United States Patent

Burch

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[54] ELEVATOR VERTICAL SHIFT AND LATERAL DOLLY CONTROL SYSTEM

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[52] **U.S. Cl.** ....**187/29 R,** 214/16.4
[51] **Int. Cl.** **B66b 1/46**
[58] **Field of Search** 187/29; 214/16.4

[56] **References Cited**

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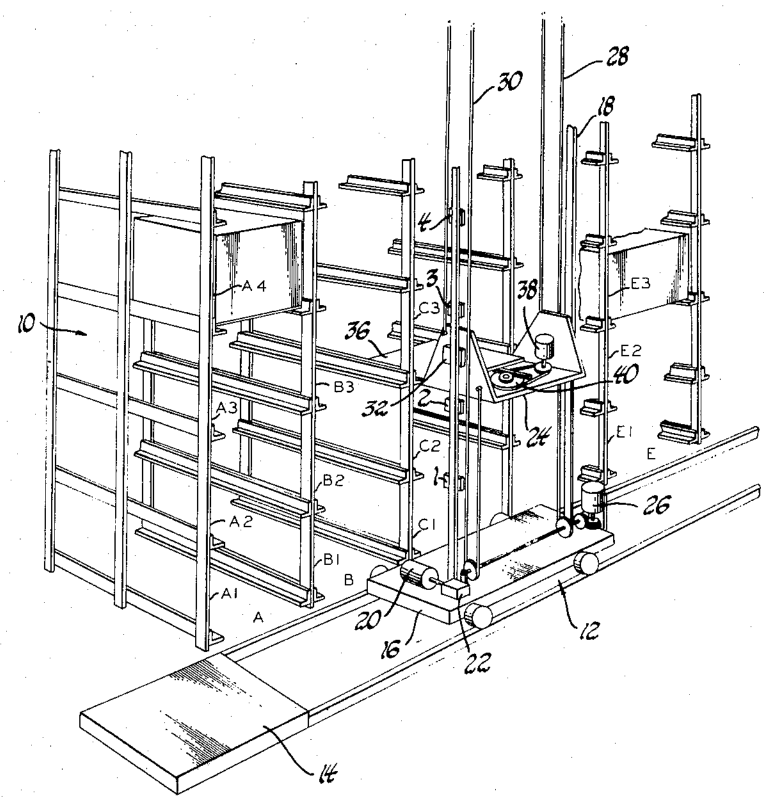
[57] **ABSTRACT**

An automatic control system is disclosed for an elevator of the type adapted for material handling in an automatic warehouse. The control system includes means for moving the elevator selectively to one of two different vertical null positions in accordance with the desired operation of either depositing or withdrawing a material unit from an adjacent bin. The first and second null positions are established by a first and second pair of transducer means on the elevator car which coact with a reference signal device on the elevator mast. The first and second transducer means may be selectively enabled and disabled to cause a shift of the elevator from one null position to the other. The elevator car is provided with a lateral dolly movable between an extended position and a retracted position for the manipulation of the material unit. An automatic control system is provided for the lateral dolly to correlate the motion thereof with the vertical shift of the elevator between the null positions in a sequence dependent on whether a material unit is being deposited or withdrawn from the bin.

