

[54] **STACKER CRANE CONTROL SYSTEM**
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[22] Filed: **Aug. 12, 1970**
[21] Appl. No.: **63,051**

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[52] U.S. Cl.....214/16.4 A, 318/600
[51] Int. Cl.....**B65g 1/06**
[58] Field of Search 214/16.4 A, 16.4 B; 318/600

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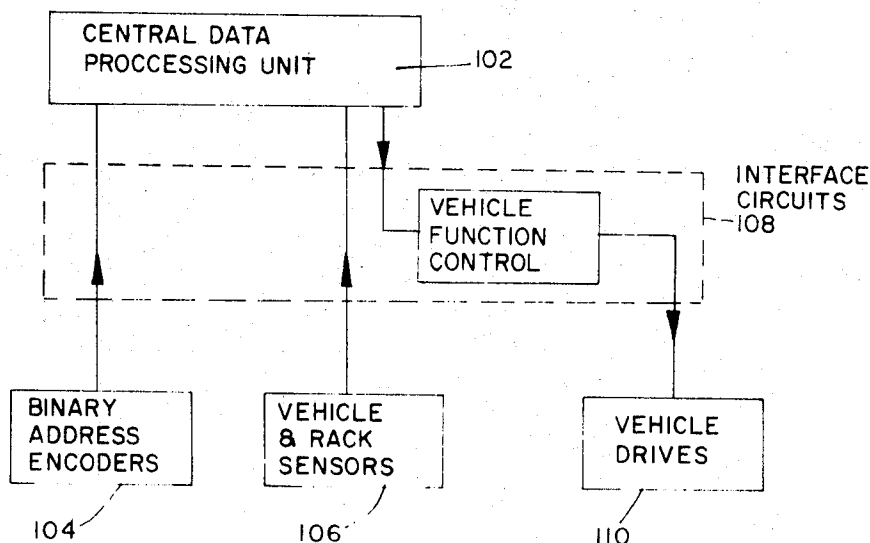
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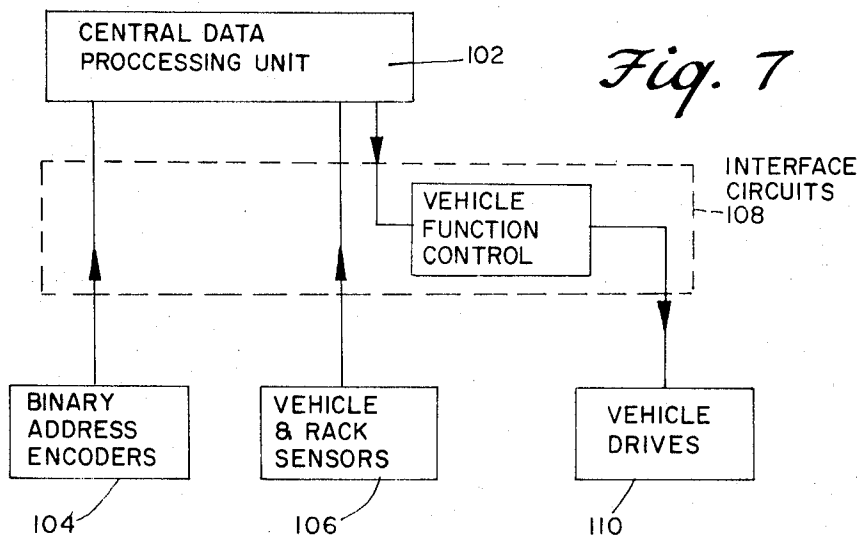
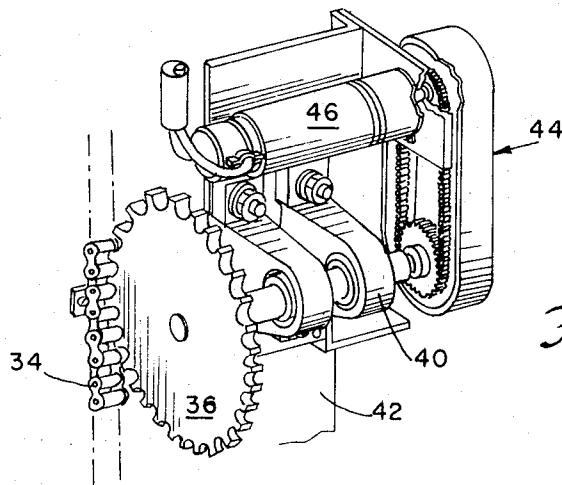
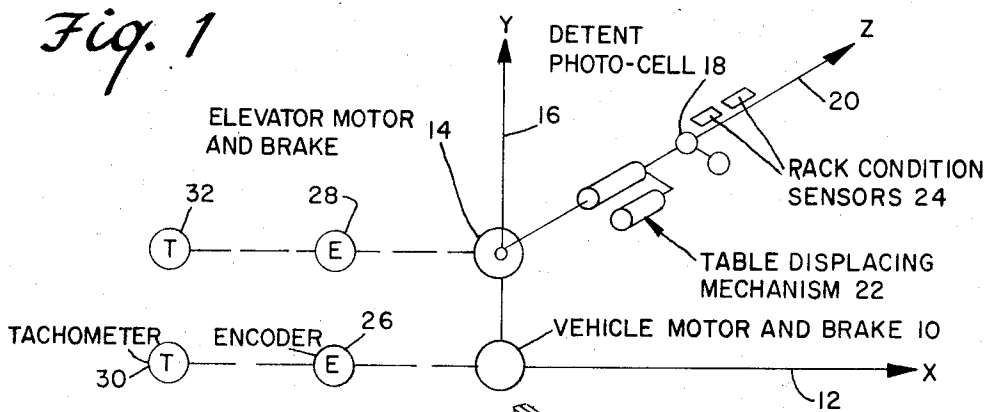
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[57] **ABSTRACT**

