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AUTOMATIC GUIDED VEHICLE

1 BACKGROUND OF THE INVENTION

This invention relates to an automatic guided vehicle having three wheels: one front wheel and a pair of rear wheels, the body of the vehicle being capable of travelling by driving the wheels.

An automatic guided vehicle of this kind has been known, which travels along a track formed on a floor by a white line or alminum foil while detecting this track by means of an optical track sensor. In this type of conventional vehicle having, for example, three wheels: one front wheel and a pair of rear wheels, the front wheel can be driven through a connection to a driving system and can be automatically steered by a steering system while the rear wheels are freely rotatable but incapable of being driven by any driving system being steered.

Another known example of the conventional automatic guided vehicle is a four-wheel vehicle having front and rear wheels the opposite sides of a center axis and having left and right wheels each of which is provided with a driving motor. In this example, all wheels are set in the forward direction and the left and right wheels are driven by the driving motors so as to perform the ordinary travelling operation of the vehicle.. The vehicle moves straight by equalizing the

81 1 speeds of rotation of the left and right wheels and
turns left or right by changing the speed ratio there-
between. At least direction of the front wheels among
the front and rear wheels can be freely changed so as to
5 follow the motion caused when the left and right wheels
are steered by changing the speed ratio therebetween.
If the front and rear wheels are rotated in the reverse
directions at the same rotational speed while the front
and rear wheels are being fixed such as to be perpen-
10 dicular to the direction of the front and rear of the
vehicle body, the body of the vehicle can be turned in
the direction indicated by the arrow about the point of
intersection of the lines which connect the front wheel
to the rear wheel and the left wheel to the right wheel.

15 However, the former type of conventional vehicle
having three wheels is designed to travel in the forward
direction alone while a track sensor provided on the
front wheel assembly is detecting the track, so that the
vehicle cannot turn and move out of the track. It is
20 therefore necessary for the minimum radius of curvature
of the track to be large enough to enable the front
wheel to be steered along the track. In order to enable
the vehicle to turn, it is necessary for the vehicle to
go out of the track and manually turned, or to provide
25 a looped track having the minimum radius of curvature.
A large additional space is thereby required. Moreover,
when there are provided a pair of parallel tracks, these
tracks must be connected to each other to ensure that

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the vehicle can move from one of these tracks to the other.

In the case of the latter type of vehicle having four wheels, it is necessary to synchronize left and right driving motors with each other or to adjust the speed ratios of these motors in relation to the steering operation. While this type of vehicle is capable of turning on the track, it can turn only about the point of intersection of the four wheels. Also it is not capable of laterally moving out of the track.

10 SUMMARY OF THE INVENTION

The present invention has been made in consideration of these problems, and an object of the present invention is to provide a three-wheel automatic guided vehicle capable of turning at terminal ends or desired points on a track with a minimum radius of curvature without the provision of any loop of the track and is capable of laterally travelling out of the track.

In accordance with one aspect of the invention, there is provided an automatically guidable vehicle for movement across a surface, which vehicle has a main body, including front and rear portions, and a longitudinal axis and which comprises:

a front wheel located at the front portion of the main body;
a pair of rear wheels located at the rear portion of the main body;

front and rear support members connected to the main body, the front wheel being rotatable within the front support member and the rear wheels being rotatable within respective rear support members about axes of rotation which extend substantially parallel to the surface, in use;

a steering shaft mounted on the front wheel support member;
steering drive means mounted on the main body and being connected operatively with the steering shaft for rotation of the front wheel about an axis perpendicular to the surface, in use;

steering state detecting means connected operatively with the main body for detecting movement of the steering shaft caused by said steering drive means;

a link mechanism connected operatively with said steering state detecting means;

travel drive means for driving the front and rear wheels across the surface, in use;

5 electromagnetic clutch means disposed between part of said travel drive means and each of the rear wheels; and

rear wheel angle setting means arranged to rotate and maintain each of the rear wheels about an axis perpendicular to the surface, in use, and being controllable by and connected operatively with
10 said steering drive means and said steering state detecting means through the link mechanism, the arrangement being such the vehicle can travel forward, laterally or turn, whereby, when turning, the front and rear wheels are positioned at angles to the longitudinal axes of the vehicle and said electromagnetic clutch means is
15 engaged, so that the driving force of said travel drive means is transmitted to the rear wheels, and, when travelling laterally, the front and rear wheels are positioned at an angle to the longitudinal axis of the vehicle and at least one of said
20 electromagnetic clutch means is engaged, so that the driving force of said travel drive means is transmitted to at least one of the rear wheels.

