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(54) CONTROL AND MONITORING APPARATUS FOR POSITIONING A LOAD-HANDLING VEHICLE

(71) We, JUNGHEINRICH UNTERNEHMENSVERWALTUNG KG, a Kommanditgesellschaft organised under the laws of the Federal Republic of Germany, of Friedrich-Ebert-Damm 129, 2000 Hamburg 70, Germany, 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:

This invention relates to control and monitoring apparatus for positioning a load-handling vehicle.

The invention relates particularly but not exclusively to such apparatus for positioning a warehousing vehicle.

An electronic control for shelf loading apparatus is described in the journal "deutsche hebe- und foerdertechnik", August 1967, pages 25 to 31. In this prior art control the vehicle includes several reflex signal barriers, and a pair of mutually offset strip-shaped reflector elements are arranged along the path of travel of the vehicle. This arrangement enables an indication of direction of travel of the vehicle to be obtained in dependence upon the sequence of signals reflected by the reflector elements, by suitably processing two pulses having a time-lag. The controller includes a counter for sequencing in the one or in the opposite direction by addition or subtraction according to the direction of travel. In this manner, the instantaneous actual vehicle position may be detected and this actual position may be compared with a stored target value indicative of the target such as a position along a corridor between shelves.

The signal providing means may consist of photo-electrically scanned reflectors and suitable photoelectrical receiver elements.

When the vehicle arrives at a target the vehicle will be stopped as soon as both the reflex signal barriers coincide with their respective pulse indicia. This prior art control requires complicated signal conversion and signal processing operations. There is no adjustment or adaptation feature, as may optionally be desired for correction purposes. This prior art control system merely provides a measurement of the distance from a target, by comparing actual and target values, in order to reduce the vehicle speed during a suitable time interval before the vehicle arrives at the target.

By the French patent 2,092,392 it is already known to provide reflecting elements in a strip-shaped configuration whereby the longitudinal extension of the reflecting elements corresponds exactly to the spacing of two reflex light barriers that are mounted on the vehicle. With this arrangement the vehicle may be brought to stop accurately in a desired stop position whereby the actual stop position is reached by the vehicle when both photo-electrical receivers receive signals. In this heretofore known control assembly the direction of travel is likewise determined in dependence upon the sequence of signals at the two receivers.

Prior art arrangements in which signals are derived in dependence upon the position of reflex signal barriers at the ends of elongate reflecting elements are disadvantageous insofar as the movement of the vehicle along the path of travel must be controlled precisely with respect to the stops. If the vehicle is not in an exact parallel alignment with the path of travel, then the accurate relationship to the spacing between the reflex signal barriers on the vehicle gets lost because in an askew position of the vehicle there will necessarily be a greater spacing in the plane of the strip-shaped reflecting elements or of the pairs of reflecting elements. This in fact severely interferes with the positional accuracy.

The same drawbacks will likewise be encountered in another heretofore known system according to the British patent 1,421,722 in which pairs of horizontally spaced reflecting strips are provided at every stop. In the system described in this British patent the spacing of the reflex signal barriers is selected according to the spacing of the two reflectors in each pair.

In the system of the aforedescribed British patent the detection of the direction of travel of the vehicle is likewise effected in dependence upon the sequence of the signals obtained and by a comparison of target and actual values by means of logic circuitry.

By the German Offenlegungsschrift 2,235,951, there has become known a control system in which a hoisting carriage may be controlled with respect to different stop regions within the restricted height of the hoisting mast by a pair of angular encoders one of which performs not more than a single full revolution during a complete hoisting stroke and thereby provides binary signals during this revolution by means of several tracks of different configurations. Each binary signal corresponds to the length of the stop range. Another angular encoder serves to determine the exact position of the hoisting carriage within a stop range of a plurality of stop ranges. This angular encoder is selected to provide signals along a hoisting path corresponding to the maximum extent of a stop range.

The aforedescribed control system of this German specification permits a precise positioning of the hoisting carriage by subjecting the various actual value indicating signals of the angular encoders to a comparison of actual and target values. The target value may be program-dated manually.

The system described in this German specification includes additional photoelectrical sensors for scanning indicia along walls or pillars of a shelf in order to sense numbers indicative of shelf partitions or subdivisions. By a follow-up of the actual value the movement of the hoisting carriage may be controlled precisely. This control system is relatively complicated and allows to monitor only restricted path lengths such as the hoisting stroke of a lifting mechanism in a warehouse vehicle because the one angular encoder is only allowed to perform one full revolution while the hoisting carriage moves from its one to its other limit of hoisting stroke.

It is the object of the present invention to provide improved control and monitoring apparatus for positioning a vehicle.

According to this invention there is provided control and monitoring apparatus for positioning a load-handling vehicle at predetermined stations on a path of travel, comprising a responder located at each station on the path, each responder having a scanning edge perendicular to the direction of travel of the vehicle along the path, a pair of scanning devices mounted on the vehicle, each scanning device being adapted to provide a signal as the device passes the scanning edge of each responder, the two scanning devices being separated from one another by a distance measured lontitudinally of the vehicle which corresponds to a range of stopping positions at each station, each said responder being shorter than the distance between the two scanning devices, a pulse generator adapted to supply a train of pulses corresponding to predetermined path increments in the said range, the pulse train being initiated by a signal from the scanning device which first passes the scanning edge of each responder and terminated by a signal from the other scanning device unless there is a preselected stopping position within the said range of stopping positions, and means for stopping the vehicle at a preselected count of pulses in the train corresponding to a preselected stopping position within the said range.

