

## Description

### DISTANCE MEASURING DEVICE FOR VEHICLES

#### Technical Field

[0001] This invention relates to a vehicle distance detecting apparatus, which is designed to be capable of decreasing a cumulative error in a distance traveled, when the distance traveled is detected with the use of an acceleration sensor.

#### Background Art

[0002] As an electronic toll collection system in a toll road, a radio-based toll collection system is available. With the radio-based toll collection system, communications are carried out between a base station installed at a tollbooth of the toll road and an onboard or on-vehicle machine installed on a vehicle (automobile) to perform recognition and authentication of the vehicle and payment. As the communications between the base station and the on-vehicle machine, dedicated short-range communications (DSRC) are generally used.

The use of such a radio-based toll collection system enables the vehicle to pass the tollbooth in a nonstop, cashless manner.

[0003] Further, a GPS toll charging system, which detects the position of the vehicle, the route of travel, the distance traveled, and the traveling time by use of the global positioning system (GPS), and charges a toll based on the detection data, is under study as a next-generation radio-based toll collection system.

[0004] With the GPS toll charging system, radio waves

transmitted from a GPS satellite are received by a GPS receiver installed on the on-vehicle machine. The GPS receiver detects the travel position of the vehicle based on the received radio waves. When the vehicle enters a charging area (for example, a specific urban area), charging of a toll starts, and when the vehicle departs from the charging area, charging of the toll ends. While the vehicle is traveling in the charging area, the vehicle position, the travel route, the travel distance, and the traveling time are detected.

The on-vehicle machine starts recording of the travel route at a time when the vehicle enters the charging area, determines the distance traveled based on the travel route when the vehicle exits from the charging area, charges a toll based on the travel distance, and transmits charging information to a charging center.

[0005] Such a GPS toll charging system can abolish the tollbooth (gate facilities) which has been necessary under the conventional radio-based toll collection system.

[0006] Under the GPS toll charging system, when the vehicle is unable to receive radio waves transmitted from the GPS satellite and cannot perform GPS positioning, for example, while the vehicle is running in a tunnel, a self-sustaining sensor is used to detect the distance traveled, and information on position detected by the GPS receiver is corrected with the traveled distance detected by the self-sustaining sensor.

[0007] In some vehicles, a vehicle speed sensor, which determines a vehicle speed by detecting the rotational speed of a wheel (or, for example, a drive shaft for transmitting

a rotational drive force to the wheel), has hitherto been used as the self-sustaining sensor. By integrating vehicle speed signals outputted from such a type of vehicle speed sensor, the distance traveled is obtained, and the positional information is corrected with the thus obtained traveled distance.

[0008] The vehicle speed sensor is certainly provided in the vehicle (automobile), and a signal from the vehicle speed sensor is sent to a vehicle speed meter, where a vehicle speed is displayed.

[0009] Further, there is a vehicle of a type in which the vehicle speed sensor is connected to a plug socket provided at a position on a lower side of a steering wheel, and a plug socket provided, for example, at a position below a front passenger's seat (i.e., floor surface), via signal lines so that vehicle speed signals can be withdrawn from the plug sockets exposed to the outside in this manner.

[0010] However, the positions of installation of such plug sockets differ according to the type of the vehicle. Thus, the work of connecting the on-vehicle machine and the plug sockets together has been individual work conformed to the type of the vehicle, and has been complicated work.

Some vehicle types are lacking in the above-mentioned plug sockets. With these vehicle types, vehicle speed signals have not been withdrawable to the outside. As a result, the distance traveled has not been successfully found from the vehicle speed signal.

With a two-wheeled vehicle, withdrawal of vehicle speed pulses to the outside is not assumed, and there are no plug sockets for withdrawing vehicle speed pulses to the

outside.

[0011] To avoid the complicated work, etc. associated with the vehicle speed sensor, it is common practice to provide the on-vehicle machine with an acceleration sensor, and calculate the speed and the distance traveled from acceleration signals based on detection by the acceleration sensor, instead of using signals from the vehicle speed sensor.

[0012] Fig. 10 shows a conventional technique by which to calculate a vehicle speed and a distance traveled with the use of an acceleration sensor 1. As shown in Fig. 10, an acceleration signal a outputted from the acceleration sensor 1 installed on an on-vehicle machine is integrated by a first integrator 2 to obtain a speed signal b indicating a vehicle speed. This speed signal b is integrated by a second integrator 3 to obtain a distance signal c indicating a distance traveled. That is, the acceleration signal a is integrated twice to obtain the distance signal c.

[0013] Patent Document 1: JP-A-9-196691

#### Disclosure of the Invention

##### Problems to be solved by the invention

[0014] With the conventional technique which uses the acceleration sensor 1 to calculate the vehicle speed and the distance traveled, as shown in Fig. 10, an error, such as small noise involved in the acceleration signal a, causes an error in the travel speed signal b, with the result that the cumulative error of the acceleration signal c grows over time.

[0015] This will be explained with reference to Figs. 11(a) to 11(c). In Figs. 11(a) to 11(c), a short dashed line

represents a measured value or a calculated value, and a solid line represents a true value.

If vibration (acceleration) acts on the acceleration sensor 1 for some cause, or if vibration (acceleration), which actually has not occurred, is erroneously detected because of thermal noise or the like, when the vehicle is at a standstill or stationary, the acceleration sensor 1 measures the vibration and outputs the acceleration signal a, as shown in Fig. 11(a). At this time, the true value, namely, acceleration due to running or travel, is zero.

That is, although acceleration (true value) due to travel is zero since the vehicle is stationary, the acceleration signal a as noise is outputted.

[0016] Once the acceleration signal a as noise is outputted as shown here, the speed signal (calculated value) b increases, although the vehicle is stationary, as shown in Fig. 11(b).