In accordance with another aspect of the invention, there is provided an automatically guidable vehicle for movement across a surface, which vehicle has a main body, including front
25 and rear portions, and a longitudinal axis and which comprises:

only one front wheel located at the front portion of the main body;

a pair of rear wheels located at the rear portion of the main body;

30 front and rear support members connected to the main body, the front wheel being rotatable within the front support member and the rear wheels being rotatable within respective rear support members about axes which are substantially parallel to the surface, in use;

a steering shaft mounted on the front wheel support member;

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steering drive means mounted on the main body and being connected operatively with the steering shaft for rotation of the front wheel about an axis perpendicular to the surface, in use;

steering state detecting means connected operatively with the
5 main body for detecting movement of the steering shaft caused by said steering drive means;

a link mechanism connected operatively to said steering state detecting means;

travel drive means for driving the front and rear wheels
10 across the surface, in use;

clutch means disposed between part of said travel drive means and each of the rear wheels; and
rear wheel angle setting means arranged to rotate and maintain each of the rear wheels about an axis perpendicular to the surface,
15 in use, and being controllable by and connected operatively with said steering drive means and said steering state detecting means via the link mechanism, the arrangement being such that the vehicle can travel forward, laterally or turn, whereby, when turning, the front and rear wheels are positioned at angles to the longitudinal
20 vehicle axis and said clutch means is engaged so that the driving force of said travel driving means is transmitted to the rear wheels and, when travelling laterally, the front and rear wheels are positioned at an angle to the longitudinal vehicle axis and at least one clutch of said clutch means is engaged so that the driving
25 force of said travel drive means is transmitted to at least one of the rear wheels.

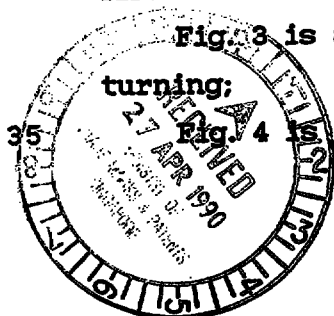
BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic plan view of a first embodiment of the
30 present invention;

Fig. 2 is a perspective view of the external appearance of the first embodiment;

Fig. 3 is an illustration of the first embodiment at the time of turning;

Fig. 4 is an illustration of the first





1 embodiment at the time of travelling in a lateral direction;

Fig. 5 is an illustration of another example of the turning operation of the first embodiment;

5 Fig. 6 is a schematic plan view of a second embodiment of the present invention;

Fig. 7 is an exploded perspective illustration of the general construction of the second embodiment;

Fig. 8 is an illustration of the external
10 appearance of the second embodiment;

Fig. 9 is a schematic plan view of the second embodiment;

Figs. 10a and 10b are enlarged illustration of the movement of an essential part of the second embodi-
15 ment;

Fig. 11 is a schematic plan view of the second embodiment at the time of spinning turn;

Fig. 12 is a schematic plan view of the second embodiment at the time of travelling in the lateral
20 direction;

Fig. 13 is an illustration of the movement of the second embodiment at the time of spinning turn;

Fig. 14 is an illustration of the movement of the second embodiment at the time of travelling in a
25 lateral direction;

Figs. 15a and 15b are schematic illustrations of a third embodiment of the present invention; and

Figs. 16a and 16b are schematic illustrations

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(28)

1 of the third embodiment at the time of spinning turn and travelling in a lateral direction.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An automatic vehicle which represents an embodi-
5 ment of the present invention will be described below with reference to the accompanying drawings.

A main body 1 of a vehicle having three wheels, that is, a front wheel 2 and a pair of rear wheels 3 and 4 is provided with a chassis 5 and a cover
10 6 which covers the outer surface of the main body. The front wheel 2 is adapted to be driven by a driving motor 7. A timing pulley 9 integral with a wheel bracket 8 of the front wheel 2 is driven by a steering motor 10 via a timing belt 11, to steer the front wheel 2. The wheel
15 bracket 8 has an optical type track sensor 13 for detecting a track 12 formed on a floor by a white line or aluminum foil. The front wheel 2 is steered while the steering motor 10 is being driven in accordance with the detection of the track 12 effected by the track sensor
20 13.

The rear wheels 3 and 4 are provided with driving motors 7a and 7b, and are driven in a manner similar to that with the front wheel 2 such that timing pulleys 9a and 9b integral with wheel brackets 8a and
25 8b are driven by steering motors 10a and 10b via timing belts 11a and 11b. At the time of normal travelling, as shown in Fig. 1, the steering motors 7a and 7b for



1 the rear wheels 3 and 4 are not driven and are maintained
to be disconnected therefrom by means of clutches or the
like which are disposed between the rear wheels 3 and 4.
Therefore, in this state, the rear wheels 3 and 4 can
5 freely rotate. Also, in the normally travelling state,
the steering motors 10a and 10b are not driven, and the
rear wheels 3 and 4 are locked in the forward direction.

Figs. 1 and 2 show the normally travelling
state of the vehicle thus constituted, in which the
10 vehicle travels along the track 12 in the forward
direction while detecting the track 12 by means of the
track sensor 13. When the front wheel 2 is steered
along the curved portion of the track 12, the rear wheels
3 and 4 can follow the front wheel 2 along the curved
15 portion since they are disconnected from the driving
motors 7a and 7b to be free.