In operation, when the vehicle passes a station, two sequential signals are provided, and there is effected a path-of-travel count that differes from a stopping range path count of the said pulses. The stopping range path count only covers a relatively short section of a stopping range but enables this section to be subdivided into a plurality of short path increments, as represented by the said pulses, and thus not only allows the vehicle to approach the station and to come to a standstill at this station but furthermore allows the vehicle to be controlled additionally within the stopping range of the station so as to precisely select the stopping position within the stopping range. The erasing of the stopping range path count when the vehicle is moving past the station furthermore allows this control to be employed along relatively extended paths of travel that include a great plurality and virtually an unlimited number of stations. Advantageously, vehicle dependent parameters relating to the height position of a hoisting carriage that is movable up and down along a hoisting frame, and relating to a load carried by the hoisting carriage may be applied to a preselected stopping range path counter. This expedient allows an exact positioning of the vehicle because in this manner may be taken into consideration variable conditions along a path of travel. Thus e.g. may be taken up by the loading platform of the vehicle loads at several subsequent stations along the path of travel, and these loads may be unloaded at another station along the same path of travel and at a predetermined height. Since deformations of the hoisting frame are dependent upon the weight of the load, the exact position of a load may vary with respect to the center of the vehicle.

Further parameters may likewise be taken into consideration.

In accordance with another preferred embodiment, the stopping range path counter may provide a signal indicative of the direction of travel of the vehicle. This feature allows simplification of the control assembly in comparison to heretofore known control systems in which the direction of travel must be deduced from the actual sequence of the two signals.

According to a particularly preferred embodiment of the method of the present invention the first of the two sequential signals is provided when the vehicle moves past substantially the midway position of a stopping range, and a number that has been preselected for each stopping range path count is the combination of a constant signal corresponding to half the length of a stopping range the length of which is predetermined by the spacing of the two sequential signals at each station, and of a variable signal $\pm x$ that is subdivided into a plurality of path pulses whereby the sign in this combination is determined in dependence upon the direction of travel, and the magnitude of the variable is determined by specific properties of the vehicle. One advantage of this arrangement is that the above mentioned additional parameter may be taken into consideration in accordance with the magnitude of the variable signal x whereby additionally may be effected a positional adjustment of the vehicle with respect to the center of a stopping range. Another advantage is that the triggering of the first signal at substantially the midway position of a stopping range requires merely a relatively short or point type actuation element for triggering the signal. This eliminates alignment errors of the vehicle with respect to parallelism, e.g. along a shelf wall, quite apart from the fact that the arrangement is substantially simplified.

The fact that the first signal is triggered when the vehicle moves past substantially the midway position of a stopping range takes into account that a signal triggering edge may be arranged in a position slightly displaced from the midway position, for compensating the optical hysteresis of the assembly.

The stopping range path counting provides furthermore a relatively simple means for reducing the vehicle speed or changing the speed of the vehicle to a crawling speed with which the vehicle approaches the precise stop position, without any significant additional circuitry being required.

When assembling the vehicle in the factory, the scanning cevices may be mounted at precise positions and with a high accuracy. The provision of only a single scanned edge of each reflector as a signal triggering element greatly facilitates the accommodation of the edge e.g. in an industrial warehouse because only a single predetermined location has to be taken into account with respect to every station, and alignment errors as may easily occur when employing elongate strips or even pairs of strip-shaped reflectors are avoided. When e.g. mounting a reflecting tape so that the tape extends across the whole stop range and the tape is inclined, there will be obtained indication errors since in an assembly of this type the ends of the tape must be adapted precisely to the spacing of the scanning devices. The term "inclined" is also intended to point out the problems not associated with an exact horizontal arrangement but with an alignment that is parallel to the vehicle. To achieve parallelism, it is insufficient to have the tapes extend in a direction parallel of the floor because the inclination of the vehicle with respect to the longitudinal axis of the vehicle may vary in dependence upon wheel conditions and especially upon the weight of a load carried by the vehicle. All of these negative parameters are eliminated in the preferred embodiment of the control system of the present invention.

Preferably, the scanned edge is located substantially midway of the stopping range. This allows particularly favorable control conditions, particularly in conjunction with the above described combination of the preselected number for a stop range path count.

In accordance with a further preferred embodiment of the present invention each vehicle may include a path pulse counter adapted to be triggered by a signal from the forward or leading scanning device when looking in the direction of travel, to provide path count pulses and a signal indicative of the travelling direction in dependence upon the sense of counting whereby are additionally provided calculating means for computing an actual value on the basis of the actual path count pulses and the count of the number of stations already passed by the vehicle, and comparator means for comparing in a known manner the actual value with a stored target value. This type of control constitutes simple means for subdividing the length of a stopping range, in order to arrive at a preselected stop position.

Advantageously the path pulse generator consists of an increment pickup coupled to a member of the vehicle that is movable in dependence upon the travelling movement of the vehicle. When employing the path pulse generator for simultaneously providing a directional signal, advantageously is used a two-track increment pickup for providing pulse that are mutually offset by 90 degrees. Suitable increment pickups are commercially available. In a mechanical coupling arrangement the increment pickup may be reset or respectively driven by a coupling connection.

