

AUTOMATIC STEERING DEVICE FOR A HEAVY-DUTY VEHICLE

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to an automatic steering device for a heavy-duty vehicle. More particularly, this invention relates to an automatic steering device for a crane.

(2) Description of the Related Art

Heretofore, various types of devices have been known for steering heavy-duty vehicles such as transfer cranes. For example, transfer cranes which are conveyed by conventional rubber tires have employed inductive wires for the operation of a steering device for the crane as well as for controlling the traveling direction of the crane. However, one disadvantage of such a system is that there is an initial construction cost for the installation of the inductive wires. Further, should the inductive wire be cut at some point, it has been very difficult to locate the place where the cut is made in order to carry out a repair. Furthermore, the repair cost for repairing a damaged system can be relatively high, as compared with the inductive wires type.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide an automatic steering device for a heavy-duty vehicle capable of controlling the traveling direction of the vehicle while facilitating repair and installation.

It is another object of the invention to provide a simplified automatic steering device for a heavy-duty vehicle.

It is further object of the invention to reduce the cost of installing an automatic steering device on a heavy-duty vehicle.

It is still another object of the invention to simplify a repair task for a damaged steering device for a heavy-duty vehicle.

Briefly, the invention relates to an automatic steering device for a heavy-duty vehicle such as a traveling crane. In accordance with the invention, the steering device includes a traveling distance measuring device for measuring the travelled distance of the vehicle and for converting the measured distance into an electrical pulse signal which is outputted from the device. In addition, the steering device includes an angle measuring device for measuring an error angle produced between a predetermined traveling direction and an actual traveling direction of the vehicle. This device also converts a measured error angle into an electrical signal which is outputted from the device.

Still further, the steering device includes a deviation calculator having respective input terminals connected to the respective measuring devices to receive each respective signal and to calculate and output a deviation signal corresponding to an off-center distance of the vehicle from the predetermined traveling direction. A controller is also connected with the deviation calculator to receive the deviation signal and to output first and second signals in response thereto in order to reduce the off-center distance of the vehicle from the predetermined traveling direction to zero.

The first and second control signals have a difference of voltage therebetween according to the absolute value of the correction signal.

The steering device also has first and second motor drivers, each of which is connected with the controller to provide first and second driving signals in response to the first and second control signals received from the controller.

Each of first and second drivers is respectively connected to first and second motors which respond to the first and second driving signals in order to control the automatic steering device of the vehicle so as to direct the vehicle into the predetermined traveling direction.

The automatic steering device operates so that the deviation calculator is able to calculate the deviation signal in dependence upon the distance travelled and the angle of deviation from the desired or predetermined traveling direction. The deviation signal is thus a measure of the distance of offset from the predetermined direction. Should the error angle attain a positive value, the vehicle is directed to move towards one side of the predetermined traveling direction, for example, to be directed to move toward the opposite side of the predetermined traveling direction, for example to the left.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of an automatic steering device for a heavy-duty vehicle in accordance with a preferred embodiment of this invention.

FIG. 2 illustrates traces for traveling of the heavy-duty

vehicle in accordance with a preferred embodiment of this invention.

FIG. 3 schematically illustrates a side view of a heavy-duty vehicle having an automatic steering device in accordance with the invention.

FIG. 4 illustrates a principle of determining an initial position of a gyro device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 3, a heavy-duty vehicle, such as a transfer crane, is provided with an automatic steering device for maintaining the crane moving in a predetermined traveling direction. In this respect, the steering device is constructed so as to sense deviations of the traveling crane from a predetermined path or traveling direction and to make corrections in the steering arrangement (not shown) of the crane in order to bring the crane back into the traveling direction intended.

The reference numerals appearing in FIG. 3 designate the followings: a crane body 1; a right wheel of the crane 2; a traveling distance measuring device formed of traveling distance sensors 10; proximity sensors 11; an electric chamber including controlling devices related to the automatic steering device 12; a dynamics-transferring belt 15; a pulley 17; a rotating pivot 19; a motor for driving the right wheel M2; and a traveling direction of the crane D.

Referring now to FIG. 1, the automatic steering device comprises a traveling distance measuring device 10; an angle measuring device 20; a deviation calculator 30 having an input

terminal connected with each output terminal of the traveling distance measuring device 10 and the angle measuring device 20; a controller 40 having an input terminal connected with an output terminal of the deviation calculator 30; left and right motor drivers 50, 52 having an input terminal connected with an output terminal of the controller 40; and motors M_1 , M_2 having input terminals connected with each output terminal of the motor drivers 50, 52.

In a preferred embodiment of this invention, for example, a sensor under the designation "TFG-160 sonic gyro" made by the Tokimec company of Japan may be used as the angle measuring device 20, and a mechanical type, gas type or laser type gyro sensor may also be used.