The manner in which the vehicle turns at a
desired point on the track 12 will be described with
reference to Fig. 3. Fig. 3 shows the vehicle when the
20 same turns as indicated by the imaginary line from the
state indicated by the solid line in which the vehicle
is ready to turn after it has stopped at a desired point
of the track 12. That is, for the preparation of
turning movement from the state shown in Fig. 1, the
25 front wheel 2 is first turned and positioned by the
actuation of the steering motor 10 to be directed per-
pendicularly to a center line L corresponding to the
direction of the front and the rear of the main body 1

1 of the automatic vehicle 1. At the same time, the rear
wheels 3 and 4 are turned by the same angle θ in the
opposite directions by the actuation of the motors 10a
and 10b so that the rear wheels 3 and 4 are respectively
5 directed slantwise and symmetrically relative to the
forward direction. If a point of intersection of lines
La and Lb which perpendicularly pass through the rear
wheels 3 and 4 at the centers thereof meets the center
line of the main body 1 at point O, the respective
10 distances between the point O and the centers of the
rear wheels 3 and 4 are equal to each other. Where this
distance is r and the distance between the point O and
the center of the front wheel 2 is R and if the rotational
speed of the front wheel is N and that of the rear wheels
15 3 and 4 is n, the speed ratio may be set to satisfy the
relationship with the distances R and r:

$$N = \frac{R}{r} n \quad \dots (1)$$

so that, when the driving motors 7 and 7a or 7b are
simultaneously driven, the front wheel 2 and the rear
wheels 3 and 4 can respectively be rotated with the
20 radii of gyration R and r about the center corresponding
to the point O. The speed ratio between the front and
rear wheels may be set on the basis of the rotational
speeds of the driving motors 7, 7a and 7b or on the
basis of those at the transmission members such as gears
25 provided between the driving motors 7, 7a and 7b and

1 the wheels 2, 3 and 4. When the vehicle is to turn in
the direction indicated by the arrow a in Fig. 3, the
rear wheel 4 is driven by the motor 7b while the rear
wheel 3 being kept free. It is stopped after slightly
5 overshooting the position in which the track sensor 13
again detects the track 12 immediately before the main
body 1 rotates through approximately 180° in the direc-
tion a. The position at which the rear wheel is stopped
in this manner is indicated by the imaginary line in Fig.
10 3. The distance between this position and the point
at which the track sensor 13 detects the track 12 is
determined by obtaining the turning angle of the front
wheel 2 from a given distance H between the track sensor
13 and the center of the front wheel 2.

15 If the direction of the front wheel 2 perpen-
dicular to the center line of the main body is reversed,
the main body 1 can be turned in the direction b, as
viewed in Fig. 3. In this case, the rear wheel 3 is
driven by the motor 7a while the rear wheel 4 is kept
20 free.

Fig. 4 shows another example of the application
of this embodiment in which the rear wheels 3 and 4 are
driven by the steering motors 10a and 10b to set the
angle θ at 90° in the same manner as that described above
25 in relation to Fig. 3. This state means that the radii
R and r are infinite. Therefore the turning operation of
the main body 1 is substantially impossible. However,
in this state, the front wheel 2 and the rear wheels 3

1 are parallel with each other, and the main body 1 can be
laterally travel in the direction indicated by the
arrow c when the front wheel 2 and the rear wheel 3 are
being driven at the same rotational speed. Accordingly,
5 it can be moved, for example, from a track 12a to a
track 12b, and it is stopped in this case in accordance
with the detection of the track 13b effected by the track
sensor 13, in the same manner as that described above.

Fig. 5 shows still another example of the
10 application in which the distance R is set to be larger
than the distance r and the point O is displaced toward
the rear wheels 3 and 4. In this case also, the speed
ratio between the front wheel 2 and the rear wheels 3 and
4 is set so as to satisfy the equation (1), thereby
15 enabling the vehicle to be turned about the point O .

It is possible to equalize the rotational
speeds of the front wheel 2 and the rear wheels 3 and 4
by setting the turning angle θ of the rear wheels 3 and
4 in a manner to equalize the distances R and r . With
20 respect to the setting of the point O , if the center of
the front wheel 2 and the rear wheels 3 and 4 is shifted
from the center of the main body 1 of the automatic
vehicle, it is possible to minimize the radius of gyration
of the main body 1 when turned by setting the point O to
25 correspond to the center of the main body 1.

If the turning angle θ of the rear wheels 3
and 4 is set so as to position the point O forwardly of
the front wheel 2, the vehicle body 1 is turned with a

(31) 1 large radius of gyration while satisfying the speed ratio condition represented by the equation (1) and selecting and driving one of the rear wheels 3 and 4 which is directed in the same direction as that of the front wheel 2.

5 This is not a practical manner of turning the vehicle, and the most extreme example of this state is shown in Fig. 4 wherein the distances R and r are infinite and θ is 90° .

Fig. 6 shows another embodiment of the present invention in which the steering motors 10a and 10b for the rear wheels 3 and 4 are omitted. In this embodiment, a sprocket 15 is provided integral on the timing pulley 9 for the front wheel 2 with an electromagnetic clutch 14 interposed therebetween, and sprockets 15a and 15b are also provided integral on the timing pulleys 9a and 9b for the rear wheels 3 and 4 with electromagnetic clutches 14a and 14b interposed therebetween. These sprockets 15, 15a and 15b are interconnected by a chain 16, and a sprocket 17 is provided to reverse the directions of rotation of the sprocket 15a and the sprocket 15b. While in this arrangement the electromagnetic clutches 14, 14a and 14b are positioned in connection, the steering force of the motor 10 for the front wheel 2 is transmitted to the timing pulleys 9a and 9b via the timing pulley 9, the electromagnetic clutch 14, the sprocket 15 the chain 16, the sprockets 15a and 15b and the electromagnetic clutches 14a and 14b. At this time, the pulleys 9a and 9b are rotated in the reverse directions by the means of

