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PATENT SPECIFICATION

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(54) IMPROVEMENTS IN OR RELATING TO REMOTE CONTROLLED TRANSPORT UNITS

(71) We, DIGITRON AG, a Swiss Body Corporate of 32, Erlenstrasse, CH-2555 Brugg-Biel, Switzerland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to remote controlled transport units.

According to the present invention, there is provided a remote controlled transport unit comprising two drive wheels, said drive wheels being pivotal whereby to steer the transport unit, sensor means pivotal with each respective wheel, each said sensor means being arranged to co-operate with a respective one of two control lines along which control signals are fed such that each said sensor means follows the corresponding control line during movement of the transport unit and pivots its associated drive wheel to cause same to follow a path determined by the control line, drive means for driving the respective drive wheels, the drive means being linked such that one wheel (B) is driven at a speed (v_B) which is determined by the speed (v_A) of the other wheel (A) in accordance with the following reationship

$$v_B = \frac{\cos \alpha}{\cos \beta} v_A$$

where α and β are the angles subtended between the direction of travel of the wheels A and B, respectively, and a line passing through the pivotal axes of the two wheels.

Preferably, the sensor means are inductive sensors.

The control lines may carry control signals at mutually different frequencies, with that corresponding inductive sensor being tuned to the associated control signal frequency. In this way the two control lines can be arranged close together without the control signals of each respective line influencing the sensor associated with the other line. An embodiment of the invention will now be described by way of example only with reference to the accompanying drawings in which:

Fig. 1 shows schematically the underside of a remote-controlled transport unit in accordance with the present invention;

Fig. 2 shows schematically different control angles for two drive wheels A and B of the unit;

Fig. 3 shows schematically different positions of the transport unit when passing around a curve;

Fig. 4 shows schematically transverse travel of the transport unit; and

Fig. 5 is a graph which represents the change in the speed of a drive wheel as a function of the angular difference between the two control angles of the drive wheels upon transverse travel for transverse travels of different angle.

Fig. 1 shows schematically the underside of a remote-controlled transport unit or truck 1. Two drive wheels 2 and 3 are provided on a line M extending parallel to the longitudinal central axis K of the transport unit 1 and the axes of rotation 4 and 5 of these wheels are orientated parallel to the bottom of the transport unit 1. The drive wheels 2 and 3 are driven by drive motors 6 and 7 respectively. On each drive wheel 2 and 3 are sensors in the form of two antennae 8 and 9 and 10 and 11 respectively, arranged so that one antenna leads and one lags behind the corresponding drive wheel in relation to its direction of travel.

Each antenna comprises two induction coils arranged on opposite sides of a central vertical plane passing through the corresponding drive wheel transversely to the axis of the wheel. The antennae are coupled with the corresponding drive wheel so that they are turned together with it through any desired control angle. Each of the drive wheels 2 and 3 may be pivoted together with its associated drive motor 6 or 7 and associated antennae 8 and 9, or 10 and 11, around a shaft 12 or 13 which is vertical, that is, perpendicular to the plane of the drawing of Figure 1. A control motor 14 or 15 is provided to pivot each of the drive wheels 2 and 3 respectively. Each control motor 14 or 15 is connected to the corresponding drive wheel 2 or 3 via a pulley 16 or 17, a corresponding belt 18 and a second pulley 20 or 21 on which the drive wheels 2, 3 and the corresponding drive motors 6, 7 are mounted.

On the opposite side of the longitudinal central axis K of the transport unit to the drive wheels, there are two ordinary caster wheels 22 and 23, although any number of caster wheels may be provided. The arrangement of the drive wheels 2 and 3 in the illustrated example is on a line M parallel to the central longitudinal axis K, but the drive wheels may be located in a mutually offset position with respect to the central longitudinal axis K, for instance, on a diagonal line across the transport unit. However, it is preferable to arrange the drive wheels 2 and 3 in the manner shown in Fig. 1 in order to obtain good straight-ahead travel of the transport unit in the direction parallel to the central longitudinal axis K.

Remote control of the drive wheels 2 and 3 and thus of the transport unit 1 is carried out as follows. The antenna which leads its associated drive wheel 2 or 3 scans a respective control or guide line, for instance an electrical conductor embedded in a surface along which the transport unit is travelling, and transmits to the associated control motor 14 or 15, control signals fed along the corresponding line. The control motor 14 or 15 then pivots the associated drive wheel 2 or 3 so that the scanning antenna lies above the guide line. The speed of a drive wheel 2 or 3 can be determined also by control signals received from the associated antenna over the corresponding guide line. One of the two antennas associated with each drive wheel operates when the transport unit 1 is moving forwards and the other operates when the transport unit 1 moves in reverse.