Furthermore, as the speed signal (calculated value) b increases, the distance signal (calculated value) c increases cumulatively with the passage of time despite the stoppage of the vehicle.

In other words, the conventional technique, by which the acceleration signal a outputted from the acceleration sensor 1 is integrated twice to obtain the distance signal c, has posed the problem that if noise is involved in the acceleration signal a, the cumulative error of the distance signal (calculated value) c increases over time.

[0017] The present invention has been accomplished in the light of the above-described conventional technology. It is an object of the invention to provide a vehicle distance

detecting apparatus for detecting a distance traveled with the use of an acceleration sensor, the vehicle distance detecting apparatus being adapted to prevent a distance signal from increasing over time because of noise despite stoppage of a vehicle, thereby decreasing the cumulative error of the distance traveled.

Means for solving the problems

[0018] An aspect of the present invention for solving the above-described problems is a vehicle distance detecting apparatus installed on a vehicle, comprising:

- an acceleration sensor for outputting an acceleration signal conformed to acceleration;

- stoppage determining means for determining, based on the acceleration signal, whether the vehicle is stationary; and

- an integrating section which has a function of integrating the acceleration signal to obtain a speed signal, and integrating the speed signal to obtain a distance signal indicating a distance traveled, followed by outputting the distance signal, and which, when the stoppage determining means has not determined that the vehicle is stationary, integrates the speed signal obtained by integrating the acceleration signal, to obtain the distance signal, or when the stoppage determining means has determined that the vehicle is stationary, forcibly brings a value of the speed signal to zero, and integrates the speed signal whose value has become zero, to obtain the distance signal.

[0019] Another aspect of the present invention is a vehicle distance detecting apparatus installed on a vehicle, comprising:

an acceleration sensor for outputting an acceleration signal conformed to acceleration;

a computing section for determining what amounts of respective frequency components are contained in the acceleration signal;

an idling frequency storage section storing an idling frequency determined beforehand according to the vehicle having the vehicle distance detecting apparatus installed thereon;

a determining section which outputs a speed reset signal if a frequency component having a largest vibration intensity of the respective frequency components found by computation in the computing section is the idling frequency stored in the idling frequency storage section; and

an integrating section which has a function of integrating the acceleration signal to obtain a speed signal, and integrating the speed signal to obtain a distance signal indicating a distance traveled, followed by outputting the distance signal, and which, when the speed reset signal has not been outputted from the determining section, integrates the speed signal obtained by integrating the acceleration signal, to obtain the distance signal, or when the speed reset signal has been outputted from the determining section, forcibly brings a value of the speed signal to zero, and integrates the speed signal whose value has become zero, to obtain the distance signal.

[0020] Another aspect of the present invention is a vehicle distance detecting apparatus installed on a vehicle, comprising:

an acceleration sensor for outputting an

acceleration signal conformed to acceleration;

a computing section for obtaining a strength of the acceleration signal;

a threshold storage section storing a threshold having a value determined beforehand according to the vehicle having the vehicle distance detecting apparatus installed thereon;

a comparing section which outputs a speed reset signal if the strength of the acceleration signal obtained by the computing section is lower than the threshold stored in the threshold storage section; and

an integrating section which has a function of integrating the acceleration signal to obtain a speed signal, and integrating the speed signal to obtain a distance signal indicating a distance traveled, followed by outputting the distance signal, and which, when the speed reset signal has not been outputted from the comparing section, integrates the speed signal obtained by integrating the acceleration signal, to obtain the distance signal, or when the speed reset signal has been outputted from the comparing section, forcibly brings a value of the speed signal to zero, and integrates the speed signal whose value has become zero, to obtain the distance signal.

[0021] Another aspect of the present invention is a vehicle distance detecting apparatus installed on a vehicle, comprising:

an acceleration sensor for outputting an acceleration signal conformed to acceleration;

a computing section for obtaining an engine speed based on a tachometer signal;

a determining section which outputs a speed reset signal if the engine speed has become a preset idling speed; and

an integrating section which has a function of integrating the acceleration signal to obtain a speed signal, and integrating the speed signal to obtain a distance signal indicating a distance traveled, followed by outputting the distance signal, and which, when the speed reset signal has not been outputted from the determining section, integrates the speed signal obtained by integrating the acceleration signal, to obtain the distance signal, or when the speed reset signal has been outputted from the determining section, forcibly brings a value of the speed signal to zero, and integrates the speed signal whose value has become zero, to obtain the distance signal.

[0022] Another aspect of the present invention is a vehicle distance detecting apparatus installed on a vehicle, comprising:

an acceleration sensor for outputting an acceleration signal conformed to acceleration;

a determining section which outputs a speed reset signal if a parking brake is kept on; and

an integrating section which has a function of integrating the acceleration signal to obtain a speed signal, and integrating the speed signal to obtain a distance signal indicating a distance traveled, followed by outputting the distance signal, and which, when the speed reset signal has not been outputted from the determining section, integrates the speed signal obtained by integrating the acceleration signal, to obtain the distance signal, or when the speed

reset signal has been outputted from the determining section, forcibly brings a value of the speed signal to zero, and integrates the speed signal whose value has become zero, to obtain the distance signal.