The operation of the automatic steering device for the heavy-duty vehicle is described as follows.

When a crane is traveling, the non-uniformal motor driver characteristics and the load variation as well as unexperienced operator's skill may occasion the crane to travel off-center along the desired traveling direction for the crane.

The traveling distance measuring device 10, generally installed in the wheels of the transfer crane measures the traveling distance l_n of the transfer crane and converts the measured distance into an electric pulse signal which is then outputted to the deviation calculator 30. The angle measuring device 20 measures an error angle θ_n produced between the predetermined traveling direction axis of the transfer crane and converts the measured angle into an electric signal which is then

outputted to the deviation calculator 30.

The deviation calculator 30 samples data signals about the traveling distance l_n and error angle θ_n inputted from the traveling distance measuring device 10 and angle measuring device 20 at predetermined time intervals Δt , e.g. every 10msec and calculates an off-center distance δ_n from the input signals using the following expression.

$$\delta_n = \delta_{n-1} + l_n \sin \theta_n \quad \text{-----} \quad (1)$$

The error angle θ_n of the transfer crane, as shown in FIG. 2, attains positive values θ_1, θ_3 , if the crane travels to the left (as viewed) against the initially-predetermined traveling direction. On the contrary, the error angle θ_n of the transfer crane attains negative values θ_2 , if the crane travels to the right against the initially-predetermined traveling direction. In the same manner, the value of $(l_n \sin \theta_n)$ becomes positive, if the crane travels to the left against the initially-predetermined traveling direction, and becomes negative, if the crane travels to the right against the initially-predetermined traveling direction. In such a case, if the off-center distance of the transfer δ_n found through the above expression (1) attains a positive value, the transfer crane is on the left side against the central traveling direction. On the other hand, if the off-center distance attains a negative value, the transfer crane is on the right side against the central traveling direction.

The data signal about the off-center distance δ_n of the transfer crane found by the deviation calculator 30 is outputted to the controller 40, and the controller 40 controls the motor

drivers 50, 52 so that the transfer crane can travel in the direction opposite to the sign of the off-center distance δ_n , in order to reduce the value of the off-center distance to zero.

In the meantime, this invention adopts a steering technique that controls the traveling direction by setting the rotating speed of the left and right wheels 2 to be different from each other's. Accordingly, if the off-center distance attains a positive value, the controller 40 controls the left and right motor drivers 50, 52, so that the motor M_1 for driving the left wheel contacting the left motor driver 50 can rotate relatively faster than the motor M_2 for driving the right wheel contacting the right motor 52. As a result, the transfer crane travels to the right. On the other hand, if the off-center distance attains a negative value, the controller 40 controls the left and right motor drivers 50, 52, so that the motor M_1 for driving the left wheel contacting the left motor driver 50 can rotate relatively more slowly than the motor M_2 for driving the right wheel contacting the right motor 52.

Two output signals of the controller 40 that are outputted to the left and right motor drivers 50, 52 are controlled to have a voltage difference V between them in proportion to the absolute value of the off-center distance δ_n of the transfer crane, and the off-center distance δ_n of the transfer crane is thereby removed.

In order to remove the off-center distance δ_n of the transfer crane, the voltage difference V of the output signals outputted by the controller 40 to the motor drivers 50, 52 can

be found as follows:

$V = K_p \delta_n$: in the case of the controller 40 operating as a proportional controller

$V = K_v (\Delta \delta / \Delta t) + K_p \delta_n$: in the case of the controller 40 operating as a proportional differential controller

In the above expressions, $\Delta \delta = \delta_n - \delta_{n-1}$, K_p and K_v are proportional constant, respectively.

If the output signals having the above size are inputted to the motor driver 50, 52, the motor drivers 50, 52 drive both the motors M_1 , M_2 at different speed from each other, according to the input signal.

The rotating power of the motors M_1 , M_2 is transferred to the pulley 15 fixedly disposed on the rotating pivot 19 of the left and right wheels 2 via, e.g. the belt 15 or another mechanical means. As a result, the traveling direction of the transfer crane is controlled in accordance with the difference of the number of the rotation transmitted to the rotating pivot 19 of both the wheels.

The gyro device used as the angle measuring device 20 of FIG. 1 just functions measuring an angle, and in order that the crane automatically travels, it is necessary to reset a position of starting point, i.e. a position where the angle of the gyro device attains a value of zero.

FIG. 4 illustrates a principle of determining an initial position of the gyro device. The reference numerals appearing in FIG. 4 designate the followings: 9 a pair of magnets fixedly disposed at a starting point where the transfer crane travels;

and D a traveling direction of a crane.