Alternately, there may be provided an electrical connection or coupling arrangement. It is especially preferred to provide a drive wheel engaging the floor or a peripheral region of a tire of a vehicle wheel on a non-driven axis, for driving the increment pickup. The vehicle may furthermore include an odometer wheel for driving the path pulses generator that consists of an increment pickup. Thus the vehicle may suitably be provided with an odometer wheel that is optionally extensible in a downward direction.

In a control system including a target value input, a signal responsive actual value detector, a comparator and a motor controller, an advantageous modification provides a functional connection connecting the comparator to the path pulse generator and adapted to deactivate the path pulse generator in the absence of a stored target position at a station being approached by the vehicle in dependence upon the trailing scanning device moving past the scanned edge of a reflector, and to set the path pulse generator into standby.

When employing a counter for counting the number of stations which the vehicle has passed, the counter is preferably adapted to be set for a length of travel corresponding to stations arranged along a corridor between shelves by the trailing scanning device on the vehicle responsive to the triggering of this trailing scanning device when the vehicle moves backwardly, and the path pulses generated by the path pulse generator are being subtracted from this set length of travel. In this manner, the problem of positioning during forward and rearward travel may be solved in a particularly favorable manner by means of the path pulse counter. If the vehicle moves backwardly into a corridor between shelves, a forward signal indicating the indicia of the last stop is generated, in addition to a constant that practically represents, in the rhythm of counting between stops, the spacing from the last stop and the end of a corridor between shelves so that when triggering signal indicia upon the entry of the vehicle into the corridor between shelves thc count will be effected backwardly in the described manner.

The perpendicular scanned edge of a signal triggering element suitably consists of the edge of a short strip of reflecting material. In combination with the scanning devices and an evaluator is provided a switching device for controlling the evaluation of the signals from the scanning devices in dependence upon the direction of travel of the vehicle in a manner so that in the one direction of travel such as in the forward travel direction the transition from a bright to a dark condition triggers a control signal, and in the other direction of travel, i.e. in the rearward travel direction the transition from a dark to a bright condition triggers a control signal. This arrangement ensures that always one and the same edge of a short strip of reflecting material is effective to provide a signal independently of the direction of travel.

In a particularly preferred embodiment there may be provided a correction calculator adapted to receive at its inputs signals indicative of specific properties of the vehicle, and providing at its output signals to the actual value detector or to the comparator respectively. This allows to vary the path pulses for the exact positioning, i.e. the above mentioned variableF x. Advantageously, the vehicle includes measuring devices for producing signals indicative of specific properties of the vehicle. These measuring devices may e.g. include a height indicator for detecting the position of the hoisting carriage, and a load weighing device at the load receiving member of the hoisting carriage, for providing corresponding signals indicative of specific properties of the vehicle.

In combination with an actual value detector and a comparator may be provided a counter providing a zero count in its path pulse counting for a position midway of the stop range. When the count arrives at zero, the vehicle is brought to a standstill. In this type of counting, the correction values are applied by increasing or decreasing the number of path count pulses required to arrive at the zero count in dependence upon the correction magnitudes and upon the direction of travel. By introducing correction values, the zero count will be obtained when the vehicle is in a position that is offset from the center of the stop. The introduction of correction values may suitably be achieved by a voltage comparison in a comparator circuit having a center tap. Opposite voltage are applied to this circuit. One of these opposite voltages varies in response to the path count, and the other voltage varies in response to the correction values. Instead of feeding opposite voltages to a comparator circuit, there may be adjusted correspondingly components in branches of this comparator circuit.

The invention will now be described, by way of example, with reference to the accompanying drawings wherein

Figure 1 is a fragmentary schematical top view of a path of travel, for explaining the method of operation and respectively the design of a control system in accordance with the present invention;

Figure 2 is a schematical illustration for explaining the operation of the inventive system;

Figure 3 is a schematical illustration similar to Fig. 2 for explaining a specific method of operation;

Figure 4 is a block circuit diagram of a comparator for determining a corrected stop position;

Figure 5a is a schematical perspective view of the operational components of a two-track increment pickup that is suitable for the control system of the present invention;

Figure 5b illustrates two graphs showing wave forms constituting the output voltages of an increment pickup of the type shown in Fig. 5a;

Figure 6 is a schematical block circuit diagram of a control system in accordance with the present invention; and

Figure 7 is a schematical lateral elevational view of a vehicle having a hoisting mechanism.

Referring first to Fig. 1, there is shown a short section of a path of travel 8 along which are provided several reflectors such as the three reflectors 4, 5 and 6. Each reflector 4 to 6 defines a scanned edge 1, 2, 3 respectively. The term "scanned edge" is intended to indicate that this edge of the reflector serves to derive a triggering signal when being scanned or sensed by a control member of the vehicle. The reflectors with one scanned edge each define stations or stops such as operator's positions and may for example be located along a storage shelf assembly 7 for positioning a vehicle 9 that moves along the path of travel 8. The vehicle 9 is shown schematically in top view and includes a pair of scanning devices or reflex signal barriers 10, 11 at the vehicle side facing the scanned edges 1, 2 and 3. The spacing 12 of the reflex signals barriers 10, 11 in the direction of movement of the vehicle 9 is different from the longitudinal extension of each of the reflectors 4 to 6 in this direction of movement, and this spacing 12 may exceed the longitudinal extension of any of the reflectors 4 to 6. The longitudinal extension of each of the reflectors is of neglegible importance because this parameter does not affect the control functions, and these control functions are merely dependent upon the scanned edges 1 - 3 that extend perpendicularly of the direction of travel of the vehicle. The reflex signal barriers 10 and 11 cooperate with the scanned edges preferably by photo-electrical means. Thus the vehicle may be provided with light sources and radiation sensitive semiconductor elements for detecting light radiation reflected by the reflectors onto the radiation sensitive elements. The control actuating means may however be of a different type, e.g. using ulorasonic reflectors or employing inductive or magnetic fields, suitable responders being provided in place of the optical reflectors.