10 Claims, 5 Drawing Figures



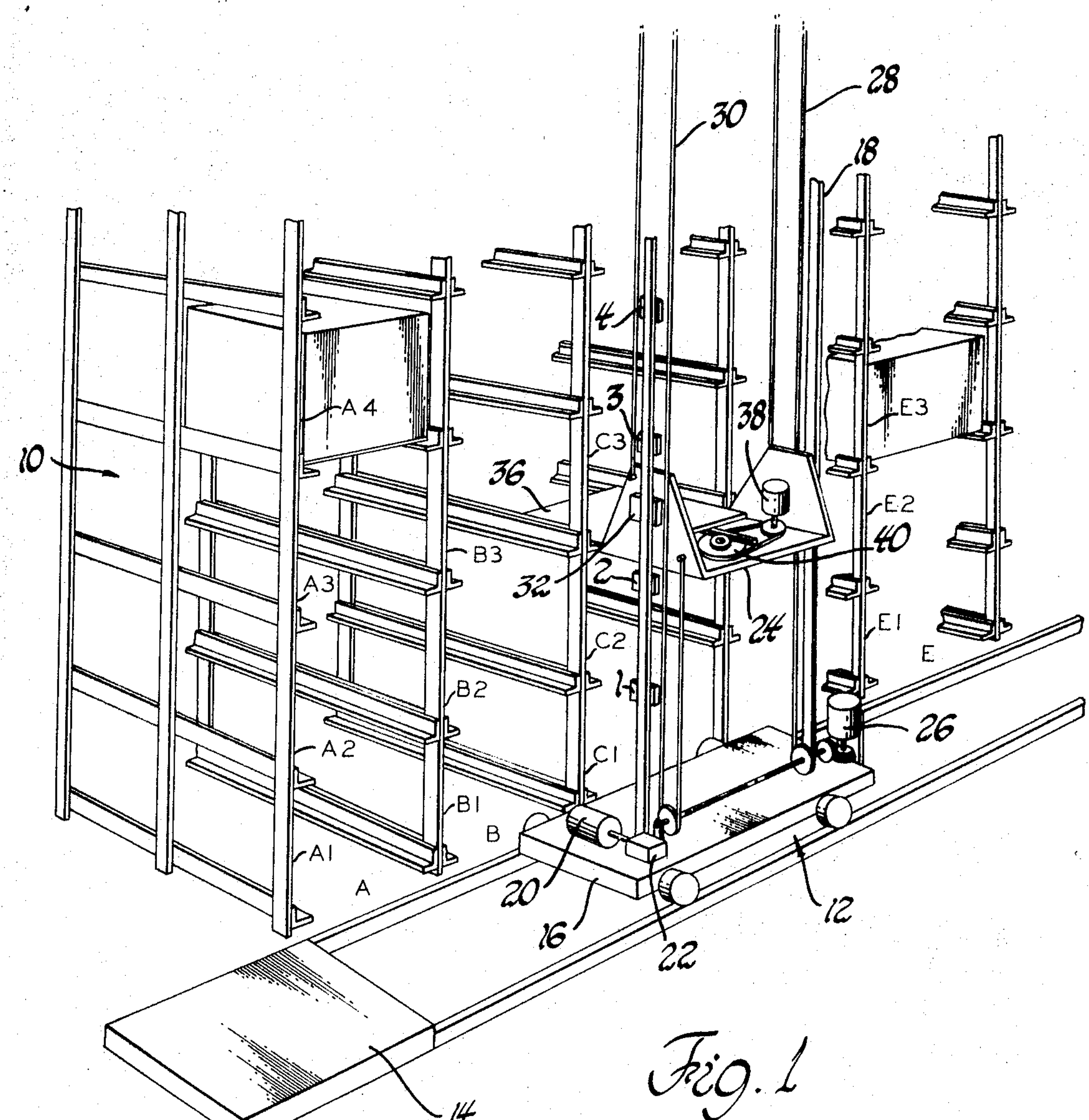


Fig. 1

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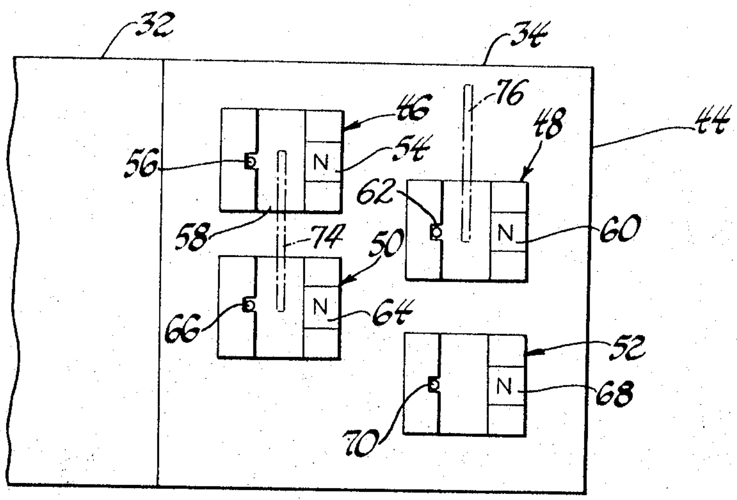