[0023] Another aspect of the present invention is a vehicle distance detecting apparatus installed on a vehicle, comprising:

- an acceleration sensor for outputting an acceleration signal conformed to acceleration;

- a computing section for determining what amounts of respective frequency components are contained in the acceleration signal, and also obtaining a strength of the acceleration signal;

- an idling frequency storage section storing an idling frequency determined beforehand according to the vehicle having the vehicle distance detecting apparatus installed thereon;

- a threshold storage section storing a threshold having a value determined beforehand according to the vehicle having the vehicle distance detecting apparatus installed thereon;

- a stoppage determining section which outputs a speed reset signal if a frequency component having a largest vibration intensity of the respective frequency components found by computation in the computing section is the idling frequency stored in the idling frequency storage section, and if the strength of the acceleration signal obtained by the computing section is lower than the threshold stored in the threshold storage section; and

- an integrating section which has a function of

integrating the acceleration signal to obtain a speed signal, and integrating the speed signal to obtain a distance signal indicating a distance traveled, followed by outputting the distance signal, and which, when the speed reset signal has not been outputted from the stoppage determining section, integrates the speed signal obtained by integrating the acceleration signal, to obtain the distance signal, or when the speed reset signal has been outputted from the stoppage determining section, forcibly brings a value of the speed signal to zero, and integrates the speed signal whose value has become zero, to obtain the distance signal.

#### Effects of the Invention

[0024] According to the present invention, the speed signal obtained by integrating the acceleration signal is further integrated to obtain the distance signal indicating the distance traveled. On this occasion, it is determined whether the vehicle is at a standstill or stationary. When it is determined that the vehicle is at a standstill or stationary, the value of the speed signal is forced into zero. The speed signal, which has become zero, is integrated to find the distance traveled.

Thus, even if an acceleration signal as a noise is outputted during stoppage of the vehicle, the speed signal is forced into zero value in this case. Thus, the defect that the distance signal increases over time, namely, the increase in cumulative error, can be prevented.

Consequently, the vehicle distance detecting apparatus, which obtains the distance signal by use of the acceleration signal outputted from the acceleration signal, can find the distance traveled more accurately by reducing

the occurrence of cumulative error.

#### Brief Description of the Drawings

[0025] [Fig. 1] is a block diagram showing a vehicle distance detecting apparatus according to Embodiment 1 of the present invention.

[Fig. 2(a)] is a characteristics view showing the results of FFT computation when a vehicle stops to bring an engine into an idling operation state, in which an engine speed becomes an idling frequency.

[Fig. 2(b)] is a characteristics view showing the results of FFT computation when the vehicle is traveling.

[Fig. 3(a)] is a characteristics view showing the status of a vehicle speed signal.

[Fig. 3(b)] is a characteristics view showing the status of a distance signal.

[Fig. 4] is a block diagram showing a vehicle distance detecting apparatus according to Embodiment 2 of the present invention.

[Fig. 5(a)] is a characteristics view showing the effective value (rms) of acceleration  $a_d$  when the vehicle stops to bring an engine into an idling operation state.

[Fig. 5(b)] is a characteristics view showing the effective value (rms) of the acceleration  $a_d$  when the vehicle is traveling.

[Fig. 6] is a block diagram showing a vehicle distance detecting apparatus according to Embodiment 3 of the present invention.

[Fig. 7] is a block diagram showing a vehicle distance detecting apparatus according to Embodiment 4 of the present invention.

[Fig. 8] is a block diagram showing a vehicle distance detecting apparatus according to Embodiment 5 of the present invention.

[Fig. 9] is a determination characteristics view showing the determination technique of a stoppage determining section in Embodiment 5.

[Fig. 10] is a block diagram showing a conventional technology for calculating a vehicle speed and a distance traveled with the use of an acceleration sensor.

[Fig. 11(a)] is a characteristics view showing acceleration.

[Fig. 11(b)] is a characteristics view showing the status of a vehicle speed signal.

[Fig. 11(c)] is a characteristics view showing the status of a distance signal.

#### Description of the Numerals and Symbols

[0026] 10, 20, 30, 40, 50 Vehicle distance detecting apparatus

11, 21, 31, 41, 51 Acceleration sensor

12, 22, 32, 42, 52 A/D converter

13, 23, 33, 53 Computing section

14, 54a Idling frequency storage section

24, 54b Threshold storage section

15, 35, 45 Determining section

25, 35 Determining section

55 Stoppage determining section

16, 26, 36, 46, 56 Integrating section

a, da Acceleration signal

b Vehicle speed signal

c Distance signal

Ne Engine speed  
ta Tachometer signal  
sb Parking brake signal  
R Speed reset signal

#### Best Mode for Carrying Out the Invention

[0027] The best mode for carrying out the present invention will now be described in detail based on the following embodiments:

##### Embodiment 1

[0028] Fig. 1 shows a vehicle distance detecting apparatus 10 according to Embodiment 1 of the present invention. This vehicle distance detecting apparatus 10 is provided, for example, in an on-vehicle machine equipped with a GPS receiver.

[0029] The vehicle distance detecting apparatus 10 has an acceleration sensor 11, an A/D converter 12, a computing section 13, an idling frequency storage section 14, a determining section 15, and an integrating section 16.

[0030] When acceleration acts, the acceleration sensor 11 outputs an acceleration signal a which is an analog signal conformed to the acting acceleration. The A/D converter 12 converts the acceleration signal a, as the analog signal, into an acceleration signal da which is a digital signal.

[0031] The computing section 13 performs the fast Fourier transform (FFT) computation of the acceleration signal da. By performing the FFT computation, it can be determined what amounts of what frequency components are contained in the acceleration signal da.

[0032] Fig. 2(a) shows the results of FFT computation when a vehicle stops to bring an engine into an idling operation

state, in which the engine speed becomes an idling frequency. Fig. 2(b) shows the results of FFT computation when the vehicle is traveling.

In the idling operation state, the vibration intensity of the frequency component of an idling frequency (e.g., 10 Hz) predetermined according to the vehicle is the largest, as shown in Fig. 2(a). While the vehicle is traveling, the vibration intensity of the frequency component of a traveling frequency (e.g., 42 Hz) predetermined according to the vehicle is the largest, as shown in Fig. 2(b).