In order to explain the control system in somewhat greater detail, Fig. 2 shows the transport unit 1 with the drive wheels 2 and 3 indicated schematically and the line M passing through the vertical, pivotal axes of the two drive wheels 2 and 3. The inclination of the diametral central plane 25 of the drive wheel 2 to the line M is designated as control angle α of the drive wheel 2 and inclination of the diametral central plane 26 of the drive wheel 3 to the line M is designated as control angle β. If the speed of drive of the drive wheel 2 is designated as v_A and that of the drive wheel 3 v_B, then the drive speeds of the two drive wheels 2 and 3 should be so related that the following relationship applies:

$$v_B = \frac{\cos\alpha}{\cos\beta} V_A,$$

which may also be expressed as:

$$V_A = \frac{\cos\beta}{\cos\alpha} v_B$$

Such a function can easily be achieved by electronic control means. The relationship between the drives of the two wheels is preferably such that either one of the two wheels can be chosen selectively to act as the controlling wheel, with the other wheel being driven at a speed determined by the speed of the controlling wheel in accordance with the above relationship.

If α and β are equal, the drive wheels 2 and 3 travel with the same speed. However, if the control angles α and β differ from each other, the two drive wheels 2 and 3 will automatically be driven at different speeds.

This relationship between the speed of the two drive wheels enables the transport unit to be driven around relatively sharp curves in a relatively simple manner as is illustrated in Figure 3. In Fig. 3, the same transport unit is shown in three different successive positions I, II and III. Each reference number is designated with either a single prime mark or two-prime marks, or three-prime marks, corresponding to the three positions. The drive wheels of the transport unit are designated 32 and 33. The drive wheel 32 is guided along a first guide line or loop 34 and the second drive wheel 33 is guided along a second guide line or loop 35. When the transport unit 1 is to be driven straight ahead, the guide lines 34 and 35 lie close together and are parallel to each other. The guide lines 34, 35 only follow different paths at curves in the route of the transport unit. The arrows indicate the direction of movement of the two drive wheels 32 and 33. In position I, the transport unit 31′ is on the last portion of a straight section for which the control angles of the two drive wheels 32′ and 33′ are each zero and therefore the speeds of the two drive wheels are the same.

In position II, the drive wheel 32″ has a larger control angle than the drive wheel 33″. This means that the drive speeds of the two drive wheels will be different but related as indicated above and thus the drive speed of the drive wheel 32″ is greater than the drive speed of the drive wheel 33″. In this way, the transport unit 31″ is moved as rapidly as possible back into a position in which its central longitudinal axis extends parallel to the guide lines 34 and 35, as shown in position III. Due to the different drive speeds of the drive wheels, no undesired turning or displacement of the transport unit 1 takes place.

Fig. 4 illustrates the application of the described steering control system for the transverse travel of a transport unit. A transport unit 41 having drive wheels A and B is shown in two successive positions I and II in solid line and in dashed line respectively. In position I the drive wheels A and B have the same control ngle $\alpha 1$ and $\beta 1$ of 45°. The drive speeds v_A and v_B are therefore the same. The transport unit is thus displaced laterally at an angle of 45° with respect to its central longitudinal axis. If, as a result of any disturbance, the drive wheel A is driven at higher speed than the drive wheel B, then the control angle $\alpha 2$ decreases as compared with the angle $\alpha 1$ since the antenna of the drive wheel A strives to remain on its associated guide line 44. At the same time, however, since the antenna of the drive wheel B also tries to remain on its guide line 45 the control angle 2 of this drive wheel increases as compared with the control angle 1. The transport unit 41 has therefore turned in position II as compared with position I. If this is not corrected, the transport unit 41 would continue to turn until the orientation of the transport unit 41 becomes such that the antenna of the drive wheel B could no longer follow its guide line 45 and the transport unit 41 would thus lose its contact with the control system. Such correction is, however, automatically provided by linking the speeds of the two wheels in the manner described. Thus, if the transport unit 41 reaches a condition corresponding to that shown in position II, the drive speed of the drive wheel B is increased or the drive speed of the drive wheel A is reduced so that the equilibrium condition of position I is again established.