Fig. 2

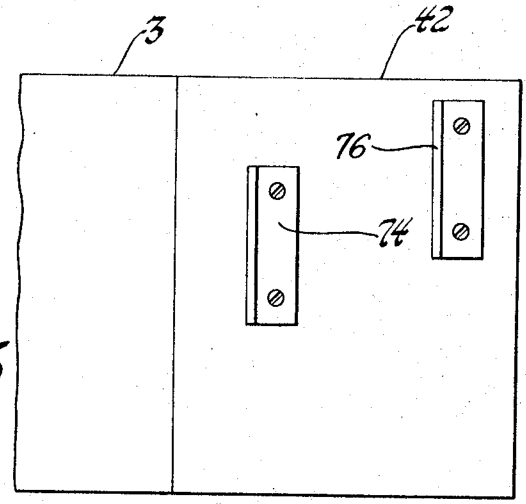

Fig. 3

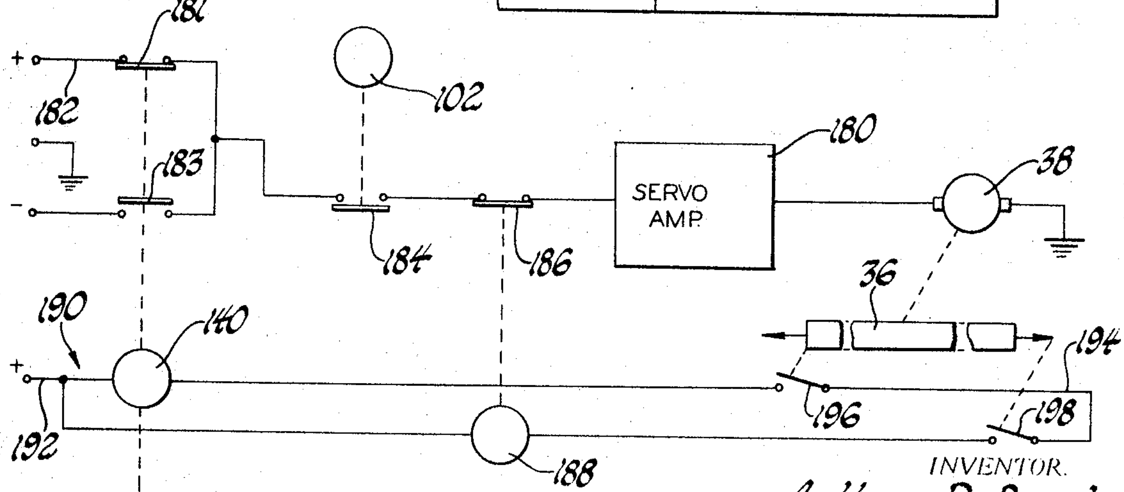

Fig. 4

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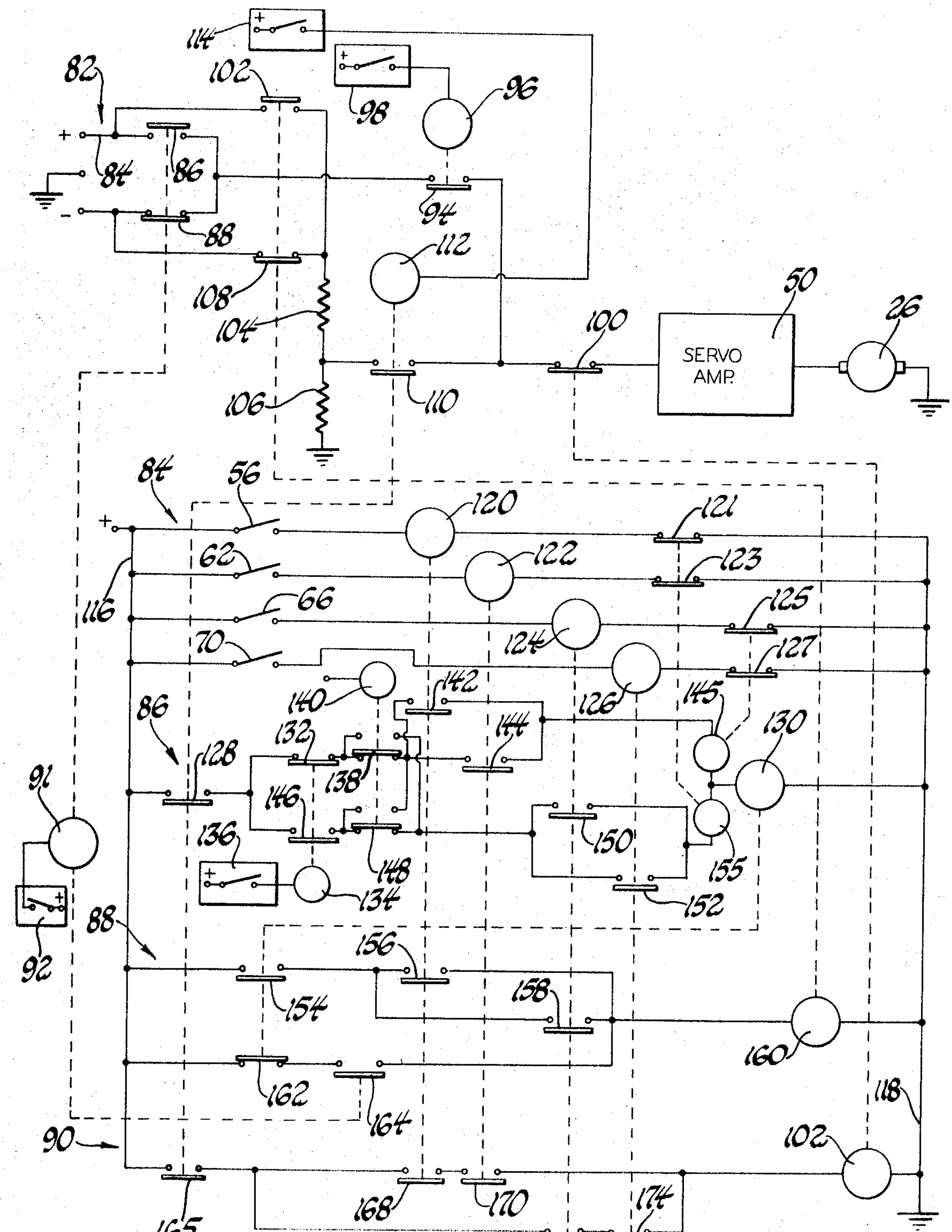

Fig. 5

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ELEVATOR VERTICAL SHIFT AND LATERAL DOLLY CONTROL SYSTEM

This invention relates to control systems for material handling vehicles and, more particularly, it relates to elevator control for depositing a material unit or withdrawing it from storage.

Automatic warehouse systems have been developed in which a very large number of storage bins are arranged in rows and columns on each side of multiple access aisles and are served by automatically controlled material handling vehicles. Such a vehicle, commonly called a stacker vehicle, is adapted to pick up a material unit at a load station and to move under automatic control to a destination station and deposit the material unit in a storage bin at such station. Similarly, the stacker vehicle may automatically pick up a material unit from a storage bin at any station and move automatically to the load station or to another storage bin and deposit the material unit. Such a system has been developed in which automatic control means reads the addresses on the stations while the vehicle is enroute for controlling the motive power means of the vehicle. A system of this type is disclosed in U.S. Pat. No. 3,503,530 issued to A. R. Burch et al. on Mar. 31, 1970 for "Transfer Cart for Transferring an Article Handling Vehicle Between Aisles of a Warehouse."

In systems of the type referred to above the stacker vehicles include a mast and an elevator car movable therein for access to the storage bins at different elevations. The elevator car is adapted to move under automatic control to the vertical level of the assigned bin and assume a null position relative thereto which insures accurate alignment of the elevator car with the bin for transfer of a material unit. The elevator car is provided with a dolly which is movable laterally into the bin area for deposit or withdrawal of the material unit. In order to manipulate the material unit for deposit or withdrawal, the elevator car may be moved upwardly after the extension of the lateral dolly to lift the material unit from its support prior to the retraction of the lateral dolly to the elevator car. For deposit of a material unit this sequence may be reversed. For this purpose, an upper level null position and a lower level null position are established for the elevator car and a control system which correlates the operation of the lateral dolly with the vertical null positioning of the elevator car is provided. Such a control system is disclosed and claimed in the copending patent application Ser. No. 782,559 (Docket 1972) filed by Arthur R. Burch et al. on Dec. 10, 1968 for "Depositing Means for Material Handling Systems" which is assigned to the same assignee of the present application. In the control system just referred to, the elevator car is provided with a transducer for sensing a null signal element on the mast of the stacker vehicle to control movement of the car to the null position. To manipulate the material unit in the deposit and withdrawal modes of operation as described above, the transducer on the elevator car is shiftable between an upper and lower position to establish lower and upper null positions, respectively.

This invention resides in an improvement in the automatic control system of the type referred to above for operation of an elevator or the like in deposit or withdrawal of a load. In accordance with this invention first and second null positions are established by a first and second transducer means which are spaced apart and adapted to respond to the same reference signal device. The system includes means for automatically enabling one transducer means and disabling the other for selecting the first or second null positions. Additionally, in accordance with this invention, the automatic shifting of the elevator car from one null position to the other is correlated with the motion of a load handling dolly to operate in a load deposit or load withdrawal sequence. This is accomplished by a control circuit in which the load handling dolly is enabled for operation when the elevator reaches a null position according to the prescribed deposit or withdrawal mode. When the dolly is actuated to its extended position, a control circuit causes switching of the null position transducers thus effectively shifting the elevator away from its null position and disabling the dolly actuator until the elevator car has reached the newly established null position. Thereupon the dolly control circuit is enabled to return the dolly to its retracted position.

Additionally, in accordance with this invention, there is provided a null positioning system for an elevator car in conjunction with the first and second null transducer means which affords a high degree of accuracy in positioning the car at either null position. This is accomplished by a pair of transducer means, each of which includes a pair of sensors which function in the manner of a proximity detector and a signal device coacting therewith to establish the reference position. The null position is established when the sensors are operated simultaneously in response to sensing predetermined portions of the signal devices.

A more complete understanding of this invention may be obtained from the detailed description which follows taken with the accompanying drawings in which:

FIG. 1 is a diagrammatic representation of an automatic warehouse system including the storage bins and the stacker vehicle;

FIG. 2 shows the transducer;

FIG. 3 shows the signal device;

FIG. 4 and FIG. 5, taken together, are a schematic diagram of the automatic control system for the elevator car and lateral dolly.

Referring now to the drawings, there is shown an illustrative embodiment of the invention in an automatic warehouse system wherein a self-propelled stacker vehicle is adapted to transport a material unit between a selected storage bin and a load station or between two storage bins. The control system in which the invention is embodied exercises control over the elevator on the stacker vehicle to cause it to shift between an upper and lower null position in a sequence which enables the lateral dolly of the elevator to deposit or withdraw a material unit from a bin.