Loads are transferred between stations by horizontal and vertical movement of a pallet table on an elevator mechanism carried by a vehicle from which the table is horizontally extended and retracted when aligned with a preselected storage rack. A computer is interconnected with motion propelling and controlling apparatus on the vehicle through interface circuitry to process command data from an input library and vehicle position, motion data and rack condition from sensors to produce the movement desired for effecting load transfers.

20 Claims, 9 Drawing Figures





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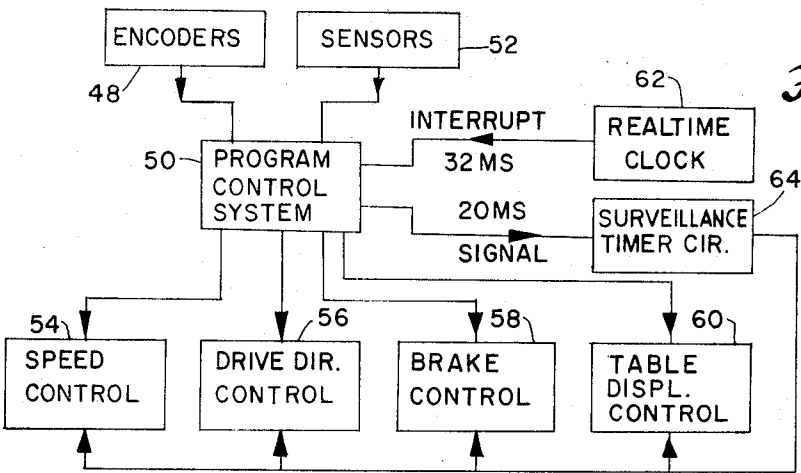