When the vehicle 9 moves along the path of travel 8 toward the left as shown in the drawing, i.e. in the direction indicated by the arrow on the vehicle, corresponding to forward travel, then the scanned edges 1 - 3 are disposed at the rearwardly disposed or trailing edges of the reflectors 4 to 6 when looking in the direction of travel. With this direction of travel and the described arrangement, the reflex signal barriers are adapted to provide a control signal upon the transition from a bright to a dark condition in the radiation sensitive elements. When passing the scanned edge 3, the reflex signal barrier 10 generates a signal which initiates a stop range path count by actuating a path pulse counter that continues counting until the trailing reflex signal barrier 11 moves past the scanned edge 3 and thereby generates another signal. By this other signal the path pulse counter is again reset. The sequence of the signals generated by the two reflex signal barriers 10 and 11 allows a path-of-travel count to be advanced to indicate that the vehicle has moved past the stop which is characterized by the scanned edge 3.

As may be seen from the above explanations, the path pulse counter delivers a series of path pulses along a path of travel 12, and therefore this path pulse counter may be termed "path pulse generator" in the following. Within this path of travel 12, the vehicle may be stopped at any position with respect to the scanned edge 3, provided a stop has been preselected. The distance 12 corresponds to a stop range within which the vehicle 9 may be manoeuvered.

When the vehicle 9 travels along the path of travel 8 in a reverse direction, i.e. backwardly, the above described operations are reversed insofar as the path pulse generator is triggered by the reflex signal barrier 11 and will again be deactivated by the reflex signal barrier 10 if the vehicle is not intended to be brought to a standstill at this stop. With this direction of travel, directional elements in the signal generators of the reflex signal barriers are adjusted so as to provide signals only when a reflector 4 - 6 is being approached, i.e. when the reflected signal or the received signal is provided at the scanned edges 1 - 3.

In other words, the control signals are being triggered for transitions from a dark to a bright condition, and this in contrast to forward travel in which the signals are triggered when the vehicle moves away from a reflector and there occurs a transition from a bright to a dark condition.

As illustrated in Fig. 2, the reflex signal barrier 10 when moving past the scanned edge 1 in the direction indicated by the arrow on the vehicle (shown partly by a dash dot line) triggers path count pulses 13 of short length, and since the generation of these pulses 13 is dependent upon the movement of the vehicle, these pulses indicate the distance between the forward or leading reflex signal barrier 10 when looking in the direction of travel and the scanned edge 1. As will be apparent, the single scanned edge 1 allows to indicate the exact position of the vehicle within a stop range as predetermined by the path length 12 between the two reflex signal barriers 10 and 11. The path count pulses 13 indicated schematically in Fig. 2 are counted in the controller described further below. If the vehicle continues to move forwardly when no target has been program-dated within this stop range, the path count pulses will be generated until the trailing reflex signal barrier 11 moves past the scanned edge 1 and during this passage provides a signal by which the path count pulses 13 in the controller are erased. The described embodiment allows an exact positioning of the vehicle within the range 12, provided, of course, a target has been program-dated or preselected within this range that is "covered" by the path count pulses 13. For proper operation, the scanned edges would have to be located at the forward end of a stop range at each stop.

Figure 3 illustrates an arrangement similar to the one shown in Fig. 2, for explaining a specific method of positioning a vehicle with respect to the scanned edge 1, within a stop range corresponding to the distance 12. In this embodiment, the reflex signal barrier 10 when moving past the scanned edge 1 sets a signal corresponding to a number, as will be explained more in detail in the following. This number or the signal corresponding thereto may be applied to the path pulse generator or to a comparator for target detection or an actual value detector respectively. With respect to the number of path count pulses within a stop range, the number is composed of a constant 14 corresponding to half the length of the distance 12, a variable relating to a program-dated stop and to specific properties of the vehicle. In Fig. 3, this variable is indicated by two arrows 15 and 16 whereby the portion of the signal or the variable in the direction of the arrow 16 would be added to the constant 14, and the portion of the signal or the variable in the direction of the arrow 15 would be subtracted from this constant 14.

If the variable were to correspond to arrow 16, there will be obtained the program-dated stop position indicated at 17 within the stop range 12, and the vehicle will be brought to a standstill when having moved through the distance from the reflex signal barrier 10 to the stop position 17, after the reflex signal barrier 10 has provided a first signal.