In order to determine a position of starting point, when the two proximity sensors 11 of the crane body 1 are placed on the magnets 9 by moving the crane body 1, a signal is produced from the proximity sensors 11. Then, the position of the crane is considered exactly parallel to the traveling direction, and the angle of the gyro device is reset to be zero. Accordingly, the gyro device, i.e. the angle measuring device produces a curved angle against the traveling direction of the crane.

If the steering device operates after the position of starting point of the angle-device operates after the position of starting point of the angle-measuring device is determined, the traveling motor M comes to rotate. The rotating power is transferred to the left and right wheels 2 via the belt 15, whereby the crane travels.

Accordingly, the off-center distance of the traveling direction of the transfer crane is automatically controlled, and thus, the transfer crane can travel along the initially-predetermined traveling direction, without error.

As mentioned above, the present invention provides an automatic steering device for a heavy-duty vehicle which controls the crane traveling direction automatically and facilitates repair and installation.

It is to be noted that the automatic steering device may be used with any type of heavy-duty vehicle other than a transfer crane.

While this invention has been described in connection with

what is presently considered to be the most practical and preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but, on the contrary, it is intended to cover various modifications and equivalent arrangements included within the scope of the appended claims.



WHAT IS CLAIMED IS:

1. An automatic steering device for steering a heavy-duty vehicle by relatively controlling a rotating speed of two wheels, comprising:

a traveling distance measuring device for measuring a traveling distance of the vehicle, converting the measured distance into a first electrical pulse signal, and outputting said pulse signal;

an angle measuring device for measuring an error angle produced between a predetermined traveling direction and an actual traveling direction of the vehicle, converting the measured angle into a second electrical signal, and outputting said second signal;

a deviation calculator responsive to the first and second signals for outputting a deviation signal corresponding to an off-center distance of the vehicle from said predetermined traveling direction;

a controller responsive to the deviation signal for producing first and second control signals in order to reduce the off-center distance of the vehicle, said first and second control signals having a voltage difference in proportion to an absolute value of the off-center distance;

first and second motor drivers connected with said controller for producing first and second driving signals in response to said first and second control signals; and

first and second motors for driving each of said two wheels in response to said first and second driving signals.



2. An automatic steering device as set forth in claim 1, wherein said off-center distance is found by the following expression:

$$\delta_n = \delta_{n-1} + l_n \sin \theta_n,$$

where δ_{n-1} represents an N-1th off-center distance; l_n represents a traveling distance of a heavy-duty vehicle; and θ_n represents an error angle.

3. An automatic steering device as set forth in claim 2, wherein said error angle attains a positive value in response to travel of the vehicle to one side of said predetermined traveling direction, and attains a negative value in response to travel of the vehicle to an opposite side of said predetermined traveling direction.

4. An automatic steering device as set forth in claim 3, wherein said controller sets the traveling direction of the vehicle in the direction opposite to the sign of the off-center distance.

5. An automatic steering device as set forth in claim 4, wherein said controller produces said first and second control signals in order that said first control signal is larger than said second control signal, if said off-center distance has a positive value, and in order that said first control signal is smaller than said second control signal, if said off-center distance has a negative value.



6. An automatic steering device as set forth in claim 4, wherein said controller is a proportional controller.

7. An automatic steering device as set forth in claim 5, wherein said controller is a proportional differential controller.

8. An automatic steering device as set forth in claim 1, wherein said angle measuring device is a gyro sensor.

9. An automatic steering device as set forth in claim 1, further comprising a pair of proximity sensors disposed on the body of the vehicle for determining an initial position of the vehicle.

10. In combination

a transfer crane;

a steering device for maintaining said crane moving in a predetermined travelling direction, said device including:

a distance measuring device for measuring the travelled distance of said crane and outputting a corresponding first signal;

an angle measuring device for measuring an angle of deviation between an actual direction of travel of said crane and said predetermined travelling direction and outputting a corresponding second signal;

a deviation calculator connected to each said measuring device to receive said signals and to calculate and output a deviation signal corresponding to an off-



center distance of said crane from said predetermined travelling direction in dependence on said signals;

a controller connected to said calculator to receive said deviation signal and to output a first control signal and a second control signal in dependence thereon, the first and second control signals having a difference of voltage therebetween in accordance with an absolute size of said deviation signal; and

first and second motors connected to said controller to move said crane laterally of said predetermined direction in response to said first and second control signals.

11. The combination as set forth in claim 10 which further comprises first and second motor drivers connected to and between said controller and said first and second motors for producing first and second driving signals to said motors in response to said first and second control signals from said controller to drive said motors.

12. An automatic steering device for a heavy-duty vehicle substantially as hereinbefore described with reference to and as shown in the accompanying drawings.