[0033] Returning to Fig. 1, the integrating section 16 integrates the acceleration signal  $da$  to obtain a vehicle speed signal  $b$  indicating the vehicle speed, and outputs the vehicle speed signal  $b$ . The integrating section 16 also integrates the vehicle speed signal  $b$  to obtain a distance signal  $c$  indicating the distance traveled.

The thus obtained distance signal  $c$  is used to correct information on position detected by the GPS receiver.

The distance signal  $c$  is corrected so as not to increase in cumulative error, although details will be described later.

[0034] The idling frequency storage section 14 has in storage the idling frequency (e.g., 10 Hz) predetermined according to the vehicle on which the vehicle distance detecting apparatus 10 is installed.

[0035] The determining section 15 takes in the idling frequency stored in the idling frequency storage section 14, and the results of FFT computation done in the computing section 13 to determine a frequency having the largest signal

component amount (vibration intensity) of the respective frequencies found by the FFT computation, namely, the frequency whose vibration intensity peaks.

Further, if the frequency with which the vibration intensity peaks is the aforementioned idling frequency, the determining section 15 sends a speed reset signal R to the integrating section 16.

[0036] The integrating section 16 obtains the vehicle speed signal b and the distance signal c based on the acceleration signal da, as stated earlier. Upon receipt of the speed reset signal R, however, the integrating section 16 forcibly brings the value of the speed signal b to zero (resets the speed signal b), no matter what value the speed signal b immediately before entry of the speed reset signal R has.

Thus, when the vehicle stops and the engine comes into an idling operation state, the speed reset signal R is continuously outputted. Consequently, during the idling operation (stoppage of the vehicle), the value of the speed signal b obtained in the integrating section 16 continues to be zero.

[0037] Furthermore, when the speed reset signal R has not been entered, the integrating section 16 integrates the vehicle speed signal b, which has been obtained by integrating the acceleration signal a (da) ascribed to detection by the acceleration sensor 11, thereby obtaining the distance signal c.

Besides, when the speed reset signal R has been entered, the integrating section 16 integrates the vehicle speed signal b, whose value has been forced to become zero, thereby obtaining the distance signal c.

[0038] Fig. 3(a) shows the status of the vehicle speed signal b, in which a short dashed line represents a calculated value, and a solid line represents a true value. When the speed reset signal R is entered into the integrating section 16 at a time T, the value of the vehicle speed signal b becomes zero, and this zero value continues.

[0039] Fig. 3(b) shows the status of the distance signal c, in which a short dashed line represents a calculated value, and a solid line represents a true value. When the speed reset signal R is entered into the integrating section 16 at a time T, the value of the speed signal b becomes zero forcedly after the time T. Thus, the value of the distance signal c continues to be the value at the time T.

That is, after the time T, the occurrence of a cumulative error, namely, the distance signal c increasing with time despite stoppage of the vehicle, can be prevented.

[0040] As described above, when the frequency having the largest signal component amount (vibration intensity) (i.e., the frequency having a peak vibration intensity) of the respective frequencies found by the FFT computation is the idling frequency, a determination is made that the vehicle is at a standstill or stationary. Based on this determination, the vehicle speed signal b is forced into zero. By so doing, it becomes possible to prevent cumulative error from being superposed on the distance signal c with the passage of time.

As a result, the value of the distance signal c indicating the distance traveled becomes more accurate.

#### Embodiment 2

[0041] Next, a vehicle distance detecting apparatus 20

according to Embodiment 2 of the present invention will be described by reference to Fig. 4. This vehicle distance detecting apparatus 20 is provided, for example, in an on-vehicle machine equipped with a GPS receiver.

[0042] The vehicle distance detecting apparatus 20 has an acceleration sensor 21, an A/D converter 22, a computing section 23, a threshold storage section 24, a comparing section 25, and an integrating section 26.

[0043] When acceleration acts, the acceleration sensor 21 outputs an acceleration signal  $a$ , which is an analog signal, conformed to the acting acceleration. The A/D converter 22 converts the acceleration signal  $a$ , as the analog signal, into an acceleration signal  $da$  which is a digital signal. As the acceleration signal  $a$  ( $da$ ), acceleration in the X-axis direction (direction of vehicle travel), acceleration in the Y-axis direction (right-and-left direction of the vehicle), and acceleration in the Z-axis direction (up-and-down direction) are outputted. Fig. 4 shows these types of acceleration collectively and generally as the acceleration signal  $a$ ,  $da$ .

[0044] The computing section 23 obtains the strength or intensity value of the acceleration signal  $da$ . Concretely, the computing section 23 sums the accelerations in the X-, Y- and Z-axis directions, calculates the average value of the acceleration signal  $da$ , and obtains the effective value of the acceleration signal  $da$ .

[0045] Fig. 5(a) shows the effective value (rms) of the acceleration  $da$  when the vehicle stops to bring the engine into an idling operation state. Fig. 5(b) shows the effective value (rms) of the acceleration  $da$  when the vehicle

is traveling.

In the idling operation state, the intensity value of the acceleration  $da$  representing the vibration intensity (e.g., the effective value (rms)) is low, as shown in Fig. 5(a). While the vehicle is traveling, the intensity value of the acceleration  $da$  representing the vibration intensity (e.g., the effective value (rms)) is high, as shown in Fig. 5(b), because engine vibration, vibration on the road surface, etc. are great.

[0046] Returning to Fig. 4, the integrating section 26 integrates the acceleration signal  $da$  to obtain a vehicle speed signal  $b$  indicating the vehicle speed, and outputs the vehicle speed signal  $b$ . The integrating section 26 also integrates the vehicle speed signal  $b$  to obtain a distance signal  $c$  indicating the distance traveled.

The thus obtained distance signal  $c$  is used to correct information on position detected by the GPS receiver.

The distance signal  $c$  is corrected so as not to increase in cumulative error, although details will be described later.