The terms "constant" and "variable" relate to signals the magnitude of which corresponds to a certain number of path count pulses 13 of the type shown in Fig. 2. The constant and the variables are schematically indicated in Fig. 3 by the distance marked 14 and the two arrows 15 and 16 respectively. In practice, the reflex signal barrier 10 triggers a constant signal 14 that will be superposed by a second signal that corresponds to the variable, as illustrated by the arrows 15 and 16. When the variable corresponds to the arrow 16, the resulting signal will select the position 17. When the variable corresponds to the arrow 15, the resulting summing signal will pre-set the stop position 18 within the stop range characterized by the distance 12. The longitudinal position resulting from the superposed signals according to any of the two arrows 15 or 16 is thereby dependent upon set stop position data and upon specific properties of the vehicle whereby the magnitude of the superposed signals is already predetermined when triggering the path pulse counter. The path pulse counter provides path count pulses in response to the actual path of travel, and these pulses are compared with the resulting signal, in thereby bringing about the standstill of the vehicle if as shown in Fig. 3 one end of the program-dated signals is reached at the stop positions 18 or 17 with respect to the reflex signal barrier 10. When the stop with the scanned edge 1 has not been targeted, the overall stop range path count, together with the signals applied, will again be erased when the reflex signal barrier 11 moves past the scanned edge 1.

The comparison may be made for example with an assembly of the type shown in Fig. 4. As shown in this Fig. 4, this assembly comprises a voltage divider 61 having two circuit legs 62, 63, with a center tap 64 in between. This center tap 64 is connected to a signal processing amplifier 65 whereby the overall assembly is arranged so as to provide a signal to a vehicle brake actuator 66 if the voltage at the center tap 64 equals zero. A variable voltage source 67 is connected to the circuit leg 63, and another variable voltage source 68 is connected to the circuit leg 62. The voltage source 67 may be activated for example by the path pulse counter so as to supply a voltage of e.g. - 10 volts in the midway position of a stop range. When under these conditions the voltage source 68 adapted to be controlled in dependence upon specific correction properties of the vehicle supplies a voltage of + 10 volts corresponding to a correction magnitude zero, then the center tap 64 will be at the signal triggering voltage level zero. In this example, the variable voltage source 68 may be adjustable within a range of from zero to 20 volts in dependence upon specific correction properties of the vehicle. If the variable voltage source 68 supplies a voltage different from + 10 volts, then the variable voltage source 67 must supply a correspondingly different voltage when the center tap 64 is to be at a voltage level of zero volts. Since the voltage supplied by the voltage source 67, however, varies in dependence upon the path count along the stop range, the voltage supplied by the voltage source 67 will balance the voltage supplied by the voltage source 68 to the center tap 64 in a position that is forwardly or rearwardly displaced with respect to the midway position of the stop range, and at this position the stop signal will be triggered.

The modified arrangement with superposed signals as indicated by the arrows 15, 16 greatly increases the manoeuvrability of the vehicle and allows the vehicle to be brought to a standstill in a plurality of positions along a stop range, thus facilitating the performance of specific operations. This important and highly advantageous characteristic cannot be realized in heretofore known tape scanners. Especially vehicle dependent and variable parameters may be introduced into the superposed signals corresponding to arrows 15, 16, and an example would be to bring the vehicle to a standstill in a position that is slightly offset with respect to the midway position of the stop range, in order to allow a more exact positioning at a certain hoisting elevation when the hoisting frame of the vehicle is for example deflected under the weight of a load.

In Fig. 5a is shown schematically a two-track increment pickup 30 comprising a rotatably mounted driven disc 19 adapted to be rotated in dependence upon the movement of the vehicle. Two tracks 69, 70 extend about the periphery of the disc 19 and include a plurality of mutually offset and partially overlapping slots or reflecting strips 20 to 23. Facing one side of these tracks is mounted a reflex transmitter/receiver 25, 26 having two photocells. Each of the two photocells is adapted and aligned to scan one of the two tracks 69 and 70. This assembly includes for example light sources when the arrangement operates by optical scanning. The reflex transmitter/receivers 25, 26 constitute components of the path pulse generator 24. As shown in Fig. 5b, the path pulse generator 24 supplies two output voltages 71, 72 at the outputs of the receivers 25, 26, and these two output voltages 71, 72 are mutually phase-shifted by 90 degrees. The sequence of these two output voltages or respectively the sense of phase shift provides the signal of the direction of travel of the vehicle. One of the two output voltages 71 and 72 is employed for providing a signal train constituting the path count pulses 13 of Fig. 2 which when triggered by the reflex signal barrier 10 represent the distance travelled by a vehicle within the stop range and provide a comparison value for a preset stop position signal.

The determination of the rotary direction of the disc 19 and thereby the direction of travel of the vehicle may be made by conventional circuitry to providing a directional signal responsive to the sequence of signals provided by the receivers 25 and 26. The overall arrangement is termed "increment pickup" in the present specification.

As may be seen from the block circuit diagram of Fig. 6, the two reflex signal barriers 10, 11 are connected to an evaluator 27. The evaluator 27 detects whether both reflex signal barriers have one after the other moved past a scanned edge in one and the same direction of movement. A switching device 73 is associated with the reflex signal barriers or the evaluator 27 respectively, and this switching device may be set in response to the direction of travel so as to provide control signals either for transitions from a bright to a dark condition or for transitions from a dark to a bright condition at the light sensitive elements of the reflex signal barriers.