Referring now to FIG. 1, an automatic warehouse including a stacker vehicle is shown in diagrammatic form. A warehouse adapted for automatic deposit and withdrawal of material units includes a storage structure with bin assemblies of which bin assembly 10 is representative. An access aisle extends between the bin assemblies and accommodates a stacker vehicle 12 movable on a track in the aisle in a forward and backward direction relative to a load station 14. The bins are arranged in columns and rows along the aisle with a column of bins being located at a station A wherein a bin is provided at different vertical levels. Similarly, a column of bins is provided at stations B, C, D, etc., with individual bins at the different vertical levels thus providing a row of bins, A1, B1, C1, D1, etc., and a row of bins A2, B2, C2, etc.

In order to deposit and withdraw material units such as are shown in bins A4 and E3 from any selected bin, the stacker vehicle 12 is adapted for automatically controlled movement forward and backward in the aisle to any station. The vehicle comprises an undercarriage 16 on a set of wheels suitably supported on rails in the aisle. The stacker vehicle also includes a superstructure or mast 18 mounted on the undercarriage and which extend to a height corresponding to the upper row of bins to be served by the stacker vehicle. The vehicle is self-propelled and includes a traction motor 20 coupled through a power transmission unit 22 to the traction wheels of the vehicle. The traction motor and other power consuming load devices on the stacker vehicle are suitably supplied with electrical power through a trolley system, not shown. By means of a longitudinal position control system which includes address means at each of the stations A, B, C, D, E, etc., and a transducer on the stacker vehicle 12, the vehicle will automatically move from its initial position to a designated destination station in accordance with a command signal representing instructions supplied by an operator to the command input for the vehicle.

The stacker vehicle 12 comprises an elevator car 24 which is movable vertically in the mast 18 and which may be positioned at any bin at a selected station. For this purpose the elevator car **24** comprises an elevator motor **26** which is connected through a drive unit to the elevator cables **28** and **30** at opposite sides of the car **24**. In order to provide for automatic control of the elevator car **24**, each level of the bin assembly or the bin row is provided with the bin row address means **1, 2, 3, 4**, etc., mounted on the mast **18** of the stacker vehicle. A bin row transducer **32** is mounted on the side of the elevator car for coaction with the bin row address means and is operatively connected with the control system for the elevator motor **26** to control the movement of the elevator car to any assigned bin row, in accordance with the instructions supplied to the command input of the stacker vehicle by an operator.

In order to provide for deposit or withdrawal of a material unit from a selected bin, the elevator car **24** is provided with a lateral platform or dolly which is normally at rest in a retracted position on the elevator car but which is automatically movable to an extended position into the adjacent bin. For this purpose, the dolly **36** is provided with a drive motor **38** and a drive unit **40** adapted to extend or retract the dolly from the elevator car **24**. The automatic control system for the dolly **36** is adapted when the elevator car is properly positioned at the bin address to initiate a cycle of operation in which the dolly is first actuated to its extended position and then is actuated to its retracted position. However, the control system for the dolly is correlated with the control system for the vertical positioning of the elevator car referred to above so that the elevator car undergoes a vertical displacement from a first null position to a second null position while the dolly is in its extended position. The sequence of such movement of the dolly is determined by the command input to the stacker vehicle which includes instructions as to operation of the dolly in either the withdraw mode or in the deposit mode at the assigned bin. If the withdraw mode is indicated by the instructions so that a material unit is to be removed from the assigned bin, then the elevator car **24** is initially positioned at the lower null position wherein the dolly **36** is aligned just below the bottom surface of the material unit or the pallet which it is supported. In this position the dolly is moved to its extended position underneath the pallet for the material unit and then the elevator is shifted in its vertical position from the lower null position to the upper null position thus lifting the pallet off of the support in the bin. Then the control system causes the dolly to be moved to its retracted position thereby withdrawing the material unit from the bin and placing it on the elevator car **24**. On the other hand, if the input instructions call for a deposit mode, the elevator car **24** is initially positioned at the upper null position which positions the pallet under the material unit somewhat above the support member in the bin. Then the dolly is caused to move to its extended position thereby moving the material unit to a position in the bin. Upon reaching the extended position the elevator car is caused to shift to its lower vertical null position which moves the dolly downwardly until the material unit rests on the support members of the bin and slightly further to clear the dolly from the material unit. Then the dolly is caused by the control system to move to its retracted position on the elevator car thus completing the deposit cycle. In this condition the elevator car is empty and ready for movement to another bin in accordance with the instructions supplied.

As referred to above, an automatic warehouse system, as thus far described with reference to FIG. **1**, is fully disclosed in detail in U.S. Pat. No. 3,503,530 granted to Arthur R. Burch et al. on Mar. 31, 1970 for "Transfer Cart For Transferring an Article Handling Vehicle Between Aisles of a Warehouse" and in application Ser. No. 782,559 (Docket 1972) filed by Arthur R. Burch et al. on Dec. 10, 1968 for "Depositing Means for Material Handling Systems," both of which are assigned to the same assignee as the present application.

As stated above, the present invention relates to the automatic control system for causing the movement of the elevator car between the upper and lower null positions in correlation with the motion of the lateral dolly between its extended and

retracted positions. Since the automatic longitudinal control system for the stacker vehicle and the coarse or fast vertical control system for the elevator car form no part of the present invention and may take different forms, including that disclosed in detail in the above-mentioned patent and patent application, no additional description thereof is required herein. The present invention will be described further with reference to the automatic vertical shift control system and the lateral dolly control system with the elevator car positioned at a selected bin C3 by the associated bin address means **3** and the transducer **32**.

In FIG. **2**, the transducer **32** is illustrated with a null position transducer **34** and in FIG. **3** the bin address means **3** is represented with an additional section comprising a null position signal device **42** which is mounted upon the mast of the stacker vehicle in alignment with the transducer **34** as will be described.