Fig. 3

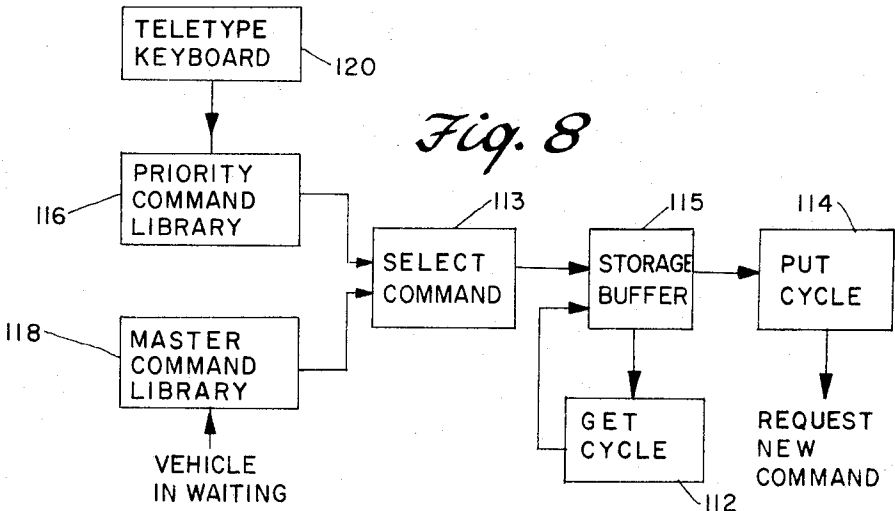


Fig. 8

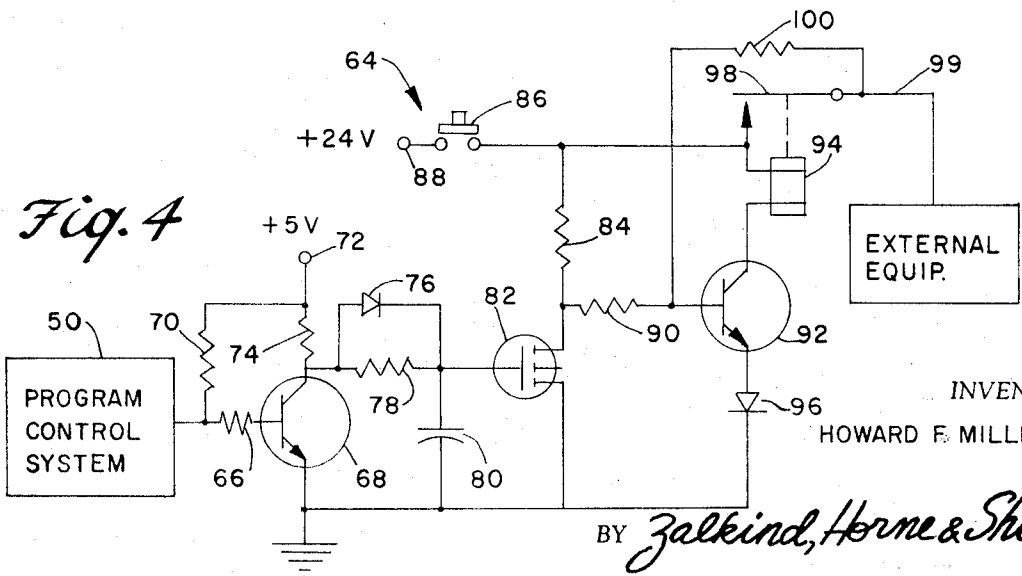


Fig. 4

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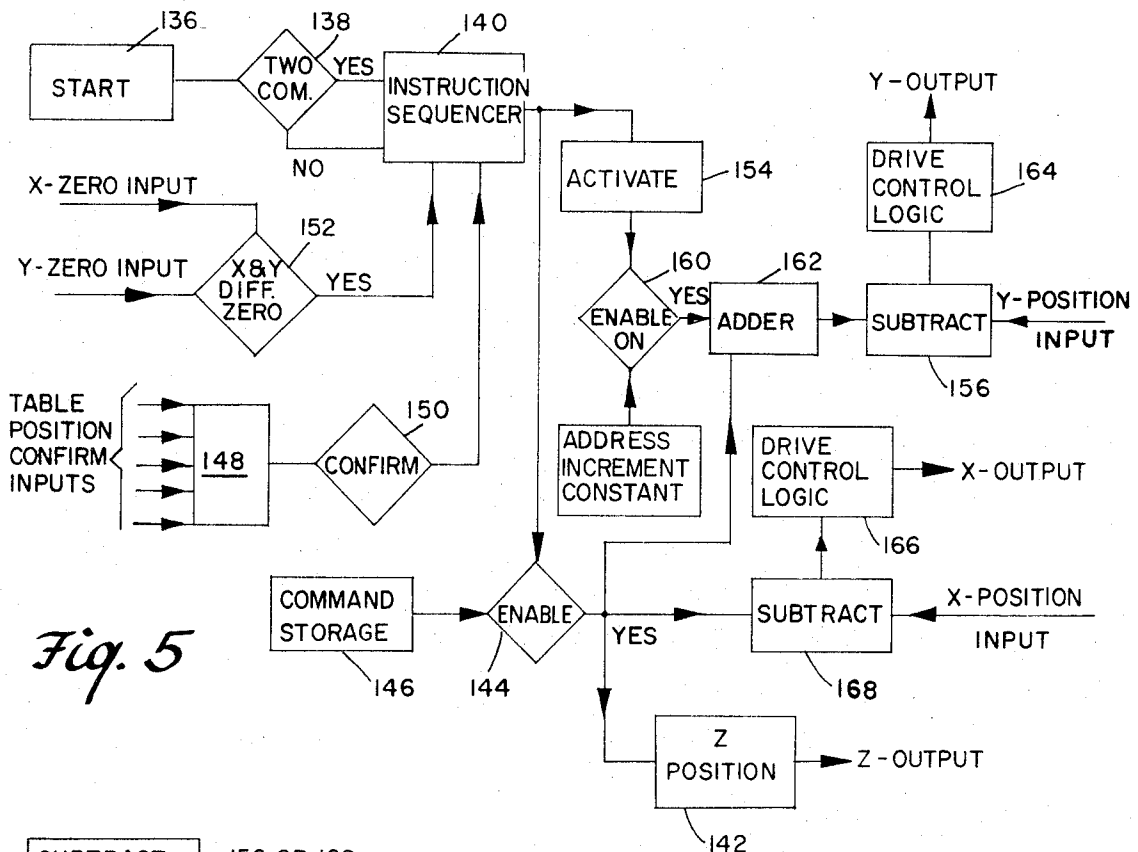