1 the sprocket 17. Therefore, the rear wheels 3 and 4 are
turned to be divergent forwardly of the main body 1 in
the same manner as in the above-described case. In this
case, the rotational speeds of the sprockets 15a and 15b
5 suffice to be equalized to that of the sprocket 15 so
that the timing pulleys 9a and 9b for the rear wheels 3
and 4 are turned by 90° in response to the turning move-
ment of the front wheel 2 toward the lateral direction,
namely, the turning movement of the timing pulley 9 of
10 90° . Also, the speed ratio of the sprockets may be
changed to reduce the turning angle of the rear wheels 3
and 4 and therefore set suitably the above-described
turning angle θ . Each pair of the electromagnetic
clutches 14, 14a and 14b and the sprockets 15, 15a and 15b
15 may be replaced with two pairs having different speed
ratios so that it is possible to select one of two
different turning angles θ of the rear wheels 3 and 4
by connecting one of the electromagnetic clutches in each
combination of two pairs. That is, the rear wheels are
20 designed to be turned by utilizing the steering drive
force of the front wheel 2 while taking into account of
the fact that the direction of the front wheel 2 is set
to be perpendicular to that of the main body during both
operations of turning movement and lateral movement of
25 the vehicle.

During the normal travelling operation of the
vehicle thus constituted, the electromagnetic clutches
14, 14a and 14b are in the released state so that the

32 1 turning force generated when the front wheel 2 travels is
not transmitted to the rear wheels 3 and 4. When the
vehicle turns or laterally travels, the electromagnetic
clutches 14, 14a and 14b are actuated so that the rear
5 wheels 3 and 4 are turned by a predetermined angle θ in
response to the turning movement of the front wheel 2 in
the lateral direction. During the turning movement or
the lateral travelling of the vehicle, the driving motor
7 for the front wheel 2 and selected one of the driving
10 motors 7a and 7b for the rear wheels 3 and 4 (depending
upon the direction of the turning movement or the lateral
travelling) are driven to cause turning or lateral
travelling of the vehicle while the front wheel 2 is main-
tained in a direction perpendicular to the longitudinal
15 axis of the vehicle and the rear wheels 3 and 4 are main-
tained at an angle θ relative to the longitudinal axis
of the vehicle.

Fig. 7 shows an exploded perspective view of
the general construction of an automatic vehicle according
20 to a second embodiment of the present invention; Fig. 8
shows an illustration of the external appearance of this
vehicle; and Fig. 9 shows a schematic plan view of this
vehicle at the time of normal travelling. The automatic
guided vehicle of this embodiment travels along a track
25 A formed on a floor by a white line or aluminum foil,
and comprises a front wheel 101, a pair or rear wheels
102 and 103, and a main body B which includes a chassis
104 and a cover 105. On a wheel bracket 106 of the front

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1 wheel 101 are mounted a motor 107 for driving the front
wheel 101, a gear box 108 of the motor 107, a steering
shaft 109, a timing pulley 110 and steering cam 111
provided integral on the steering shaft 109, an optical
5 type track sensor 112, and so forth. A drive shaft 113
to which the driving force of the driving motor 107 is
transmitted via the gear box 108 extends through the
steering shaft 109 and is connected to a sprocket 116 by
an electromagnetic clutch 115 which is mounted on the
10 bracket 114.

The timing pulley 110 is normally operated and
rotated via a timing belt 120 by a pulley 119 which is
driven by a steering motor 118 mounted on a metal support
member 117. These members constitute a steering drive
15 assembly. The steering motor 118 is normally driven in
accordance with a steering command issued upon the detec-
tion of the track A on the floor by the track sensor 112,
and the timing pulley 110 is correspondingly rotated to
control, via the wheel bracket 106, the direction of the
20 steering of the front wheel 101 and simultaneously rotate
the steering cam 111.

The assemblies including the rear wheels 102
and 103 are constructed as described below. Some parts
of the assembly of the rear wheel 102 are illustrated as
25 if they are transparent to show the internal construction.
The rear wheels 102 and 103 are respectively supported
by wheel brackets 121 and have steering shafts 122
formed integral with the wheel brackets 121, and slide

(351) arms 123 and 124 mounted therewith. Drive shafts 125 extend through the steering shafts 122, and have the upper portions thereof connected to sprockets 129 and 130 by electromagnetic clutches 127 and 128 which are mounted on brackets 126, and the lower portions thereof arranged such that gears 133 mounted on the rear wheels 102 and 103 are driven via bevel gears 131 and pinion gears 132. The sprockets 129 and 130 are connected to the sprockets 116 via a roller chain 134, so that the torque of the driving motor 107 is transmitted when the electromagnetic clutch 115 is connected. A chain tensioner 135 for tensioning the roller chain 134 has an arm 137 with a sprocket 136, and a spring 138 which is adapted to maintain a constant tension of the roller chain 134.