[0047] The threshold storage section 24 has in storage a threshold  $sh$ . The value of the threshold  $sh$  is set to be a value between the intensity value of the acceleration  $da$  during the idling state of the vehicle where the vehicle distance detecting apparatus 20 is installed and the intensity value of the acceleration  $da$  during the traveling state of the vehicle where the vehicle distance detecting apparatus 20 is installed.

[0048] The comparing section 25 compares the threshold  $sh$  stored in the threshold storage section 24 with the intensity

value of the acceleration signal  $da$  computed in the computing section 23.

Further, if the intensity value of the acceleration signal  $da$  is lower than the threshold  $sh$ , the comparing section 25 sends a speed reset signal  $R$  to the integrating section 26.

[0049] The integrating section 26 obtains the vehicle speed signal  $b$  and the distance signal  $c$  based on the acceleration signal  $da$ , as stated earlier. Upon receipt of the speed reset signal  $R$ , however, the integrating section 26 forcibly brings the value of the speed signal  $b$  to zero (resets the speed signal  $b$ ), no matter what value the speed signal  $b$  immediately before entry of the speed reset signal  $R$  has.

Thus, when the vehicle stops and the engine comes into an idling operation state, the speed reset signal  $R$  is continuously outputted. Consequently, during the idling operation (stoppage of the vehicle), the value of the speed signal  $b$  obtained in the integrating section 26 continues to be zero.

[0050] Furthermore, when the speed reset signal  $R$  has not been entered, the integrating section 26 integrates the vehicle speed signal  $b$ , which has been obtained by integrating the acceleration signal  $a$  ( $da$ ) ascribed to detection by the acceleration sensor 21, thereby obtaining the distance signal  $c$ .

Besides, when the speed reset signal  $R$  has been entered, the integrating section 26 integrates the vehicle speed signal  $b$ , whose value has been forced to become zero, thereby obtaining the distance signal  $c$ .

[0051] As described above, when the intensity value of the

acceleration signal  $da$  is lower than the threshold  $sh$ , a determination is made that the vehicle is at a standstill or stationary. Based on this determination, the vehicle speed signal  $b$  is forced into zero. By so doing, it becomes possible to prevent cumulative error from being superposed on the distance signal  $c$  with the passage of time.

As a result, the value of the distance signal  $c$  indicating the distance traveled becomes more accurate.

Embodiment 3

[0052] Next, a vehicle distance detecting apparatus 30 according to Embodiment 3 of the present invention will be described by reference to Fig. 6. This vehicle distance detecting apparatus 30 is provided, for example, in an on-vehicle machine equipped with a GPS receiver.

[0053] The vehicle distance detecting apparatus 30 has an acceleration sensor 31, an A/D converter 32, a computing section 33, a determining section 35, and an integrating section 36.

[0054] When acceleration acts, the acceleration sensor 31 outputs an acceleration signal  $a$ , which is an analog signal, conformed to the acting acceleration. The A/D converter 32 converts the acceleration signal  $a$ , as the analog signal, into an acceleration signal  $da$  which is a digital signal.

[0055] The computing section 33 is fed with a tachometer signal  $ta$  from a tachometer (not shown) provided in the vehicle.

The computing section 33 performs the FFT computation of the tachometer signal  $ta$ , or extracts the pulse interval of the tachometer signal  $ta$ , to obtain an engine speed  $Ne$ .

In further detail, the computing section 33 performs

the FFT computation to obtain a frequency component having the highest vibration intensity, and computes the engine speed  $N_e$  conformed to the frequency of the frequency component having the highest vibration intensity. That is, a computation is performed on the assumption that the higher the frequency of the frequency component having the highest vibration intensity is, the higher the engine speed  $N_e$  is.

Also, a computation is performed on the assumption that the shorter the pulse interval of the tachometer signal  $t_a$  is, the higher the engine speed  $N_e$  is.

[0056] The integrating section 36 integrates the acceleration signal  $d_a$  to obtain a vehicle speed signal  $b$  indicating the vehicle speed, and outputs the vehicle speed signal  $b$ . The integrating section 36 also integrates the vehicle speed signal  $b$  to obtain a distance signal  $c$  indicating the distance traveled.

The thus obtained distance signal  $c$  is used to correct information on position detected by the GPS receiver.

The distance signal  $c$  is corrected so as not to increase in cumulative error, although details will be described later.

[0057] The determining section 35 determines whether the engine speed  $N_e$  sent from the computing section 33 has become a preset idling speed. If the engine speed  $N_e$  is the idling speed, the determining section 35 sends a speed reset signal  $R$  to the integrating section 36.

[0058] The integrating section 36 obtains the vehicle speed signal  $b$  and the distance signal  $c$  based on the acceleration signal  $d_a$ , as stated earlier. Upon receipt of the speed reset signal  $R$ , however, the integrating section 36 forcibly

brings the value of the speed signal b to zero (resets the speed signal b), no matter what value the speed signal b immediately before entry of the speed reset signal R has.

Thus, when the vehicle stops and the engine comes into an idling operation state, the speed reset signal R is continuously outputted. Consequently, during the idling operation (stoppage of the vehicle), the value of the speed signal b obtained in the integrating section 36 continues to be zero.

[0059] Furthermore, when the speed reset signal R has not been entered, the integrating section 36 integrates the vehicle speed signal b, which has been obtained by integrating the acceleration signal a (da) ascribed to detection by the acceleration sensor 31, thereby obtaining the distance signal c.

Besides, when the speed reset signal R has been entered, the integrating section 36 integrates the vehicle speed signal b, whose value has been forced to become zero, thereby obtaining the distance signal c.