Fig. 5

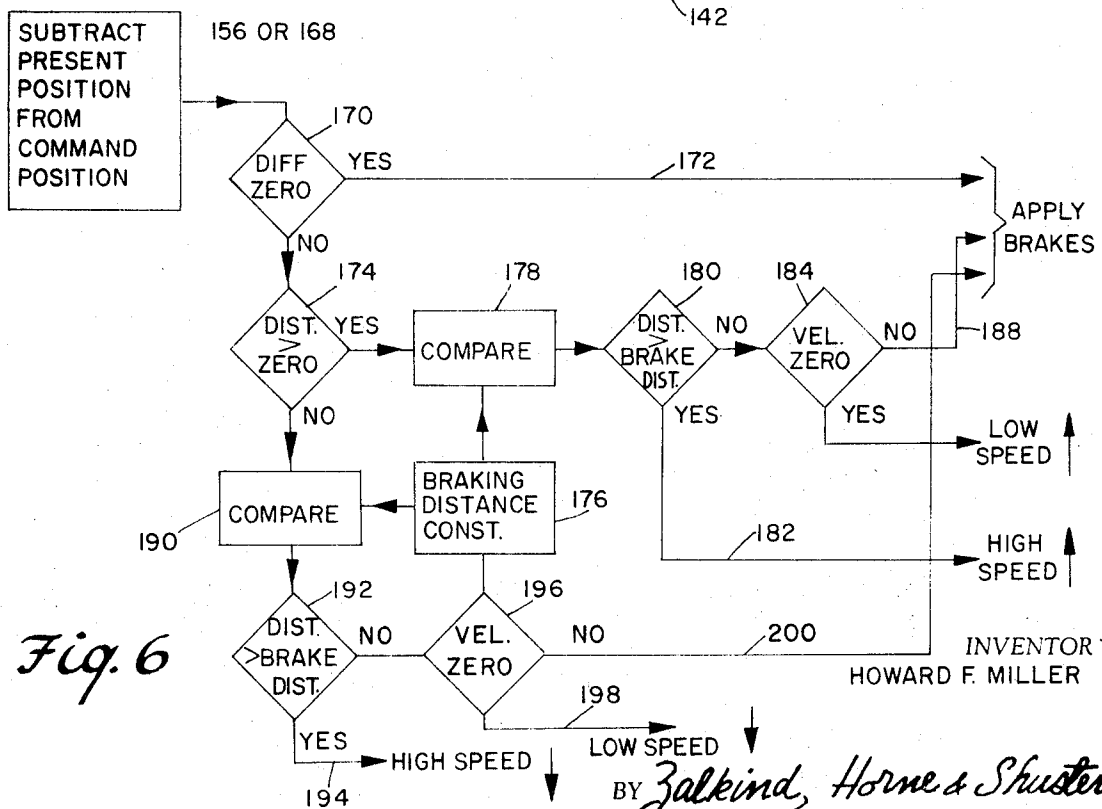


Fig. 6

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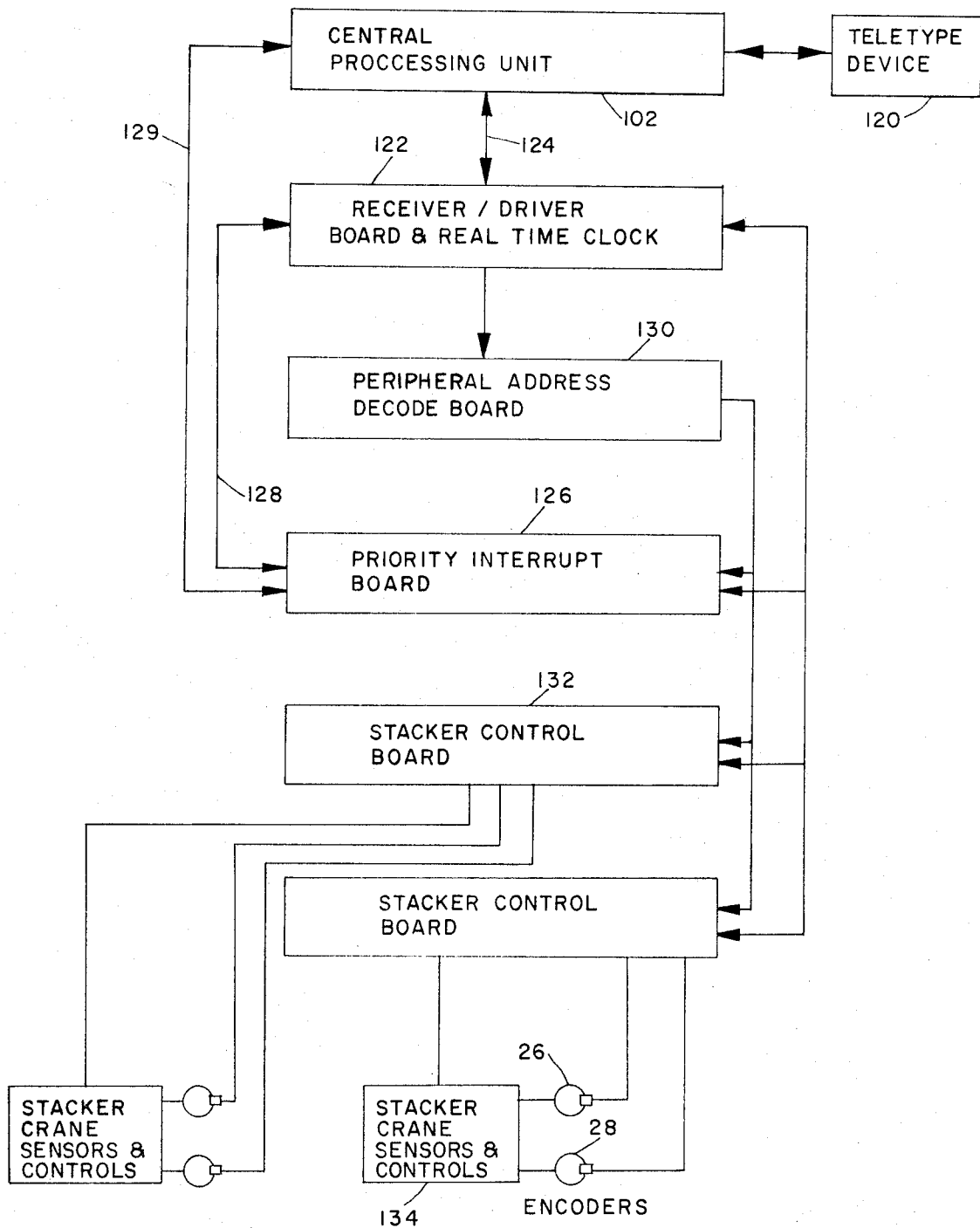


Fig. 9

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STACKER CRANE CONTROL SYSTEM

This invention relates to the transfer of loads on pallets by means of a stacker crane control arrangement such as disclosed in prior copending application Ser. No. 840,667, filed July 10, 1969, owned in common with the present application by the same assignee.