Transducer **34** includes sensing means which are responsive to the presence or absence of a magnetic field and function in the manner of a proximity detector with respect to the signal elements on the null position signal device **42**. As shown in FIG. **2** the transducer comprises a support plate **44** suitably of metallic construction and which is mounted in a vertical plane on the elevator car with the orientation indicated in the drawing. The transducer includes a first or upper pair of sensors **46** and **48** which are offset relative to each other as shown. The transducer also includes a second or lower pair of sensors **50** and **52** which are offset relative to each other as shown. All of the sensors are of the same construction and the description thereof will be given with reference to the sensor **46**. The sensor comprises a magnetic field producing means or permanent magnet **54** suitably of bar shape and a magnetic field responsive means in the form of a magnetic reed switch **56** and which are disposed oppositely to each other in spaced relation. The sensor **46** includes a nonmagnetic body which in horizontal cross-section is of U-shape. The body is constructed of a nonmagnetic material such as aluminum or a molded resin and supports the permanent magnet **54** in one leg thereof and the magnetic reed switch **56** is supported in a slot in the opposite leg. The magnetic reed switch **56** is a conventional type of single pole two terminal switch wherein a reed-type armature is adapted to open the contacts in the presence of a magnetic field at a predetermined field strength and to close the contacts in the absence thereof. The sensor **48** is provided with a permanent magnet **60** and a reed switch **62**. In a similar manner the transducer **50** is provided with a permanent magnet **64** and a reed switch **66**, and the sensor **52** is provided with a permanent magnet **68** and a reed switch **70**.

The null position signal device **42** on the bin address means **3**, as shown in FIG. **3**, comprises a support plate **72** suitably of metallic construction and a pair of plates or vanes **74** and **76** mounted thereon. The vanes **74** and **76** are of magnetic material, such as sheet steel, and have a magnetic permeability which is high relative to that of air. The vanes **74** and **76** are suitably formed with a mounting flange secured to the support plate **72** and are positioned thereon so that the vane **74** is in alignment with the air gap of the sensors **46** and **50** and the vane **76** is in alignment with the air gap of sensors **48** and **52**. Furthermore, the vanes **74** and **76** are axially or vertically offset so that the upper edge of vane **74** is vertically spaced from the lower edge of vane **76** about the same distance as the vertical spacing between the reed switch **56** of sensor **46** and the reed switch **62** of the sensor **48**. The vanes **74** and **76** are of the same vertical length. The vanes **74** and **76** are of such size and in a position on the support plate **72** in its mounting on the mast of the stacker vehicle so that the elevator car in moving into or through the bin level represented by signal device **3** moves the transducer **34** so that vane **74** coacts with sensors **46** and **50** and vane **76** coacts with sensors **48** and **52**. It is noted, however, that since the vane **74** is aligned with the air gaps of sensors **46** and **50** it is straddled thereby without physical contact or engagement. Similarly, since vane **76** is aligned with the air gaps of sensors **48** and **52** it is straddled thereby without physical contact or engagement therewith.

As described above, in each of the sensors the reed switch is sensitive to the magnetic field of the associated permanent magnet and in the presence of such field the contacts of the reed switch are maintained in an open condition. However, with the vane of magnetic material disposed in the air gap of the sensor the magnetic field of the permanent magnet is distorted thereby because the vane represents a path of low magnetic reluctance for the magnetic flux and, accordingly, the flux field intensity in the vicinity of the reed switch is reduced causing the reed switch contacts to open. It is to be noted that the vanes **74** and **76** which occupy relative positions as shown in phantom lines on FIG. **2** are effective in the position indicated to cause the closure of the reed switch **56** of sensor **46** and simultaneously to cause the closure of the reed switch **62** in the sensor **48**. In the position shown, the upper edge of the vane **74** is approximately on line between the reed switch **56** and the magnet **54** and similarly the lower edge of the vane **76** is approximately on line between the reed switch **62** and the magnet **60**. Over a very small range of vertical movement of the transducer **34** the reed switches **56** and **62** will remain closed. However, if the transducer **34** moves beyond this limited range in the upward direction, reed switch **56** will open and if the motion beyond this range is in the downward direction the reed switch **62** will open. A similar relationship will exist between the sensors **50** and **52** and the vanes **74** and **76**, respectively.

The arrangement of the transducer and signal device described above is only one of several space relationships that may be employed. For example, the signal vanes **74** and **76** may be aligned horizontally with each other and the pair of sensors **46** and **48** may be vertically offset relative to each other, and the pair of sensors **50** and **52** would likewise be offset. Alternatively, the sensor pairs may be horizontally aligned and the signal vane may be vertically offset. Also the sensor may be paired up with sensors **46** and **50** constituting one pair and sensors **48** and **52** constituting the other pair.

Referring now to FIGS. **4** and **5**, an automatic control system is shown for moving the elevator car into the upper or lower null position selectively and correlating the lateral dolly motion between its extended and retracted positions. Referring first to FIG. **5** the system is adapted to control the energization of the elevator drive motor **26** which, as shown in FIG. **1**, moves the elevator in the vertical direction. The energization of the drive motor **26** is controlled by a servo amplifier **80** having its output connected with the motor and having its input connected with a signal voltage source **82**. In general, the control circuit further comprises the sensor circuit **84**. A null sensor selector circuit **86**, a transition or reversing control circuit **88** and a null responsive circuit **90**. The sensor circuit **84** and the sensor selector circuit **86** are controlled in accordance with a command signal for deposit or withdrawal of a material unit at the selected bin and by the position of the lateral dolly.

The transition or reversing circuit **88** responds to the null sensor selector circuit **86** to cause the elevator drive control to be transferred from and to ensure that the same direction of travel is maintained. It also operates to reverse the direction of the servo in the nulling mode of operation if the elevator car should overshoot the null position. The null responsive circuit **90** is controlled by the sensor circuit **84** and is effective in response to a null position of the elevator car to produce a null signal and deenergize the elevator drive motor **26**.

The control circuits shown in FIGS. **4** and **5** employ relays of the electro-magnet type with movable switching contacts as is quite conventional for control circuits, depending upon the application and performance required. It will be appreciated that the control circuits may also be implemented with the use of solid state switching devices and in certain applications such implementation will be found to be preferable.

The servo amplifier **80** for controlling the energization of the elevator vertical drive motor **26** is of the so-called "bang-bang" type and is adapted for on-off operation. When the input signal to the servo amplifier is of one polarity it will energize the motor in one direction and when it is of the other polarity it will energize the motor for rotation in the opposite direction. The speed of the motor is determined by the magnitude of the input signals and in the present system the motor is operated in either a high speed mode for moving between bins or in a low-speed or null-mode for seeking the null position at a given bin. The servo signal source **82** comprises a DC voltage source **84** having positive and negative supply terminals and a ground connection as indicated. For high-speed operation of motor **26** the voltage source **84** may be connected with positive polarity for upward direction through switch contacts **86** and with negative polarity for downward direction through switch contacts **88**. The direction of movement of the elevator is controlled by a direction control relay **91** connected with contacts **86** and **88** and energized to produce upward motion by a direction command input switch **92**. The signal voltage at the contacts **86** or **88** is applied through contacts **94** of a high-speed relay **96** which is energized to produce high-speed operation by a speed command input switch **98**. The high-speed signal voltage is further applied through null switch contacts **100** to the input of the servo amplifier **80**. The contacts **100** are actuated by a null relay **102** in the null responsive circuit **90**, as will be described subsequently.