[0060] As described above, when the engine speed Ne is the idling speed, a determination is made that the vehicle is at a standstill or stationary. Based on this determination, the vehicle speed signal b is forced into zero. By so doing, it becomes possible to prevent cumulative error from being superposed on the distance signal c with the passage of time.

As a result, the value of the distance signal c indicating the distance traveled becomes more accurate.

#### Embodiment 4

[0061] Next, a vehicle distance detecting apparatus 40 according to Embodiment 4 of the present invention will be

described by reference to Fig. 7. This vehicle distance detecting apparatus 40 is provided, for example, in an on-vehicle machine equipped with a GPS receiver.

[0062] The vehicle distance detecting apparatus 40 has an acceleration sensor 41, an A/D converter 42, a determining section 45, and an integrating section 46.

[0063] When acceleration acts, the acceleration sensor 41 outputs an acceleration signal a, which is an analog signal, conformed to the acting acceleration. The A/D converter 42 converts the acceleration signal a, as the analog signal, into an acceleration signal da which is a digital signal.

[0064] The integrating section 46 integrates the acceleration signal da to obtain a vehicle speed signal b indicating the vehicle speed, and outputs the vehicle speed signal b. The integrating section 46 also integrates the vehicle speed signal b to obtain a distance signal c indicating the distance traveled.

The thus obtained distance signal c is used to correct information on position detected by the GPS receiver.

The distance signal c is corrected so as not to increase in cumulative error, although details will be described later.

[0065] The determining section 45 is connected to a parking brake detecting sensor (not shown) and, when the brake is kept on by a parking brake, a parking brake signal sb is inputted from the parking brake detecting sensor.

Upon receipt of the parking brake signal sb, the determining section 45 sends a speed reset signal R to the integrating section 36.

When the vehicle is at a standstill or stationary,

the brake is applied by the parking brake, whereby the parking brake signal sb is entered. Thus, it can be determined that the vehicle is stationary.

[0066] The integrating section 46 obtains the vehicle speed signal b and the distance signal c based on the acceleration signal da, as stated earlier. Upon receipt of the speed reset signal R, however, the integrating section 46 forcibly brings the value of the speed signal b to zero (resets the speed signal b), no matter what value the speed signal b immediately before entry of the speed reset signal R has.

Thus, when the vehicle stops and the engine comes into an idling operation state, the speed reset signal R is continuously outputted. Consequently, during the idling operation (stoppage of the vehicle), the value of the speed signal b obtained in the integrating section 46 continues to be zero.

[0067] Furthermore, when the speed reset signal R has not been entered, the integrating section 46 integrates the vehicle speed signal b, which has been obtained by integrating the acceleration signal a (da) ascribed to detection by the acceleration sensor 41, thereby obtaining the distance signal c.

Besides, when the speed reset signal R has been entered, the integrating section 46 integrates the vehicle speed signal b, whose value has been forced to become zero, thereby obtaining the distance signal c.

[0068] As described above, when the parking brake is kept on, a determination is made that the vehicle is at a standstill or stationary. Based on this determination, the vehicle speed signal b is forced into zero. By so doing, it becomes

possible to prevent cumulative error from being superposed on the distance signal c with the passage of time.

As a result, the value of the distance signal c indicating the distance traveled becomes more accurate.

Embodiment 5

[0069] Next, a vehicle distance detecting apparatus 50 according to Embodiment 5 of the present invention will be described by reference to Fig. 8. This vehicle distance detecting apparatus 50 is provided, for example, in an on-vehicle machine equipped with a GPS receiver.

[0070] The vehicle distance detecting apparatus 50 is suitable when installed on a manual transmission car or vehicle which has a manual transmission and in which a driver shifts gears.

[0071] The manual transmission vehicle can run freely even when the clutch is disengaged or even when the gears are in a neutral state, but the engine is at idle. If, at this time, the vehicle is judged to be at a standstill or stationary simply because the engine is idling, an erroneous determination is made that the engine is at a standstill, although it is not in a stationary state.

[0072] In the manual transmission vehicle, moreover, the engine speed can be increased by revving up the engine at idle during stoppage of the vehicle. At this time, the number of vibrations at a high engine speed is larger than the number of vibrations at idle. If the vehicle is judged to be traveling simply because of this, an erroneous determination is made that the vehicle is traveling, although it is not in a traveling state.

[0073] The vehicle distance detecting apparatus 50 of the

present embodiment has been developed to prevent the above-mentioned erroneous determinations in the manual transmission vehicle.

[0074] As shown in Fig. 8, the vehicle distance detecting apparatus 50 has an acceleration sensor 51, an A/D converter 52, a computing section 53, an idling frequency storage section 54a, a threshold storage section 54b, a stoppage determining section 55, and an integrating section 56.

[0075] When acceleration acts, the acceleration sensor 51 outputs an acceleration signal a, which is an analog signal, conformed to the acting acceleration. The A/D converter 52 converts the acceleration signal a, as the analog signal, into an acceleration signal da which is a digital signal. As the acceleration signal a (da), acceleration in the X-axis direction (traveling direction of the vehicle), acceleration in the Y-axis direction (right-and-left direction of the vehicle), and acceleration in the Z-axis direction (up-and-down direction) are outputted. Fig. 8 shows these types of acceleration collectively and generally as the acceleration signal a, da.

[0076] The computing section 53 performs two types of computation.

[0077] As the first computation, the computing section 53 performs the fast Fourier transform (FFT) computation of the acceleration signal da. By performing the FFT computation, it can be determined what amounts of what frequency components are contained in the acceleration signal da. The results of this determination are sent to the idling frequency storage section 54a and the stoppage determining section 55.

In the idling operation state, the vibration intensity of the frequency component of an idling frequency (e.g., 10 Hz) predetermined according to the vehicle is the largest. While the vehicle is traveling, the vibration intensity of the frequency component of a traveling frequency (e.g., 42 Hz) predetermined according to the vehicle is the largest.