The signals thus derived are subsequently fed to a counter 28 the output of which is connected to an actual value detector 29 for the actual counting operation of the vehicle. The vehicle includes an increment pickup 30 such as the one shown in Fig. 5a, and the output of this pickup 30 is connected to a system 31 for providing path count signals, and to an associated system 32 for providing travel direction signals. The travel direction signals are supplied via a functional line 33 to a sign store 34. The output of the sign store 34 is connected through a functional line 35 with the evaluator 27 and the switching device 73, and through another functional line 36 to the actual value detector 29. The signals supplied to the evaluator 27 set the evaluator so that the evaluator determines which of the two reflex signal barriers 10 or 11 will supply the so-called first signal for triggering the devices 31, 32, and which of the two reflex signal barriers will reset the path count signal device 31. The corresponding control operation will be performed through the functional connection 37. Concurrently with the setting of the evaluator 27, the signal processing will be adapted to the direction of travel, for the proper indication of the scanned edge.

The functional line 36 connecting the output of the sign store 34 to an input of the actual value detector 29 applies to this detector a correction value in dependence upon the direction of travel, the order to ensure that effectively the scanned edges 1 to 3 of the reflectors are evaluated. The output of the path count signal device 31 is connected through a functional connection 38 to the actual value detector 29 because the position of the vehicle within a stop range is part of the actual value if a stop is program-dated within the stop range of a stop, in addition to the signal provided by the counter 28. The output of the actual value detector 29 is connected through a functional connection 39 to a comparator 40. Another input of the comparator 40 is connected through a functional connection 41 to the output of a target selector 42 for providing a target value. The output of the comparator 40 is connected through a functional connection 43 to a motor controller 44. When the comparator provides a signal indicating that the vehicle approaches a stop with a stop position, the motor controller 44 brings the vehicle to a standstill at the desired position. A functional connection 61 between the comparator 40 and the path count signal device 31 allows to erase the path count signal and to set the device 31 into standby if the comparator 40 does not detect any program-dated stop.

An important aspect of this system is a correction calculator 45. This correction calculator 45 may have two inputs 46, 47 connected to corresponding measuring devices 48, 49 respectively for providing specific properties of the vehicle such as the weight of a load carried by the vehicle and the stacking height of a load of a hoisting mechanism. These measured values are to be considered merely as examples, and there may of course be provided other parameters. The specific correction parameters for a vehicle with respect to the hoisting mechanism assembly and to forward or backward travel of the vehicle are introduced in dependence upon the sign provided by the sign store 34.

The correction calculator 45 is connected by a functional connection 50 to the actual value detector 29 so that the instantaneous actual value may be corrected in the actual value detector 29 before this value is introduced into the comparator. This correction corresponds to signals of the type illustrated by arrows 15, 16 in Fig. 3.

Additionally, there may be provided a stop position tolerance selector 51 for providing a tolerance signal to the motor controller 44, and a shelf corridor identificator 52 connected through a functional connection 53 to the actual value detector 29 for transmitting a signal appearing at the input 54 of the shelf corridor identificator 52 to the actual value detector. These signals appearing at the input 54 may serve to identify the initiation of stop range path counting in a corridor between shelves and the end of this corridor from which the counting starts. In dependence upon signals of this type as picked up at each end of a corridor between shelves, there will be activated adding and/or subtracting circuits in the actual value detector, in logical combination with signals provided from the sign store 34.

Referring to Fig. 7, the vehicle 9 of Fig. 1 is shown schematically by its contours in elevation. The vehicle 9 includes a hoisting mechanism with a hoisting frame along which may be moved in opposite directions upwardly and downwardly a hoisting carriage 56. The vehicle 9 is furthermore provided with an odometer wheel 58 adapted to be adjusted into a downwardly extending position by a transmission 57. The odometer wheel 58 serves to drive the increment pickup 30. The hoisting carriage 56 includes a load weighing device 59. The assembly of hoisting frame 55 and hoisting carriage 56 is provided with a height indicator 60 for detecting the actual position of the hoisting carriage 56. These measuring devices provide signals to the inputs 46, 47 of the correction calculator 45. The measuring devices 59, 60 are conventional. The vehicle may be supported by wheels 74 and 75 (only the wheels on one side being shown). Fig. 7 furthermore illustrates another type of drive assembly for an increment pickup 30', this assembly including a drive disc 76 drivingly engaging the circumference or a tire of the vehicle wheel 75. The vehicle 9 also includes two reflex signal barriers 10, 11 that are mounted on one side of the vehicle at the same spacing from the ground.

WHAT WE CLAIM IS:

1. A control and monitoring apparatus for positioning a load-handling vehicle at predetermined stations on a path of travel, comprising a responder located at each station on the path, each responder having a scanning edge perpendicular to the direction of travel of the vehicle along the path, a pair of scanning devices mounted on the vehicle, each scanning device being adapted to provide a signal as the device passes the scanning edge of each responder, the two scanning devices being separated from one another by a distance measured longitudinally of the vehicle which corresponds to a range of stopping positions at each station, each said responder being shorter than the distance between the two scanning devices, a pulse generator adapted to supply a train of pulses corresponding to predetermined path increments in the said range, the pulse train being initiated by a signal from the scanning device which first passes the scanning edge of each responder and terminated by a signal from the other scanning device unless there is a preselected stopping position within the said range of stopping positions, and means for stopping the vehicle at a preselected count of pulses in the train

corresponding to a preselected stopping position within the said range.

2. Apparatus as claimed in claim 1, in which the scanning edge of each responder is positioned at the mid-point of the range of stopping positions for the associated station and the predetermined pulse count corresponding to a preselected stopping position in the said range is a number formed by summing a constant corresponding to half the length of the said range and a variable ± x the sign of which is determined by the direction of travel of the vehicle and the magnitude of which is determined by selected specific properties of the vehicle.