For the low-speed or nulling operation of the drive motor **26** the voltage source **84** is connected for positive polarity and upward motion through switch contacts **102** across voltage divider resistors **104** and **106** and is connected for negative polarity and downward direction through switch contacts **108** to the voltage divider resistors. The signal voltage is further applied through switching contacts **110** and contacts **100** to the input of the servo amplifier **80**. Switch contacts **110** are operated by a null mode selector relay **112** which is energized for null mode selection by an address arrival command switch **114**.

The transducer circuit **84**, the sensor selector circuit **86** and the transition or reversing circuit **88** and the null responsive circuit **90** are connected for energization between a supply voltage line **116** and a ground or return line **118**. The transducer or sensor circuit **84** includes the reed switch **56** of sensor **46** connected in series with a control relay **120** and contacts **121** between the voltage supply line **116** and return line **118** so that the relay is pulled in when the reed switch **56** and contacts **121** are closed. Similarly, the circuit includes the reed switch **62** of sensor **48** connected in series with the control relay **122** and contacts **123**. Also, the reed switches **66** and **70** of the sensors **50** and **52** are connected in series, respectively, with the control relays **124** and **126** and the contacts **125** and **127**.

The null sensor selector circuit **86** includes, in series, switch contacts **128**, which are normally open and actuated by the address arrival relay **112**. The circuit also includes a first branch circuit for energizing a transition relay **130**. The first branch circuit comprises switch contacts **132** actuated by a mode relay **134** which in turn is energized by a mode command switch which determines operation of the elevator car in either the deposit or withdrawal mode. The first branch circuit further includes switch contacts **138** of a reversing switch which is actuated by a vertical shift control relay **140** which in turn is energized from the lateral dolly control circuit of FIG. **4**, which will be described subsequently. The branch circuit also includes switch contacts **142** and **144** connected in parallel and actuated respectively by the control relays **120** and **122**. A circuit is completed through a sensor selector relay **145** and the transition relay **130** to the return line **118**. The transition or null sensor selector circuit **86** includes a second branch which extends through switch contacts **146** actuated by the relay **134** and switch contacts **148** of the reversing switch which is actuated by the relay **140**. The branch circuit further includes switch contacts **150** and **152** connected in parallel and actuated by the control relays **124** and **126**, respectively. The circuit is completed through a sensor selector relay and the transition relay **130** to the return line **118**.

The transition or reversing circuit **88** adapted to maintain energization of the motor **26** in transition between high-speed and lowsspeed of the nulling mode of operation. It includes a first branch circuit with switch contacts **154** which are actuated by the transition relay **130**. This circuit further includes switch contacts **156** and **158** which are connected in parallel and actuated respectively by the control relays **122** and **124**. The first branch circuit is completed through a reversing control relay **160** to the return line **118**. The reversing control relay **160** actuates the switch contacts **102** and **108** which are adapted to energize the servo amplifier for upward and downward direction, respectively. The transition or reversing control circuit **88** includes another branch extending through switch contacts **162** which are actuated by the transition relay **130** and switch contacts **164** which are actuated by the direction control relay **91**. This circuit is completed through the transition relay **160** to the return line **118**.

The null responsive circuit **90** includes switch contacts **166** which are actuated by the address arrival relay **112**. The circuit further includes switch contacts **168** and **170** in series with each other and actuated by the control relays **120** and **122**, respectively, and a parallel circuit including contacts **172** and **174** in series with each other and actuated by the control relays **124** and **126**, respectively. The circuit is completed through the null relay **102** to the return line **118**. The null relay **102**, as previously mentioned, actuates the switch contacts **100** in the input of the servo amplifier **80**.

Referring now to FIG. **4**, there is illustrated the lateral dolly control system which, as previously mentioned, is interrelated with the elevator car vertical shifter control system just described with reference to FIG. **5**. The lateral dolly **36** on the elevator car is moved between its retracted and extended positions by the reversible motor **38**. The energization of the motor **38** is controlled by a servo amplifier **180** which is of the "bang-bang" type adapted for on-off operation and receives its input signal from a signal voltage source **182**. The voltage source **182** includes positive and negative supply terminals and a ground or return terminal as indicated. A signal voltage of positive polarity causes the servo amplifier to energize the motor **38** in a direction to extend the lateral dolly and a signal voltage of negative polarity causes retraction of the lateral dolly. The supply voltage source is connected to the input of the servo amplifier through switching contacts **184** which are actuated by the null relay **102** in the null sensing circuit **90** of the vertical shifter control system shown in FIG. **5**. The input signal to the servo amplifier is also applied through switch contacts **186** which are actuated by a control relay **188** energized in response to positioning of the lateral dolly **36** in its retracted position, as will be described later.

The lateral control system also includes a lateral dolly position responsive circuit **190** which extends between a voltage supply line **192** and a return line **194**. This circuit includes the control relay **140** in series with a position responsive switch **196** which is closed when the lateral dolly **36** reaches its extended position. The control relay **140** actuates the switch contacts **181** and **183** to change the polarity of the signal voltage from positive to negative, which correspond to extending and retracting motion respectively, when the relay is energized. At the same time the relay **140**, as referred to with reference to FIG. **5**, actuates the reversing switch including contacts **138** and **148** (as shown in FIG. **5**) to effect a disconnection of one set of sensors and the connection of the other set. The lateral tolly circuit **190** also includes the control relay **188** and, in series therewith, a position responsive switch **198** which is closed in response to placement of the lateral dolly in its retracted position. When the relay **188** is energized, contacts **188** are opened and de-energize the motor **38**.