Briefly, the arrangement disclosed in the prior copending application aforementioned, involves a carrier vehicle movable along a track parallel to a rack having open face bins on either side of the track. A movable platform or table is mounted on the carrier vehicle in such a manner as to facilitate pickup of pallets stored in the racks by extending the table to either side of the track perpendicular to the horizontal movement of the carrier vehicle and vertical movement of the pallet table on the vehicle by means of an elevator mechanism.

The improvement of the present invention resides in the provision of a control system consisting of several interconnected electronic and electro-mechanical devices integrated in order to provide complete automatic control over the movement of the pallet table or platform by the elevator drive mechanism, the vehicle propelling and motion controlling mechanisms and table extension and retraction apparatus carried by the vehicle in order to effect a transfer of loads on the pallets between preselected storage racks or a preselected storage rack and a loading station.

In accordance with the present invention, the control system involves the positioning of the pallet table aforementioned in three different planes of motion. Thus, the carrier vehicle is movable along the track in one horizontal direction perpendicular to the second vertical direction along which the pallet table is moved by an elevator mechanism carried on the carrier vehicle. At any desired point of travel along the first and second directions, the pallet table is extended from a center position along a third horizontal direction perpendicular to the two other directions or retracted from an extended position in order to either deposit or pick up a load from a selected storage rack. The position of the pallet table and its speed is sensed by angle shaft encoders and tachometers associated with the vehicle propelling and elevator drive mechanisms. Detectors are also provided to verify alignment between the pallet table and preselected rack as well as to determine the condition of the rack. The data obtained from the sensors and detectors is periodically sampled through the interface circuitry by the computer within which it is processed together with input command data to produce motion controlling signals transmitted through the interface circuitry to the drive motors, displacing mechanism and brake devices for producing the desired motion of the pallet table until a program cycle is completed resulting in the desired transfer of a load on the pallet table being operated on.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

FIG. 1 is a diagrammatic and graphical representation of the motion control and sensing arrangement of the present invention.

FIG. 2 is a partial perspective view of a typical angle shaft encoder utilized with the present invention.

FIG. 3 is a block diagram illustrating the basic system associated with the present invention.

FIG. 4 is an electrical circuit diagram illustrating one of the electronic components shown in FIG. 3.

FIG. 5 is a schematic block diagram illustrating the signal control logic associated with the system of the present invention.

FIG. 6 is a more detailed diagrammatic illustration of the drive control logic of FIG. 5.

FIG. 7 is a block diagram illustrating the data interchange system associated with the present invention.

FIG. 8 is a block diagram illustrating the command logic associated with the system of the present invention.

FIG. 9 is a block diagram illustrating the arrangement of interface logic components associated with the system of the present invention.

Referring now to the drawings in detail, FIG. 1 relates to the movement and positioning of a pallet table by a structural arrangement, the details of which are disclosed in the prior copending application aforementioned, wherein a carrier vehicle is propelled in a first horizontal direction along a track by means of a vehicle motor and brake mechanism generally referred to by reference numeral 10 in FIG. 1, the direction of movement being denoted by the X axis 12. At the same time, an elevator motor and brake mechanism 14 is rendered operative to control motion of the pallet table relative to the load carrier vehicle in a vertical direction denoted by the Y axis 16 in FIG. 1. When the pallet table is in alignment with a preselected storage rack, as registered by a detent photo cell 18, it may be extended in a third horizontal direction denoted by Z axis 20 perpendicular to the other two directions. A table displacing mechanism generally denoted by reference numeral 22 effects such extension of the table from a center position on the elevator mechanism to one of two predetermined depths along the Z axis 20. The rack is accordingly provided with sensors 24 as diagrammatically illustrated in FIG. 1 in order to determine the condition of the rack. Also associated with the mechanisms 10 and 14, are angle shaft encoders 26 and 28 by means of which the position of the load carrying table is monitored relative to the X and Y axes. The speed of the load carrying table during movement is also monitored along the X and Y axes by tachometers 30 and 32.