From the relationship specified, it will be seen that for a constant speed v_B, an increase in speed v_A will occur when either angle α is increased or angle β is reduced, and consequently the speed v_A will reduce. This relationship therefore tends to neutralize any errors in the drive speed of the drive wheels.

In Fig. 5 there is a graph of the change in speed Δv_A of one drive wheel in percent as a function of the angular difference $\Delta\gamma=\beta-\alpha$ between the control angles of the two drive wheels for differenl values of the control angle β of the other drive wheel. The three curves each correspond to a specific transverse-displacement control angle β, as seen in Fig. 4. The curves are given for β=20°, β=50°, and β=80°. As can be noted from the graph, the smallest dependence of a change in speed v_A as a function of the angular difference $\beta-\alpha$ is obtained for small values of β, namely β=20°. The greatest dependence, on the other hand, is obtained for β=80°. The graph thus shows that with large control angles, for instance β=80°, a large speed compensation also takes place.

At the same time, however, it follows from this graph that the maximum permissible control angle must be less than 90° since at this angle two completely linear loops with absolutely precise distance between them would be required in order that no deviations at the two antennae occur. Even very small angular errors would cause comparatively large changes in speed in one of the drive wheels. For this reason, in practice 80° is preferred as the maximum value for the control angle.

Although either drive wheel can act as the controlling wheel with the speed of the other wheel being changed as a function of the control angles, the controlling wheel is preferably the faster of the two drive wheels which maintains a predetermined speed, with the drive speed of the other drive wheel being controlled as a function thereof.

The arrangement described permits improved control of the transport unit around curves, particularly tight curves.

WHAT WE CLAIM IS:—

1. A remote controlled transport unit comprising two drive wheels, said drive wheels being pivotal whereby to steer the transport unit, sensor means pivotal with each respective wheel, each said sensor means being arranged to co-operate with a respective one of two control lines along which control signals are fed such that each said sensor means follows the corresponding control line during movement of the transport unit and pivots its associated drive wheel to cause same to follow a path determined by the control line, drive means for driving the respective drive wheels, the drive means being linked such that one wheel (B) is driven at a speed (v_B) which is determined by the speed (v_A) of the other wheel (A) in accordance with the following relationship

$$v_B=\frac{\cos\alpha}{\cos\beta}v_A$$

where α and β are the angles subtended between the direction of travel of the wheels A and B, respectively, and a line passing through the pivotal axes of the two wheels.

2. A transport unit according to claim 1, wherein the drive wheels are so arranged that their pivotal axes are arranged on a line parallel with the longitudinal axis of the vehicle.

3. A transport unit according to claim 1 or

claim 2, wherein the sensor means are inductive sensors.

4. A transport unit according to claim 3, wherein the respective sensor means are tuned to different control signal frequencies whereby the transport unit can be controlled by two control lines having different control signal frequencies.