[0078] In the second computation, the computing section 53 obtains the strength or intensity value of the acceleration signal  $da$ . Concretely, the computing section 53 sums the accelerations in the X-, Y- and Z-axis directions, calculates the average value of the acceleration signal  $da$ , and obtains the effective value of the acceleration signal  $da$ . The intensity value of the acceleration signal  $da$  is sent to the threshold storage section 54b and the stoppage determining section 55.

In the idling operation state, the intensity value of the acceleration  $da$  representing the vibration intensity (e.g., the effective value (rms)) is low. While the vehicle is traveling, the intensity value of the acceleration  $da$  representing the vibration intensity (e.g., the effective value (rms)) is high, because engine vibration, vibration on the road surface, etc. are great.

[0079] The integrating section 56 integrates the acceleration signal  $da$  to obtain a vehicle speed signal  $b$  indicating the vehicle speed, and outputs the vehicle speed signal  $b$ . The integrating section 56 also integrates the vehicle speed signal  $b$  to obtain a distance signal  $c$  indicating the distance traveled.

The thus obtained distance signal  $c$  is used to correct

information on position detected by the GPS receiver.

The distance signal  $c$  is corrected so as not to increase in cumulative error, although details will be described later.

[0080] The idling frequency storage section 54a has in storage an idling frequency (e.g., 10 Hz) predetermined according to the vehicle where the vehicle distance detecting apparatus 50 is installed.

[0081] The threshold storage section 54b has in storage a threshold  $sh$ . The value of the threshold  $sh$  is set to be a value between the intensity value of the acceleration  $da$  during the idling state of the vehicle where the vehicle distance detecting apparatus 50 is installed and the intensity value of the acceleration  $da$  during the traveling state of the vehicle where the vehicle distance detecting apparatus 50 is installed.

[0082] The stoppage determining section 55 takes in the idling frequency stored in the idling frequency storage section 54a, and the results of the FFT computation done in the computing section 53 to determine a frequency having the largest signal component amount (vibration intensity) of the respective frequencies found by the FFT computation, namely, the frequency whose vibration intensity peaks.

Further, the stoppage determining section 55 determines whether the frequency with which the vibration intensity peaks is the aforementioned idling frequency.

[0083] The stoppage determining section 55 also compares the threshold  $sh$  stored in the threshold storage section 54b with the intensity value of the acceleration signal  $da$  computed in the computing section 53.

Further, the computing section 55 determines whether the intensity value of the acceleration signal  $da$  is lower than the threshold  $sh$ .

[0084] Then, the stoppage determining section 55 makes stoppage determinations as shown in Fig. 9.

That is, the stoppage determining section 55 makes the following determinations:

(i) If "the frequency with which the vibration intensity peaks is the idling frequency", and if "the intensity value of the acceleration signal  $da$  is higher than the threshold  $sh$ ," a determination of a travel with the clutch being disengaged or the gears being in the neutral position is made.

(ii) If "the frequency with which the vibration intensity peaks is the idling frequency", and if "the intensity value of the acceleration signal  $da$  is lower than the threshold  $sh$ ," a determination is made that the vehicle is at a standstill or stationary.

(iii) If "the frequency with which the vibration intensity peaks is higher than the idling frequency", and if "the intensity value of the acceleration signal  $da$  is higher than the threshold  $sh$ ," a determination is made that the vehicle is traveling.

(iv) If "the frequency with which the vibration intensity peaks is higher than the idling frequency", and if "the intensity value of the acceleration signal  $da$  is lower than the threshold  $sh$ ," a determination is made that the vehicle is at a standstill or stationary and the engine is revved up in idle.

[0085] The stoppage determining section 55 sends a speed

reset signal R to the integrating section 56

when it makes the determination as in (ii) that the vehicle is at a standstill or stationary, since "the frequency with which the vibration intensity peaks is the idling frequency", and "the intensity value of the acceleration signal  $da$  is lower than the threshold  $sh$ ", and

when it makes the determination as in (iv) that the vehicle is at a standstill or stationary, and the engine is revved up in idle, since "the frequency with which the vibration intensity peaks is higher than the idling frequency", and "the intensity value of the acceleration signal  $da$  is lower than the threshold  $sh$ ".

[0086] The integrating section 56 obtains the vehicle speed signal  $b$  and the distance signal  $c$  based on the acceleration signal  $da$ , as stated earlier. Upon receipt of the speed reset signal  $R$ , however, the integrating section 56 forcibly brings the value of the speed signal  $b$  to zero (resets the speed signal  $b$ ), no matter what value the speed signal  $b$  immediately before entry of the speed reset signal  $R$  has.

Thus, when it is determined based on the above determination (ii) or (iv) that the vehicle is at a standstill or stationary, the speed reset signal  $R$  is continuously outputted. Consequently, during the stoppage of the vehicle, the value of the speed signal  $b$  obtained in the integrating section 56 continues to be zero.

[0087] Furthermore, when the speed reset signal  $R$  has not been entered, the integrating section 56 integrates the vehicle speed signal  $b$ , which has been obtained by integrating the acceleration signal  $a$  ( $da$ ) ascribed to detection by the acceleration sensor 51, thereby obtaining

the distance signal c.

Besides, when the speed reset signal R has been entered, the integrating section 56 integrates the vehicle speed signal b, whose value has been forced to become zero, thereby obtaining the distance signal c.

[0088] As described above, when it is determined based on the above determination (ii) or (iv) that the vehicle is at a standstill or stationary, the vehicle speed signal b is forced into zero. By so doing, it becomes possible to prevent cumulative error from being superposed on the distance signal c with the passage of time.

As a result, the value of the distance signal c indicating the distance traveled becomes more accurate.