3. Apparatus as claimed in claim 1 or claim 2, in which the pulse generator is mounted on the vehicle and is adapted to be triggered by a signal from the scanning device which is foremost in the direction of travel, to provide path count pulses and a signal indicative of the travelling direction in dependence upon the sense of counting, calculating means for computing an actual value on the basis of the actual path count pulses and a count of the number of stations already passed by the vehicle, and comparator means for comparing the actual value with a stored target value, and means for deactivating and resetting the pulse generator, in the absence of a stored target position at a station being approached by the vehicle, in response to a signal from the trailing scanning device as it moves past the scanned edge of the responder at the station.

4. Apparatus as claimed in claim 3, in which there is provided a station counter for counting the number of stations passed by the vehicle, the station counter being adapted to be set for a path of travel corresponding to stops arranged along a corridor between shelves in response to signals from the trailing scanning device when the vehicle moves backwards, the path pulses generated by the path pulse generator being subtracted from the settings of the station counter, the vehicle control means including a travel direction store adapted to be triggered by the path pulse generator, a store for a path of travel including adding and subtracting means and adapted to be triggered by the leading scanning device in the direction of travel.

5. Apparatus as claimed in claim 4, in which there are provided switching means associated with the scanning devices, the switching means being adapted to set an evaluator means in dependence upon the direction of travel to provide control signals during transitions from bright to dark or from dark to bright conditions.

6. Apparatus as claimed in any one of claims 2 to 5, in which a counter is associated with an actual value detector and a comparator, the counter providing a zero count for pulse counting midway in the range of stopping positions and adapted to receive correction values indicative of specific selected properties of the vehicle for increasing or decreasing the number of path count pulses required to arrive at the zero count.

7. Apparatus as claimed in claim 6, in which the comparator consists of a voltage divider circuit with a centre tap and two circuit legs, one of these circuit legs being adapted to receive a voltage corresponding to the pulse count, and the other of these circuit legs being adapted to receive a voltage indicative of specific correction properties of the vehicle.

8. Apparatus as claimed in claim 6 or claim 7, in which there is provided a correction calculator adapted to receive at its inputs signals indicative of specific selected properties of the vehicle, and providing at its output signals to the actual value detector or to the comparator and in which there are provided on the vehicle measuring devices for providing signals indicative of specific selected properties of the vehicle, including a height indicator for detecting the position of a load-lifting carriage and a load weighing device for measuring the load on a load receiving member of the carriage.

9. Apparatus as claimed in claim 3, in which the pulse generator comprises an increment pickup coupled to a member of the vehicle that is movable in dependence upon the travelling movement of the vehicle.

10. Apparatus as claimed in claim 9, in which a drive disc of the increment pickup is in driven engagement with the circumference or a tyre of a wheel of the vehicle wheel.

11. Apparatus as claimed in claim 9 or claim 10, in which the increment pickup is the kind having two tracks adapted to generate pulses.

12. Apparatus as claimed in claim 3, in which the vehicle includes an odometer wheel adapted to drive an increment pickup forming the pulse generator.

13. Control and monitoring apparatus for positioning a vehicle at predetermined stations along a path of travel, constructed, arranged and adapted to operate substantially as described with reference to, and as shown in, the accompanying drawings.

Agents for the Applicants
MATHYS & SQUIRE
Chartered Patent Agents
10 Fleet Street
London EC4Y 1AY

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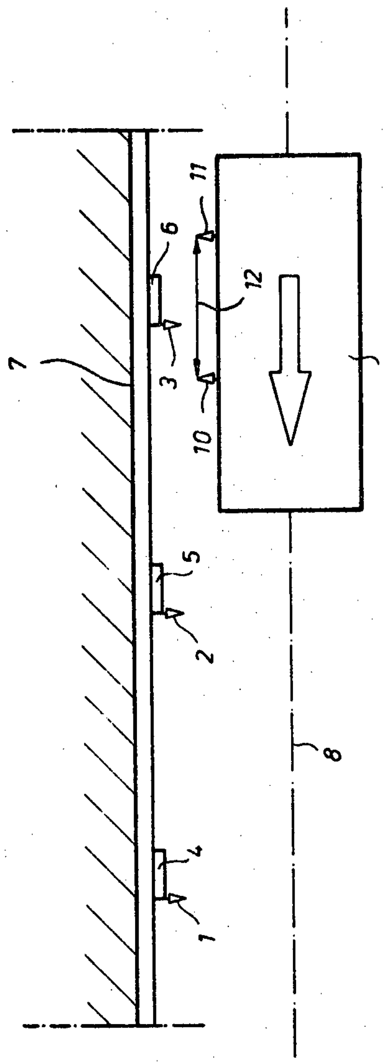
1584992 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig.1



