeated to allow the computing device to learn the locations of second slalom course **402** and jump course **409**.

[0037] Once the computing device has learned the locations of courses **401**, **402** and **403**, it is desirable for the device to automatically detect which course it is at without further user intervention. So there are shown mapped lockout regions **404** around each of the entry/exit thresholds **405**, **406** and **411**. According to the method disclosed in FIG. **6**, the device will detect which of the mapped courses is closest to its present position. The device may also selectively detect only courses of a specific type (jump or slalom) depending on its current mode of operation. If the device then determines it is within a lockout regions **404**, it will check to see if the boat is approaching from outside the entry/exit threshold and in the correct direction along the course centerline. If these criteria are met, then the device will calculate the time o the closest approach to the plane of the entry gate. At that time it will begin timing the path without any intervention from the user.

[0038] Because the locations of intermediate buoys **407** are pre-programmed, the device may provide an audible or visual indication of the passing of each intermediate buoy **407**. It may also provide intermediate times at the passing of each intermediate buoy **407**. Finally, it will calculate the time at which boat **50** passes through the opposite entry/exit threshold **405**.

[0039] In this manner the device can automatically time a pass through a memorized course without any further intervention from the user.

[0040] A driver score can also be provided based on the degree of this error which can be used to rate driver performance and confirm accuracy of the boat path through the course, which is also a criterion used in judging whether a competitive pass is valid.

[0041] Any boat speed or engine torque modification requirements which may depend on position in the course can be triggered based on Lat_{OBS} and $Long_{OBS}$ relative to the mapped course location.

[0042] As one skilled in the art will recognize, the device of the invention is one of the category of commonly understood instruments that measures an object's acceleration. The velocity of on object can be calculated by integrating the acceleration of an object over time. Further, the position of an object relative to a known starting point can be calculated by integrating the velocity of an object over time. A GPS device is one of the category of commonly understood instruments that use satellites to determine the substantially precise global position and velocity of an object. Such position and velocity measurements can be used in conjunction with timers to determine an object's instantaneous velocity and average velocity between two points, along with its absolute position at any point in time. A comparator is any analog or digital

electrical, electronic, mechanical, hydraulic, or fluidic device capable of determining the sum of or difference between two input parameters, or the value of an input relative to a predetermined standard. An algorithm is any analog or digital electrical, electronic, mechanical, hydraulic, or fluidic device capable of performing a computational process. The algorithms disclosed herein can be performed on any number of computing devices commonly called microprocessors or microcontrollers, examples of which include the Motorola® MPC555 and the Texas Instruments® TMS320

[0043] Use of observed velocity and position estimates based on inertial or other measurement sources allows for error correction of occasional glitches or interruptions in availability of accurate GPS velocity and position measurements. These can occur in the course of normal operations, either due to GPS antenna malfunction, or temporary loss of GPS satellite visibility due to overhead obstruction from bridges or overhanging vegetation and the like.

[0044] Other embodiments of the system could include automated steering of the boat down the centerline of the course making use of course location information stored as described in 0014 thru 0016 above. The present invention may be included as part of an electronic closed-loop feedback system that controls the actual angular velocity ωa of a boat propeller, and, indirectly, the actual over land velocity V_a of the watercraft propelled by that propeller.

[0045] Another embodiment allows the apparatus to track the position of a skier behind the watercraft as he/she traverses the course. This can be achieved by mounting a GPS antenna somewhere on or near the body of the skier and capturing these data concurrently with data from a tow boat mounted antenna. Such GPS antennae can be either wired or wirelessly connected to the main apparatus.

[0046] It will be apparent to those with ordinary skill in the relevant art having the benefit of this disclosure that the present invention provides an apparatus for tracking the position and velocity of a watercraft through a prescribed course without the need for measurement aids such as magnets built into the course infrastructure. It is understood that the forms of the invention shown and described in the detailed description and the drawings are to be taken merely as presently preferred examples and that the invention is limited only by the language of the claims. The drawings and detailed description presented herein are not intended to limit the invention to the particular embodiments disclosed. While the present invention has been described in terms of one preferred embodiment and a few variations thereof, it will be apparent to those skilled in the art that form and detail modifications can be made to that embodiment without departing from the spirit or scope of the invention.

We claim:

1. A system for detecting the time of an event, said system comprising:
- a position observer subsystem;
- a computing device in communication with said position observer system;
- non-volatile storage programmed with locational information describing at least one water course;
- wherein said computing device is adapted to compute a position of a watercraft relative to said water.

2. The system of claim **1** further comprising
- A user interface allowing driver inputs to permanently store and identify locations of a prescribed course using measurements derived by **1** above.

3. The system of claim **2** wherein said user interface further comprises a progress indicator adapted to substantially represent said watercrafts position relative to said mapped water course.

4. The system of claim **2** wherein said user interface is further adapted to provide an audible signal when said watercraft crosses the plane of a buoy.

5. The system of claim **1** wherein said computing device is adapted to automatically detect passage of said watercraft through defined points in said course.

6. The system of claim **1** wherein
- said permanent storage medium contains a plurality of mapped water courses; and
- wherein said computing device is adapted to automatically detect which of said plurality of mapped water courses said watercraft is entering.

7. The system of claim **1** wherein said computing device is adapted to measure driver accuracy in steering said watercraft through said mapped water course.

8. The system of claim **1**
- wherein said computing device is adapted to automatically compute a desired path through a mapped course; and
- further comprising a control system adapted to steer said watercraft along an actual path substantially in conformance with said desired path.

9. The system of claim **1** further comprising
- A computing device adapted to map and display the track of a skier relative to the course location in real time.

10. The system of claim **1** further comprising
- An algorithm adapted to map and log the track of a skier relative to the course location based on post-processing data.

11. An apparatus for measuring the position of a watercraft, said apparatus comprising:
- a GPS device capable of computing a substantially correct position of said water craft;
- a permanent storage medium containing locational information for at least one memorized water course;
- wherein said GPS device is adapted to calculate a position of said watercraft relative to said at least one memorized water course.

12. A method of detecting an event comprising the steps of:
- recording map data into a memory;
- receiving a velocity signal and a location signal;
- outputting a normalized signal based upon said velocity signal and said location signal;
- comparing said normalized to said map data;
- outputting said even based upon said comparison.

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