A swing plate 139 acts to detect the state of the steering operation in response to the rotation of the steering cam 111, and is provided at its top end with a cam follower 140 which follows in contact with the peripheral surface of the cam 111. The swing plate 139 rotatably supports a clutch plate member 141 which is coaxial with the center of rotation of the swing plate 139 and which is provided integral with an arm 142. An engaging click member 144 which is rotated by a plunger 143 is provided on the clutch plate member 141 to be engageable with a stop piece 145 on the swing plate 139, and an engaging click member 147 which is rotated by a plunger 146 is disposed to be engageable with a stop

1 piece 148. The range of the turning angle of the arm
142 corresponding to the turning angle of the swing plate
139 is determined depending upon which one of these pairs
of engaging members are engaged with each other. The
5 swinging operation of the arm 142 will be described below
with reference to Figs. 10a and 10b which show this
relationship. As the steering cam 111 rotates in the
direction indicated by the arrow (clockwise direction),
the swing plate 139 is correspondingly turned by an angle
10 θ about its rotational axis 139a to a position where one
engaging end 111a of the engaging ends of the cam 111 is
engaged with the cam follower 140 after the cam 111 has
rotated for 90° (that is, the position where the front
wheel 101 is turned to the right to be perpendicular to
15 the main body). In the state shown in Fig. 10a, the
turning angle α_1 of the arm 142 relative to the turning
angle θ of the swing plate 139 is represented by $\alpha_1 =$
 $\theta - \theta_1$, because there is a play angle θ_1 between the tip
of the engaging click member 144 and the stop piece 145.
20 On the other hand, in the state shown in Fig. 10b,
there is no play between the tip of the engaging click
member 147 and the stop piece 148, so that the turning
angle α_2 of the arm 142 is represented by $\alpha_2 = \theta$. There-
fore, it is possible to select one of the turning angles
25 α_1 and α_2 of the arm 142 by preliminarily selecting one
of the plungers 143 and 146 to operate the engaging
click member 144 or 147 before the cam 111 rotates.

37 1 If both the plungers 142 and 146 are not selected upon
rotation of the cam 111 and there is no engagement
between the engaging click members 144 and 147 and
the stop pieces 145 and 148, the arm 142 is not turned
5 by the rotation of the cam 111. If steering is
effected leftward, the cam 111 rotates in the direction
(anti-clockwise direction) reverse to that indicated
by the arrow and the other engaging end 111b of the cam
111 is engaged with the cam follower 140 when the front
10 wheel 101 is positioned to be directed to the left and
perpendicular to the main body. In this case also, the
swing plate 139 and other related members are moved in
the same manner as described above.

A rod 149 is rotatably connected to the top
15 end portion 150 of the arm 142, and the other end 151
of the rod 149 is connected to the intermediate portion
of an contact arm 152. The contact arm 152 has at its
one end a shaft 153 which is slidably fitted into a
slot 154 formed in the slide arm 123 securedly mounted
20 on the steering shaft 122 of the rear wheel 102. The
contact arm 152 has its other end a gear 155 which is not
rotatable relative to the contact arm 152. The gear 155
is engaged with a gear 157 which is non-rotatably mounted
at one end of another contact arm 156. The contact arm
25 156 has its other end a shaft 158 which is slidably fitted
into a slot 159 formed in the slide arm 124 securedly
mounted on the steering shaft 122 of the rear wheel 103.

With the arrangement described above, the

1 brackets 115, 126 and 127, metal support member 117,
a shaft 155a for the gear 155, a shaft 157a for the gear
157, and so forth are mounted on the chassis 104 in a
suitable manner. A biasing force (not shown) which
5 normally acts in the anticlockwise direction is applied
to the swing plate 139 and to the arm 142.

Next, the operation of the automatic guided
vehicle thus constituted in accordance with the present
invention will be described below.

10 At the time of normal travelling, the states
of the front wheel 101 and the rear wheels are shown in
the plan view of Fig. 9. In this case, the electro-
magnetic clutches 115, 127 and 128 are in the released
states, so that the sprocket 116 is not rotated and the
15 driving force of the driving motor 107 is not transmitted
to the rear wheels 102 and 103 while only the front wheel
101 is being driven. At this time, the track A is detec-
ted by the track sensor 112, and the vehicle travels along
the track A. During this normal travelling operation,
20 the plungers 143 and 146 are not operated, so that, even
if the cam 111 rotates to turn the swing plate 139 when
the front wheel 101 is steered to the left or right at
a curved portion or the like of the track A, the turning
force of the swing plate 139 is not transmitted to the
25 arm 142. Therefore, the rod arm 149 is not moved; the
contact arms 152 and 156 and slide arms 123 and 124 are
maintained in the states as shown in Fig. 9; the rear
wheels 102 and 103 are being locked in the forward

39 direction; the rear wheels 102 and 103 can be freely rotated in accordance the released state of the electromagnetic cluthces 127 and 128.

Next, the operation of spinning turn will be described below. When the vehicles makes a spinning turn, namely, a turn about a fixed point on it, the plunger 143 is operated previously or at the time of start of the operation, thereby outwardly projecting the engaging click member 144. The front wheel 101 is perpendicularly set in a desired direction (the direction of the spinning turn) by being driven by the steering motor 118 via the steering shaft 109 while the swing plate 139 is being turned by the steering cam 111 to turn the arm 142 by the angle α_1 , as shown in Fig. 10a. The rod 149 is pulled by the turning movement of the arm 142, and the contact arm 152 is pulled by the rod 149 to turn about the shaft 155a. The shaft 153 is simultaneously slid in the slot 154 to turn the slide arm 123 while the rotational movement of the gear 155 is transmitted to the gear 157, thereby turning the contact arm 156 so as to similarly turn the slide arm 124 via the shaft 158 and the slot 159. Both the slide arms 123 and 124 are thus turned and are held in positions shown in Fig. 11. At this time, the rear wheels 102 and 103 are divergent in the forward direction of the main body B, and they are positioned in such a manner that, if a point of intersection at which lines perpendicularly extending through the wheels 101, 102 and 103 at the centers thereof meet each other is

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1 represented by P, the distances between the point P and
the respective wheels 101, 102 and 103 are equal to one
another. If at this time the electromagnetic clutches
115 and 127 are in the connected states, the driving
5 force of the driving motor 107 is also transmitted to
the rear wheel 102 as well as to the front wheel 101,
and the main body can turn about the point P provided
that the reduction ratio is set so as to equalize the
peripheral speeds of the wheels 101 and 102 to each
10 other.