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Sheet 2

Fig. 2

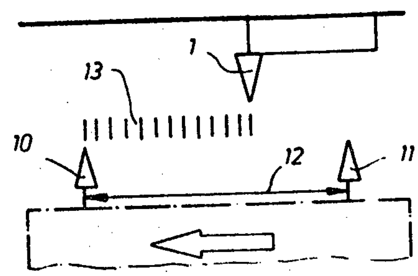


Fig. 3

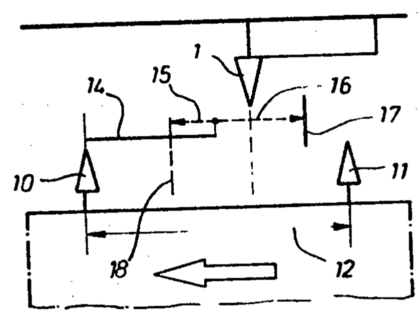


Fig. 4

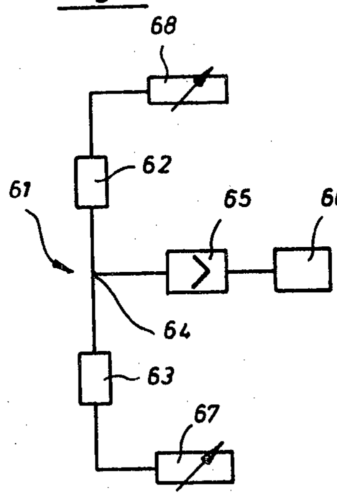


Fig. 5a

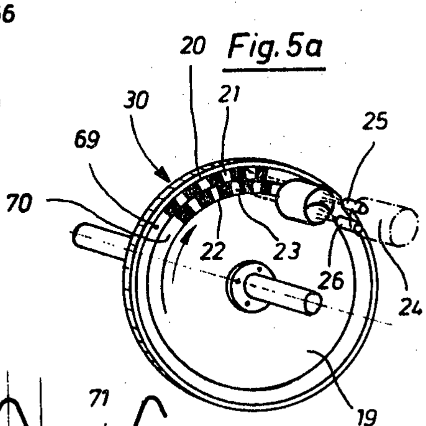
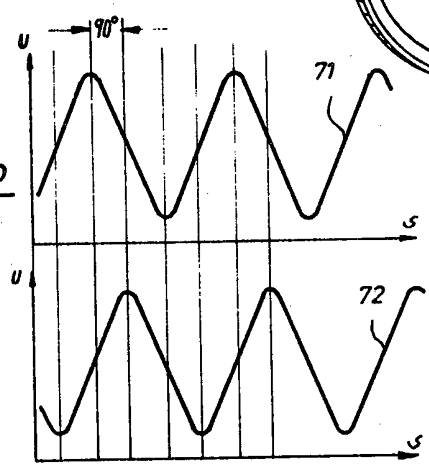


Fig. 5b



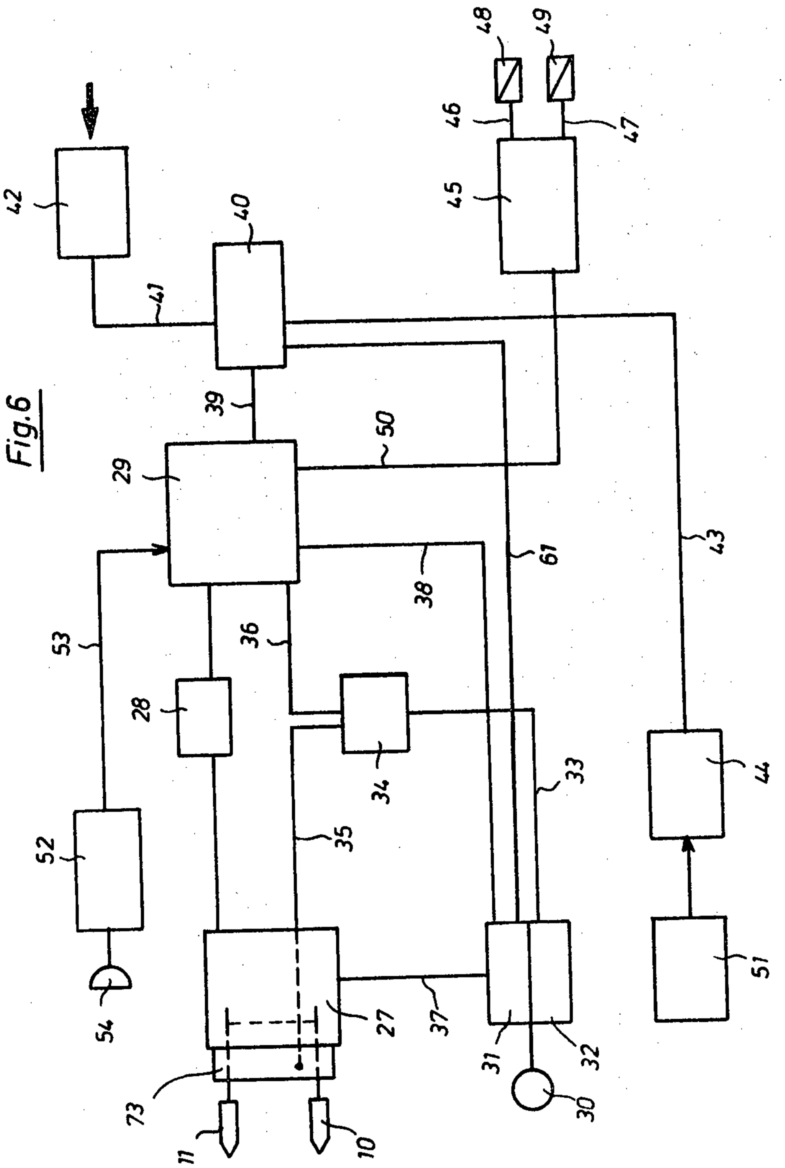

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Fig.6

Fig.7