FIG. 2 illustrates a typical arrangement through which the drive motor associated with the vehicle propelling mechanism or the elevator mechanism is drivingly connected to an angle shaft encoder in order to monitor the position of the load carrying table along either the X or Y axis as aforementioned. A drive transmitting sprocket chain 34 driven by a drive motor in the X axis or Y axis direction as disclosed in detail in the prior copending application aforementioned, is enmeshed with a driven gear 36 connected to one end of a shaft 38 journaled by bearing assemblies 40 secured to the vehicle frame 42. The end of the shaft 38 opposite the gear 36 is drivingly connected through a sprocket gear drive 44 to the input of an angle shaft encoder device 46 of a well known and commercially available type. It will therefore be apparent that when the pallet table is in motion, movement of the sprocket chain 34 parallel to the motion axis will be transmitted to its associated angle shaft encoder device 46 from

which binary signals are emitted to indicate the position of the table.

Signals from the encoders diagrammatically illustrated and denoted by reference numeral 48 in FIG. 3, are transmitted to a program control system generally referred to by reference numeral 50 which also receives data from the other sensors or detectors as aforementioned which are generally denoted by reference numeral 52 in FIG. 3. Through the control system, signals are fed to various power control components including the speed control 54 as diagrammed in FIG. 3 in order to determine the speed at which the drive motors are to propel the load carrying table along the X and Y axes. Directional control 56 on the other hand determines the directional sense in which the table is moved along the X and Y axes. In order to stop movement of the table where desired, brake apply signals are fed to the brake control 58. When the table is aligned with a preselected rack, it is extended and retracted by signals fed from the control system to the table displacing control component 60. The controls 54, 56, 58 and 60 are operative to propel the carrier vehicle and elevator mechanism in the desired directional sense toward a selected station and to reduce its speed when approaching the selected position so that the brake control may effect stoppage at a precise position. This position is monitored by binary signals from the encoders 48 at regular repeated periods of time determined by a clock mechanism 62. In accordance with the present invention, the time spacing between such positioning scans is selected to be 32 milliseconds. Faster scan rates do not offer significant improvement in control response and would cause unnecessary timing restrictions on the program. On the other hand, slower scan rates would tend to loosen the control response causing undesirable delays in the response of the drive motors. Thus, the program control system 50 receives an interrupt signal from the clock mechanism every 32 milliseconds. Upon acknowledgment of the interrupt signal, the program is fed a set of vehicle addresses from the encoders and digital inputs from the other sensors 52. Due to noise spikes entering data lines, two consecutive readings are taken before it is accepted as valid information. If two consecutive readings are not equal, two more chances are given for a valid reading. If a valid reading is still not made, the program will postpone the scan until the next time interval. If a total of three interrupts and a valid reading has not been taken, the program, for safety reasons can no longer assume control over the carrier vehicle and will remove all drive bits thereby stopping the vehicle which is placed in maintenance status.

Also associated with the system as depicted in FIG. 3 is a surveillance timer circuit 64 which operates as a protective feature to cause shutdown by control of voltage to the various power controls, for example, in the event of any malfunction of the program control system 50 from which a program cycle signal is received each 20 milliseconds.

Referring now to FIG. 4, the cycle signal from the program control system, which is generated approximately every 20 milliseconds, applies a negative cutoff voltage through signal coupling resistor 66 to transistor 68 in the surveillance timer circuit 64. The transistor 68 is otherwise maintained in a conductive state by a bias voltage applied to the base through resistors 66 and 70 connected to voltage source 72, which is also