The main body B of the automatic guided vehicle
is thus caused to effect a spinning turn as shown in Fig.
13. When the main body B of the automatic guided vehicle
is caused to effect the clockwise spinning turn from the
15 downward direction to the upward direction as viewed in
Fig. 13, the front wheel 101 and the rear wheel 102 are
driven by the driving motor 107 while the front wheel 101
and the rear wheels 102 and 103 are maintained in direc-
tions of steering, thereby turning the main body about
20 the point P. During this turning operation, the track-
sensor 112 continues to detect the track A, and detects
the track A when the front wheel 101 reaches a position
 X_1 after turning in the clockwise direction as shown in
Fig. 13. A command is output in response to the detec-
25 tion signal and is sent to a control circuit for the driv-
ing motor 107, thereby initiating the slowdown operation
of the driving motor 107. The motor is stopped when the
front wheel reaches a position X_2 after moving through

(H1)

a predetermined distance. The distance between the slowdown point and the point at which the front wheel is stopped is set to be equal to the distance H between the track sensor 112 and the front wheel 101. That is,

5 the turning angle of the front wheel may be set such that the front wheel 101 stops after moving to the extent corresponding to the distance H. This angle is calculated by, for example, counting the pulse outputs from a rotary encoder disposed on the driving shaft of the front wheel

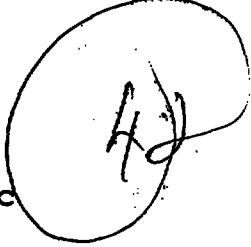
10 101. When the front wheel 101 is stopped on the track A in this manner, the stopped state is detected to cause release of the electromagnetic clutches 115 and 127, and the steering motor 118 is driven so that the front wheel is directed toward the front of the main body. Then,

15 when the track sensor 112 detects the track A, the steering operation is terminated and the normal travelling operation is again effected, thus finishing the spinning turn. At this time when the front wheel is returned to the position in the forward direction, the

20 steering cam 111 is turned, and the swing plate 139 and the arm 142 are returned by the above-described urging force. Accordingly, the rear wheels 102 and 103 are also returned by the operations of the rod 149, the arms 123 and 152, the gears 155 and 157, the arms

25 124 and 156 to the state in which they are directed to the front, as shown in Fig. 9, thereby enabling the normal travelling.

Next, the operation of lateral travelling will



1 be described. When the main body B of the automatic
guided vehicle is moved laterally, that is, in the
lateral direction relative to that of the normal travel-
ling, the plunger 146 is operated previously or at the
5 time of start of the operation, thereby outwardly pro-
jecting the engaging click member 147. The front wheel
101 is perpendicularly set in a desired direction (the
direction of the lateral travelling) by being driven by
the steering motor 118 via the steering shaft 109 while
10 the swing plate 139 is being turned by the steering cam
111 to turn the arm 142 by the angle α_2 , as shown in
Fig. 10b. The rod 149 is pulled by this turning movement
of the arm 142, and the contact arm 152 is pulled by the
rod 149 to an extent larger than that in the case of the
15 above-described spinning turn, resulting in the state
shown in Fig. 12. In this state, the slide arm 123 and
the contact arm 152 are generally perpendicular to each
other. The contact arm 156 and the slide arm 124 are
also set to be made perpendicular to each other by being
20 turned via the gears 155 and 157. At this time, the
rear wheels 102 and 103 are made perpendicular to the
forward direction of the main body B after being turned
via the slide arms 123 and 124 and the wheel brackets
121. Therefore, if at this time the electromagnetic
25 clutches 115 and 128 are in the connected states, the
driving force of the driving motor 107 is transmitted to
the rear wheel 103 as well as to the front wheel 101.
These wheels are simultaneously rotated to enable lateral

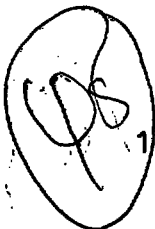
1 travelling.