The operation of the inventive control system will be described with reference to a cycle of operation in the withdraw mode, i.e., where the input command signals call for the stacker vehicle **12** to pick up a material unit from a prescribed bin such as station C, bin level **3**. It will be assumed that the stacker vehicle is positioned at station C, as shown in FIG. **1**, and the elevator car **24** has moved upwardly to level **3** at high speed in accordance with the bin address command. This would be accomplished with the command switch **98** closed which energizes relay **96** and closes the switch contacts **94** in the input of the servo amplifier **80**. This also includes a direction command signal provided by the closure of direction switch **92** which energizes relay **91** actuating the switch contacts **86** to the closed position and applying the positive signal voltage corresponding to the upward direction to the input of the servo amplifier through the contacts **94** and contacts **100**. When the elevator car arrives at the assigned level **3**, the address arrival switch **114** will be closed and the high-speed switch **98** will opened. Closure of the address arrival switch **114** energizes the address arrival relay **112** which closes the switch contacts **110** in the input circuit of the servo amplifier **80**. At this time the transition or reversing circuit **88** is operative to provide for the continued application of an input signal to the servo amplifier of the same polarity but reduced magnitude for slow speed operation. The relay **160** adapted to actuate the contacts **102** and **108** is in a de-energized condition when the direction command switch **92** calls for upward motion of the elevator car since control relay **91** is operative to open the switch contacts **164**. Furthermore, switch contacts **154** in the transition or reversing circuit **88** are open as will appear subsequently and consequently the control relay **160** is deenergized and the switch contacts **102** remain closed for upward movement of the elevator car. Thus, the supply voltage source is connected across the voltage divider resistors **104** and **106** and the relatively low voltage is applied through the switch contacts **110** and the switch contacts **100** to the input of the servo amplifier **80**.

With the continued motion of the elevator car in the upward direction at slow speed the transducer **34** thereon will be positioned oppositely the signal device **42** and the vane **74** will have entered the air gap of the sensor **46**. Accordingly, the reed switch **56** will be closed thereby and the control relay **120** is energized. Since the command input signal called for operation in the withdraw mode, the mode command switch **136** is open and the control relay **134** remains de-energized so that the switch contacts **146** are open and switch contacts **132** are closed. Since the address arrival relay **112** is energized, the switch contacts **128** in the sensor selector circuit **86** are closed. This completes the circuit through switch contacts **128, 132, 138** and **142** to energize the selector relay **145** and transition relay **130**. Thus, the circuits of sensors **46** and **48** are enabled by the contacts **121** and **123** remaining closed and the sensors **50** and **52** are disabled by the opening of contacts **125** and **127**. With transition relay **130** energized signifying that the first vane has been reached by the lower level null sensors **46** and **48** the switch contacts **154** and **162** are actuated to the closed and open position, respectively. This does not de-energize relay **160** because contacts **150** are closed by relay **120** but it places it in readiness for reversing energization of the motor **26** if necessary in the nulling operation. With the continued motion of the elevator car upwardly the null vane **76** enters the air gap of the sensor **48** and the reed Switch **62** is closed. This energizes the control relay **122** which in turn actuates switch contacts **144** and **170** to the closed position.

The closure of reed switch **62** and reed switch **56** simultaneously signifies that the elevator car has at least momentarily occupied the null position with null vanes **74** and **76** properly located with reference to sensors **46** and **48**, respectively. Assume, however, that for some reason the elevator car overshoots the null position causing sensor **46** to be carried past the null position with reference to vane **74** thereby opening the reed switch **56**. When this happens the relay **120** is de-energized and contacts **156** are opened thus de-energizing relay **160** and allowing switch contacts **102** to open and switch contacts **108** to close which applies a negative polarity signal voltage to the servo amplifier for downward motion of the elevator car. As the car moves downwardly the vane **74** will reenter the null position in the sensor **46** and the reed switch **56** will reclose thereby causing simultaneous closure of contacts 170 and contacts 168 signifying that both null vanes 74 and 76 are in the null position in their respective sensors. Accordingly, the null sensing circuit is completed through switch contacts 166 which are closed by the address arrival relay 112 and switch contacts 168 and 170. Thus, the null relay 102 is energized and the switch contacts 100 in the input of the servo amplifier are open. This removes the input signal from the servo amplifier and the drive motor 26 is de-energized with the elevator in the lower null position. With the null relay 102 energized the contacts 184 are closed in the lateral dolly control circuit shown in FIG. 4.

Thus, with the elevator in its lower null position at the bin for a withdraw mode of operation, as just described above, the lateral dolly control circuit is enabled by the closure of the switch contacts 184. This causes an input signal of positive polarity to be applied through the switch contacts 181, contacts 184 and contacts 186 to the input of the servo amplifier 180. The positive polarity input signal causes energization of the motor 38 in a direction to move the lateral dolly 36 to its extended position. On arrival at the extended position, position responsive switch contacts 196 are closed and the control relay 140 is energized. Energization of relay 140 actuates the contacts 181 and 183 to the open and closed position, respectively, thereby enabling an input signal for the servo amplifier of negative polarity corresponding to movement of the dolly and to the retracted position. Simultaneously, however, the relay 140 actuates the reversing switch in the sensor selector circuit 86 to cause the contacts 138 and 148 to open the lower fixed contacts and close the upper fixed contacts. Thus, the contacts 138 open the circuit in series with contacts 144 and 142 and the contacts 138 close the circuit through the contacts 150 and 152. This de-energizes the relay 145 and energizes the relay 155. Thus, the contacts 121 and 123 are opened and sensors 46 and 48, respectively, are disabled. At the same time switch contacts 125 and 127 are closed and the upper level sensors 50 and 52 are enabled thereby being actively responsive to the null vanes.

Accordingly, the energization of the relay 140 with the lateral dolly in the extended position causes the disablement of the lower level sensors and the enablement of the upper level sensors which in effect shifts the null position and leaves the elevator car below the newly established null position. Accordingly, the null relay 102 is de-energized because of the opening of contacts 168 and 170 in response to de-energization of the control relays 120 and 122. The de-energization of the null relay 102 allows the contacts 100 to be reclosed thereby applying a signal voltage of positive polarity corresponding to upward direction to the input of the servo amplifier. In such a condition the null vane 74 will enter the air gap of the sensor 50 and cause the reed switch 66 to close. Accordingly, the relay 124 is energized and the switch contacts 172 in the null sensing circuit 90 are closed. As the elevator moves further upward the vane 76 will move further into the air gap of sensor 52 and as the null position is reached the reed switch 70 will be closed. This will cause energization of the relay 126 and closure of the switch contacts 174. Accordingly, the null relay 102 is energized and the contacts 100 in the input circuit of the servo amplifier are opened. This causes the motor 26 to be de-energized and the elevator car is located at the upper null position.