Furthermore, the determination (ii) or (iv) is made, whereby if the engine speed is the idling frequency, and vibrations due to travel are small, it is determined that the vehicle is at a standstill or stationary. Thus, the stationary state of the vehicle, even if it has a manual transmission, can be determined accurately.

## Claims

[1] A vehicle distance detecting apparatus installed on a vehicle, comprising:

an acceleration sensor for outputting an acceleration signal conformed to acceleration;

stoppage determining means for determining, based on the acceleration signal, whether the vehicle is stationary; and

an integrating section which has a function of integrating the acceleration signal to obtain a speed signal, and integrating the speed signal to obtain a distance signal indicating a distance traveled, followed by outputting the distance signal, and which, when the stoppage determining means has not determined that the vehicle is stationary, integrates the speed signal obtained by integrating the acceleration signal, to obtain the distance signal, or when the stoppage determining means has determined that the vehicle is stationary, forcibly brings a value of the speed signal to zero, and integrates the speed signal whose value has become zero, to obtain the distance signal.

[2] A vehicle distance detecting apparatus installed on a vehicle, comprising:

an acceleration sensor for outputting an acceleration signal conformed to acceleration;

a computing section for determining what amounts of respective frequency components are contained in the acceleration signal;

an idling frequency storage section storing an idling

frequency determined beforehand according to the vehicle having the vehicle distance detecting apparatus installed thereon;

a determining section which outputs a speed reset signal if a frequency component having a largest vibration intensity of the respective frequency components found by computation in the computing section is the idling frequency stored in the idling frequency storage section; and

an integrating section which has a function of integrating the acceleration signal to obtain a speed signal, and integrating the speed signal to obtain a distance signal indicating a distance traveled, followed by outputting the distance signal, and which, when the speed reset signal has not been outputted from the determining section, integrates the speed signal obtained by integrating the acceleration signal, to obtain the distance signal, or when the speed reset signal has been outputted from the determining section, forcibly brings a value of the speed signal to zero, and integrates the speed signal whose value has become zero, to obtain the distance signal.

[3] A vehicle distance detecting apparatus installed on a vehicle, comprising:

an acceleration sensor for outputting an acceleration signal conformed to acceleration;

a computing section for obtaining a strength of the acceleration signal;

a threshold storage section storing a threshold having a value determined beforehand according to the vehicle having the vehicle distance detecting apparatus installed

thereon;

a comparing section which outputs a speed reset signal if the strength of the acceleration signal obtained by the computing section is lower than the threshold stored in the threshold storage section; and

an integrating section which has a function of integrating the acceleration signal to obtain a speed signal, and integrating the speed signal to obtain a distance signal indicating a distance traveled, followed by outputting the distance signal, and which, when the speed reset signal has not been outputted from the comparing section, integrates the speed signal obtained by integrating the acceleration signal, to obtain the distance signal, or when the speed reset signal has been outputted from the comparing section, forcibly brings a value of the speed signal to zero, and integrates the speed signal whose value has become zero, to obtain the distance signal.

[4] A vehicle distance detecting apparatus installed on a vehicle, comprising:

an acceleration sensor for outputting an acceleration signal conformed to acceleration;

a computing section for obtaining an engine speed based on a tachometer signal;

a determining section which outputs a speed reset signal if the engine speed has become a preset idling speed; and

an integrating section which has a function of integrating the acceleration signal to obtain a speed signal, and integrating the speed signal to obtain a distance signal

indicating a distance traveled, followed by outputting the distance signal, and which, when the speed reset signal has not been outputted from the determining section, integrates the speed signal obtained by integrating the acceleration signal, to obtain the distance signal, or when the speed reset signal has been outputted from the determining section, forcibly brings a value of the speed signal to zero, and integrates the speed signal whose value has become zero, to obtain the distance signal.

[5] A vehicle distance detecting apparatus installed on a vehicle, comprising:

an acceleration sensor for outputting an acceleration signal conformed to acceleration;

a determining section which outputs a speed reset signal if a parking brake is kept on; and

an integrating section which has a function of integrating the acceleration signal to obtain a speed signal, and integrating the speed signal to obtain a distance signal indicating a distance traveled, followed by outputting the distance signal, and which, when the speed reset signal has not been outputted from the determining section, integrates the speed signal obtained by integrating the acceleration signal, to obtain the distance signal, or when the speed reset signal has been outputted from the determining section, forcibly brings a value of the speed signal to zero, and integrates the speed signal whose value has become zero, to obtain the distance signal.

[6] A vehicle distance detecting apparatus installed

on a vehicle, comprising:

an acceleration sensor for outputting an acceleration signal conformed to acceleration;

a computing section for determining what amounts of respective frequency components are contained in the acceleration signal, and also obtaining a strength of the acceleration signal;

an idling frequency storage section storing an idling frequency determined beforehand according to the vehicle having the vehicle distance detecting apparatus installed thereon;

a threshold storage section storing a threshold having a value determined beforehand according to the vehicle having the vehicle distance detecting apparatus installed thereon;

a stoppage determining section which outputs a speed reset signal if a frequency component having a largest vibration intensity of the respective frequency components found by computation in the computing section is the idling frequency stored in the idling frequency storage section, and if the strength of the acceleration signal obtained by the computing section is lower than the threshold stored in the threshold storage section; and

an integrating section which has a function of integrating the acceleration signal to obtain a speed signal, and integrating the speed signal to obtain a distance signal indicating a distance traveled, followed by outputting the distance signal, and which, when the speed reset signal has not been outputted from the stoppage determining section, integrates the speed signal obtained by integrating the

acceleration signal, to obtain the distance signal, or when the speed reset signal has been outputted from the stoppage determining section, forcibly brings a value of the speed signal to zero, and integrates the speed signal whose value has become zero, to obtain the distance signal.