5. A transport unit substantially as hereinbefore described with reference to the accompanying drawings.

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Fig.1

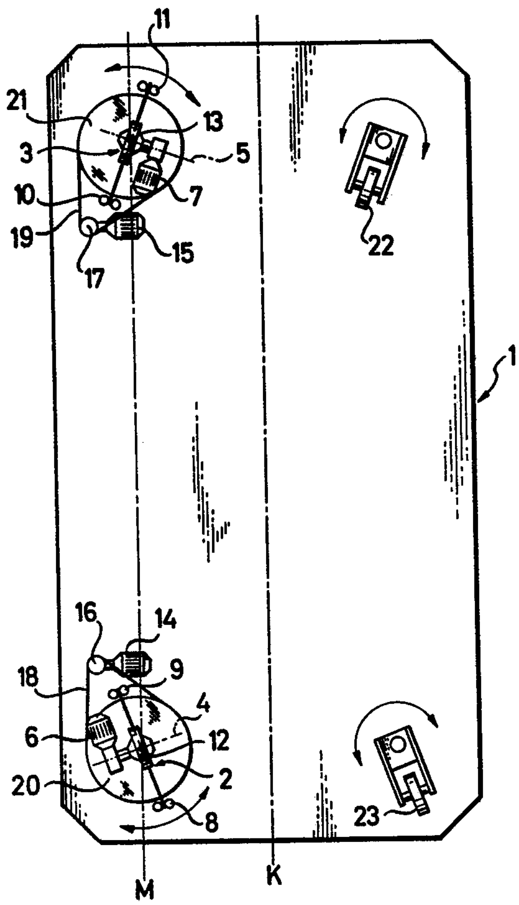

Fig. 2

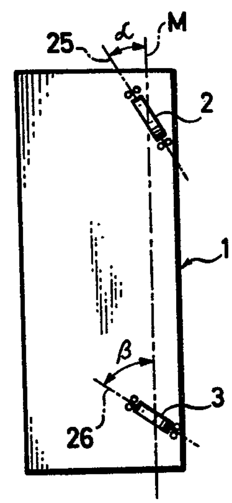

Fig. 3

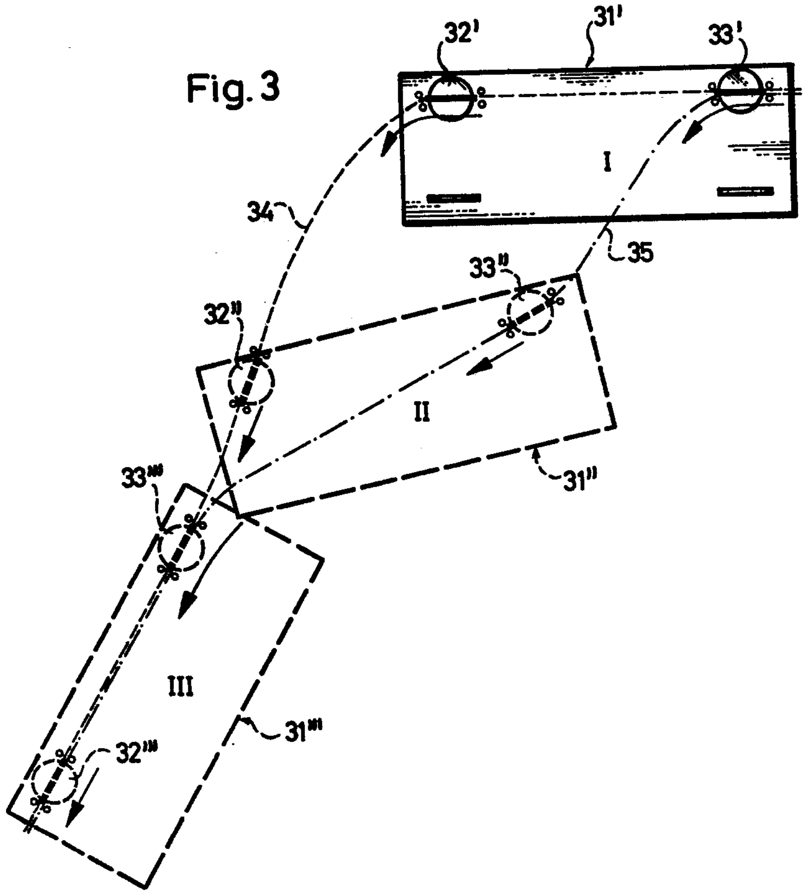

Fig. 4

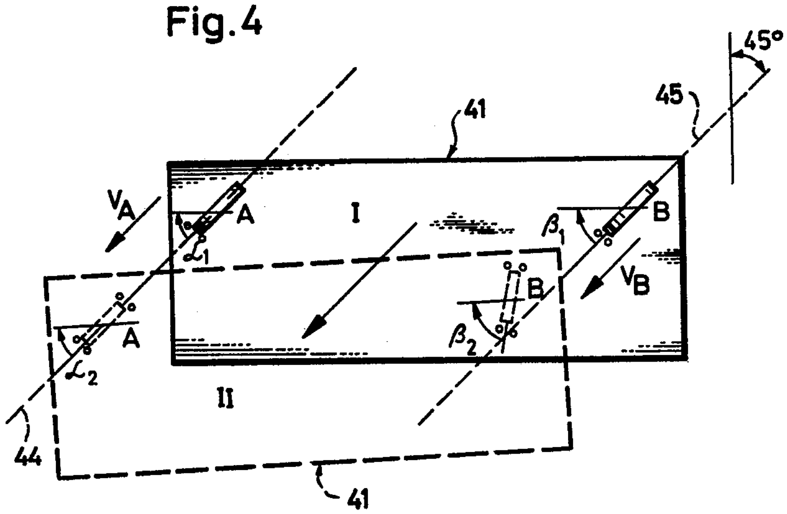

Fig.5