The movement of the elevator car from the lower null position to the upper null position with the lateral dolly 36 in the extended position operated in the withdraw mode and the material unit in the bin is lifted by the dolly in readiness for retraction to the elevator. With the null relay 102 energized as just described for this condition, the switch contacts 184 in the input of the servo amplifier are closed for operation of the lateral dolly control circuit of FIG. 4. As described above, the preceding energization of the relay 140 caused the switch contacts 183 to close for application of an input voltage of negative polarity to the servo amplifier. The signal voltage of negative polarity causes the servo amplifier 180 to energize the motor 38 to move the lateral dolly to its retracted position. When the dolly reaches the retracted position the switch contacts 198 are closed and as a result the control relay 188 is energized. Control relay 188 actuates the switch contacts 186 in the input of the servo amplifier to an open position. Accordingly, the servo amplifier signal is removed and the motor 38 is de-energized with the lateral dolly in the retracted position and the material unit loaded thereon is properly positioned aboard the elevator. The stacker vehicle is now in readiness for carrying out the succeeding command input instructions, such as movement to a different station and the deposit of the material unit in a designated bin.

The operation of the automatic control system in a deposit mode is analogous to that just described for the withdraw mode, it being understood, of course, that for deposit the elevator car will be first positioned in the upper null position and the lateral control circuit will cause the lateral dolly to move to its extended position. When this condition is reached the upper null sensors will be disabled and the lower null sensors will be enabled and the elevator car will move downwardly to the newly established lower null position. When this position is reached the lateral dolly control circuit will cause the dolly to move to its retracted position after having deposited the load in the storage bin. It will also be appreciated that the operation of the control circuit for approaching the assigned bin in a downward direction is analogous to the operation just described with respect to approach of the assigned bin with the elevator car moving in the upward direction. It will be appreciated that the dolly may be operated with bins on both sides of the aisle.

Although the description of this invention has been given with respect to a particular embodiment thereof, it is not to be construed in a limiting sense. Many variations and modifications will now occur to those skilled in the art. For a definition of the invention reference is made to the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A control system for a vehicle comprising: drive means adapted to move said vehicle, control means for energizing the drive means, a null signal device at a predetermined location, a pair of transducer means adapted to be mounted on the vehicle and spaced apart in the direction of motion, each of the transducer means comprising first and second sensors and said signal device comprising two signal elements each coating with a respective one of said sensors and each of said transducer means being responsive to a predetermined positional relation to said signal device to cause the control means to de-energize the drive means, and additional control means for selectively enabling and disabling the transducer means according to a desired mode of operation whereby the vehicle may be moved successively between first and second predetermined positions.

2. A control system for an elevator car and the like comprising: a car movable relative to a frame and drive means connected therewith, control means for energizing the drive means to move the car in a selected direction, a null signal device on the frame at a predetermined location, a pair of transducer means on the car spaced apart in the selected direction and aligned with said signal device so that the transducer is disposed opposite said device when the car approaches the predetermined location, each of the transducer means comprising first and second sensors and said signal device comprising two signal elements each coacting with a respective one of said sensors, and each of said transducer means being responsive to a predetermined positional relation to said signal device to cause the control means to stop the car, and additional control means for selectively enabling and disabling the transducer means according to a desired mode of operation whereby the car may be moved successively between first and second predetermined positions.

3. The invention as defined in claim 2 wherein said sensors each include a field producing means and a field responsive means in spaced relation to each other and each of said signal elements includes a passive field distorting means adapted to

coact with said field producing means and cause operation of the field responsive means when a predetermined positional relationship occurs.

4. The invention as defined in claim 3 wherein said field producing means comprises a magnet and said field responsive means comprises a magnetically responsive switching means and wherein said field distorting means comprises a member of magnetic material of high permeability relative to that of air.

5. The invention as defined in claim 2 wherein each of said sensors comprises a permanent magnet and a magnetic field responsive switch with an air gap therebetween and wherein said signal elements comprise a plate of magnetic material adapted to extend into said air gap, each of said switches being adapted to change from a first state to a second state when a plate of magnetic material is disposed in said air gap in a predetermined positional relationship thereto.

6. An elevator control system comprising an elevator car and drive means therefor control means connected with said drive means, said control means including a signal device at a reference position on the path of movement of said elevator car, a first transducer on the car and adapted to coact with said signal device to cause said control means to energize the drive means to move the car to a first null position, a second transducer on the car and adapted to coact with said signal device to cause said control means to energize the drive means to move the car to a second null position, said first and second transducer being spaced apart in the direction of movement, a transducer selector circuit for operatively connecting said first transducer with said control means and effectively disconnecting said second transducer therefrom and switching means connected with the selector circuit whereby the car may be moved from one null position to the other by operation of said switching means , and including a reversing circuit connected with the selected transducer and with said control means and responsive to overshoot of the null position to reverse the energization of the drive means .

7. An elevator control system comprising an elevator car and drive means therefor, control means connected with said drive means, said control means including a signal device at a reference position on the path of movement of said elevator car, a first transducer on the car and adapted to coact with said signal device to cause said control means to energize the drive means to move the car to a first null position, a second transducer on the car and adapted to coact with said signal device to cause said control means to energize the drive means to move the car to a second null position, said first and second transducer being spaced apart in the direction of movement, a transducer selector circuit for operatively connecting said first transducer with said control means and effectively disconnecting said second transducer therefrom and switching means connected with the selector circuit, wherein each of the transducer means comprises first and second sensors and said signal device comprises two signal elements each coacting with a respective one of said sensors , whereby the car may be moved from one null position to the other by operation of said switching means .

8. The invention as defined in claim 7 wherein said sensors each include a field producing means and a field responsive means in spaced relation to each other and each of said signal elements includes a passive field distorting means adapted to coact with said field producing means and cause operation of the field responsive means when a predetermined positional relationship occurs.

9. The invention as defined in claim 8 wherein said field producing means comprises a magnet and said field responsive means comprises a magnetically responsive switching means and wherein said field distorting means comprises a member of magnetic material of high permeability relative to that of air.

10. The invention as defined in claim 7 wherein each of said sensors comprises a permanent magnet and a magnetic field responsive switch with an air gap therebetween and wherein said signal elements comprise a plate of magnetic material adapted to extend into said air gap, each of said switches being adapted to change from a first state to a second state when a plate of magnetic material is disposed in said air gap in a predetermined positional relationship thereto.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,662,860 Dated May 16, 1972

Inventor(s) Arthur R. Burch

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 7, line 3, "lowsspeed" should be -- low-speed --

Col. 10, claim 1, line 44, "coating" should be -- coacting --

Signed and sealed this 3rd day of October 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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