The operation of lateral travelling is conducted as shown in Fig. 14. When the main body B of the automatic vehicle is to be laterally moved from a track A_1 to a track A_2 , rotation of the front wheel 101 and the rear wheel 103 caused by the driving force of the driving motor 107 with the front wheel 101 and the rear wheels 102, 103 maintained in the steering direction causes the automatic guided vehicle to start lateral travelling from the track A_1 to the track A_2 . During this turning operation, the track sensor 112 continues to act and is laterally moved to a position where the sensor 112 detects the track A_2 (corresponding to a position Y_1 of the front wheel 1), thereby issuing a command to the control circuit of the driving motor 107 and initiating the slowdown operation of the driving motor 107. The motor 107 is stopped when the front wheel 101 reaches a position Y_2 (a position on the track A_2) after the vehicle has moved through a predetermined distance. The principle of this operation is the same as that in the case of the above-described spinning turn. When the front wheel 101 is stopped on the track A_2 in this manner, this is detected to cause release of the electromagnetic clutches 115 and 128, and the steering motor 118 is driven so that the front wheel 101 is directed toward the front of the main body. Then, the vehicle is steered and stopped at a position where the sensor 112 having been deviated from the track A_2



1 detects the track A_2 . The vehicle thereby resumes the
position for the normal travelling, thus finishing the
operation of lateral travelling. At this time, the
rear wheels 102 and 103 are returned to the state as
5 shown in Fig. 9 in the same manner as that in the case
of the above-described spinning turn, thereby enabling
the normal travelling along the track A_2 .

The present invention will now be described
with respect to still another embodiment of the present
10 invention with reference to Figs. 15a, 15b, 16a and 16b.
In this embodiment, the above-described link mechanism
and angle setting mechanism for changing the angles of
the rear wheels 102 and 103 relative to the main body B
of the automatic vehicle via the clutch plate member 141
15 and the integral arm 142 on the swing plate 139, and
the rod 149 are replaced with other mechanisms. That is,
sprockets 160 and 161 are mounted on a shaft 139b
integral with the swing plate 139 which acts to detect
the state of steering. These sprockets are selectively
20 connected to the shaft 139b of the swing plate 139 for
rotation therewith by means of electromagnetic clutches
162 and 163. Each of the steering shafts 122 of the rear
wheels 102 and 103 has secured thereon a pair of sprockets
164 and 165. The sprockets 160 and 164 are connected
25 with each other by a roller chain 166, and the sprockets
161 and 165 are connected by a roller chain 167.
Sprockets 168 are adapted to reverse the direction of
rotation of one of the sprockets 164 of the rear wheels



102 and 103 relative to the other and also reverse the rotational direction of the sprockets 165 of these wheels. The sprockets 168 are respectively provided for the roller chains 166 and 167. The diameters of the sprockets 160 and 161 are different from each other in order to change the turning angles of the sprockets 164 and 165 relative to the turning angle (the above-described angle θ) of the swing plate 139 set by the cam 111. The sprocket 160 functions to effect a spinning turn, and the sprockets 161 functions to effect lateral travelling. When these sprockets are disengaged from the swing plate 139, the vehicle moves in the manner of normal travelling.

The operation of this embodiment shown in Figs. 15a, 15b, 16a and 16b will now be described. Fig. 15a shows the state of normal travelling in which the sprockets 160 and 161 are not connected to the shaft 139b by the action of the electromagnetic clutches 162 and 163, so that, when the front wheel 101, hence, the cam 111 is turned in accordance with the steering operation, the turning force thereof is not transmitted to the rear wheels 102 and 103. When the automatic guided vehicle makes a spinning turn, the front wheel 101 is driven and turned by the steering motor 118 to be made perpendicular to the main body B of the vehicle. If at this time the sprocket 160 has been connected to the shaft 139b by the operation of the electromagnetic clutch 162, the rear wheels 102 and 103 are turned via the sprocket 160, the chain 166 and the sprockets 164 as the

1 swing plate 139 turns. The rear wheels are thereby
positioned to be divergent in the forward direction of
the main body B of the vehicle, as shown in Fig. 16a.
When in this state the front wheel 101 and the rear
5 wheel 102 are driven, the vehicle turns about the point
P to effect a spinning turn in the same manner as that
in the case of the above-described embodiments. At the
time of lateral travelling, the rear wheels are turned
in response to the turning movement of the front wheel
10 101 to laterally direct the vehicle as shown in Fig.
16b, provided that the sprocket 161 has been connected
to the shaft 139b by the operation of the electromagnetic
clutch 163. In this state, the vehicle can laterally
travel in the same manner as that in the case of the
15 above-described embodiments.

In the embodiment shown in Figs. 15a, 15b, 16a
and 16b, components and operations other than those of
this link mechanism are the same as those of the above-
described embodiments. In this embodiment, with respect
20 to the relationship between the sprockets 160 and 161,
and 164 and 165, the diameters thereof are set so that
the change of the turning angle θ of the swing plate
139 corresponds to the predetermined change of the angles
of the rear wheels 102 and 103 (that is, the rear wheels
25 are directed to be divergent or to be perpendicular to
the main body B).

This type of link mechanism may be constituted
without using the cam 111 and the swing plate 139. For



example, members similar to the sprockets 160 and 161 and the electromagnetic clutches 162 and 163 provided in the above-described embodiment may be mounted on the steering shaft 109 and operated in a manner similar to
5 that described above, thereby steering the rear wheels.

CLAIMS

1. An automatically guidable vehicle for movement across a surface, which vehicle has a main body, including front and rear portions, and a longitudinal axis and which comprises:

a front wheel located at the front portion of the main body;

a pair of rear wheels located at the rear portion of the main body;

front and rear support members connected to the main body, the front wheel being rotatable within the front support member and the rear wheels being rotatable within respective rear support members about axes of rotation which extend substantially parallel to the surface, in use;

a steering shaft mounted on the front wheel support member;

steering drive means mounted on the main body and being connected operatively with the steering shaft for rotation of the front wheel about an axis perpendicular to the surface, in use;

steering state detecting means connected operatively with the main body for detecting movement of the steering shaft caused by said steering drive means;

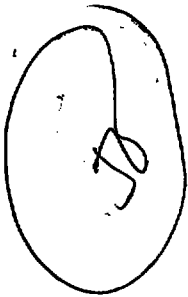
a link mechanism connected operatively with said steering state detecting means;

travel drive means for driving the front and rear wheels across the surface, in use;

electromagnetic clutch means disposed between part of said travel drive means and each of the rear wheels; and

rear wheel angle setting means arranged to rotate and maintain each of the rear wheels about an axis perpendicular to the surface, in use, and being controllable by and





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connected operatively with said steering drive means and said steering state detecting means through the link mechanism, the arrangement being such the vehicle can travel forward, laterally or turn, whereby, when turning, the front and rear wheels are positioned at angles to the longitudinal axes of the vehicle and said electromagnetic clutch means is engaged, so that the driving force of said travel drive means is transmitted to the rear wheels, and, when travelling laterally, the front and rear wheels are positioned at an angle to the longitudinal axis of the vehicle and at least one of said electromagnetic clutch means is engaged, so that the driving force of said travel drive means is transmitted to at least one of the rear wheels.

2. A vehicle according to Claim 1, wherein each of the rear wheels is rotatable about an axis perpendicular to the surface, in use, between a first position parallel to the longitudinal axis of the vehicle and a second position transverse to said longitudinal axis, the rear wheels being positionable so that the position of one of the rear wheels is a mirror image of the other of the rear wheels across said longitudinal axis.

3. A vehicle according to Claim 1 or 2, wherein the front and rear wheels each has a respective transverse axis and wherein, when turning, at least two of the front and rear wheels are driven with radii of gyration equal to the distance between the front and rear wheels and a point of intersection of the transverse axes of the front and rear wheels.



4. A vehicle according to Claim 1, 2 or 3, wherein the rotational speed N of the front wheel is:

$$N = - \frac{R}{r} n$$

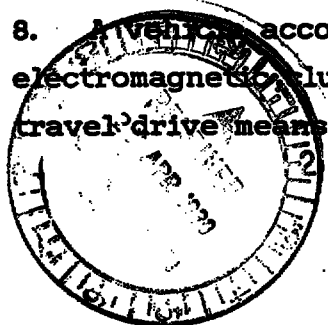
wherein, when turning, R represents the gyration of the front wheel about a predetermined axis perpendicular to the surface, r represents the radius of gyration of a rear wheel about said predetermined axis and n represents the rotational speed of the rear wheels.

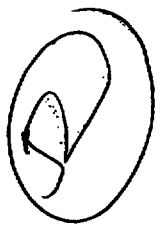
5. A vehicle according to any preceding Claim, wherein the main body is capable of turning about an axis perpendicular to the surface in use, which axis is located at the point of intersection of each of the axis of rotation, when the front and rear wheels are positioned for turning.

6. A vehicle according to any preceding Claim, wherein said steering state detecting means includes first setting means for limiting the movement of said steering state detecting means so that the rear wheels are positionable at an angle to the longitudinal vehicle axis when the front wheel is positioned transverse thereto, and second setting means for limiting the movement of said steering state detecting means so that the rear wheels are positionable transversely to the longitudinal vehicle axis.

7. A vehicle according to any preceding Claim, wherein said electromagnetic clutch means is releasable during forward travel of the vehicle, to prevent the driving force of said travel drive means from being transmitted to the rear wheels.

8. A vehicle according to any preceding Claim, wherein further electromagnetic clutch means is disposed between part of said travel drive means and the front wheel.





9. An automatically guidable vehicle for movement across a surface, which vehicle has a main body, including front and rear portions, and a longitudinal axis and which comprises:

only one front wheel located at the front portion of the main body;

a pair of rear wheels located at the rear portion of the main body;

front and rear support members connected to the main body, the front wheel being rotatable within the front support member and the rear wheels being rotatable within respective rear support members about axes which are substantially parallel to the surface, in use;

a steering shaft mounted on the front wheel support member;

steering drive means mounted on the main body and being connected operatively with the steering shaft for rotation of the front wheel about an axis perpendicular to the surface, in use;

steering state detecting means connected operatively with the main body for detecting movement of the steering shaft caused by said steering drive means;

a link mechanism connected operatively to said steering state detecting means;

travel drive means for driving the front and rear wheels across the surface, in use;

clutch means disposed between part of said travel drive means and each of the rear wheels; and

rear wheel angle setting means arranged to rotate and maintain each of the rear wheels about an axis perpendicular to the surface, in use, and being controllable by and connected operatively with said steering drive means and said steering state detecting means via the link mechanism, the arrangement being such that the vehicle can travel forward, laterally or turn, whereby, when turning, the



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front and rear wheels are positioned at angles to the longitudinal vehicle axis and said clutch means is engaged so that the driving force of said travel driving means is transmitted to the rear wheels and, when travelling laterally, the front and rear wheels are positioned at an angle to the longitudinal vehicle axis and at least one clutch of said clutch means is engaged so that the driving force of said travel drive means is transmitted to at least one of the rear wheels.

10. An automatically guidable vehicle substantially as hereinbefore described with reference to the accompanying drawings.