connected through load resistor 74 to ground in series with the collector-emitter circuit of the transistor. When transistor 68 is switched to its non-conductive state by the negative cutoff signal applied to its base, charging current is conducted through diode 76 in parallel with bleed resistor 78 to one side of the grounded capacitor 80. When a positive potential is thereby established on the positive side of capacitor 80, the field effect transistor (FET) 82 is switched on to thereby establish a conductive path between voltage source 88 and ground in series with load resistor 84 and on-off switch 86. When the FET transistor 82 is in its non-conductive state, a forward bias is applied through resistor 90 to the base of transistor 92 which is normally reverse biased by diode 96 external equipment through control voltage line 99 to the base through resistor 100. Thus, when transistor 82 is switched off, transistor 92 is switched on to complete an energizing circuit through the relay coil 94 connected in series between the source 88 and the grounded diode 96. When relay coil 94 is energized, relay switch 98 is closed so that voltage from source 88 is applied through line 99 to disable the external equipment and through resistor 100 to the base of transistor 92 for forward bias thereof maintaining the transistor conductive. With a ground going signal applied to the base of transistor 68 every 20 milliseconds, capacitor 80 never discharges to ground potential. In this condition, transistor 82 is never switched off and thereby prevents completion of a relay circuit through the transistor 92. If for any reason the ground going signal from the program control system is not timely applied to the transistor 68, FET transistor 82 is cut off to permit completion of an energizing circuit through the relay coil 94 to close normally opened relay switch 98. All peripheral operations of the control system are hence stopped. The 20 milliseconds signal applied to the surveillance timer circuit 64 is of course less than the 32 millisecond clock signal generated by the clock device 62 aforementioned.

The control system through which the encoders and sensors link the various motion controls, utilizes a central data processing unit 102 as diagrammatically illustrated in FIG. 7 showing the binary address encoders 104 and vehicle and rack sensors 106 linked with unit 102 through interface circuits 108 which also transmit vehicle function control signals from the central processing unit to the vehicle drives 110. Thus, two types of data input masks are associated with the interface circuits consisting of the binary inputs from the encoders 104 and a consolidated digital input from all of the other sensors 106. A single output to the vehicle drives 110 consists of all the required control functions for horizontal and vertical movement along the X and Y axes and movement along the Z - axis for table extension and retraction through the table displacing mechanism. The command logic associated with the control system on the other hand is diagrammed in FIG. 8 and consists of two operational cycles consisting of a GET cycle 112 by means of which a pallet is picked up from a rack and a PUT cycle 114 by means of which a pallet is stored in a preselected rack. These two cycles are associated with three types of warehouse functions in the system which are: (1) retrieve (rack to deposit station), (2) put away (deposit station to rack), and (3) transfer (rack to rack). The command logic also consists of two command libraries 116 and 118 as diagrammed in FIG. 8 for each carrier vehicle. The priority command li-

brary 116 is loaded through a teletype keyboard 120 while the master command library 118 is replenished by data from punched paper tape or other bulk storage media. When a carrier vehicle is waiting or inactive, it is eligible for assignment. The program supervisor accordingly checks for any priority command and if none, the master command library 118 is checked. When a command is available, it is retrieved from the selected library through the select command component 113, stored in the vehicle storage buffers 115 and a GET cycle is initiated.

The data processing unit 102, aforementioned, may be a Varian Data Machine Computer, Model 620/I while the teletype device 120 may be a teletypewriter, Model ASR 35. These components of the control system are interrelated with the control components of the interface circuitry as diagrammed in FIG. 9, which shows a receiver driver board 122. This receiver/driver board is interrelated with the central processing unit 102 through cable 124, to transfer information between the computer and the interface circuitry. The board 122 also contains the clock device 62 and the surveillance timer circuit 64 aforementioned. The board 122 provides in cooperation with the priority interrupt board 126, with which it is interconnected by real time clock signal line 128, a system expansion capability. The priority interrupt board 126 receives series of signals from sources such as the photocell detectors monitoring the condition of the racks, the teletype device, timing clocks, etc., to provide signal conditioning and generate interrupt signals on one of the priority lines 129 associated with the computer or data processing unit 102. Thus, several carrier vehicles may be controlled by the system of the present invention without signal interference.

Also associated with each system is a peripheral address decode board 130 operative to decode peripheral addresses necessary to select a particular peripheral device. Control signals from the central processing unit 102 are transmitted to the receiver/driver board 122 where their driving capability is increased. The output of the receiver/driver board is fed to the peripheral address decode board 130 and to the priority interrupt board 126 and control boards 132 simultaneously to which boards 132 the stacker crane sensors and controls 134 are connected as well as the aforementioned encoders 26 and 28 supplying digital information to the associated control boards 132. The peripheral address decode board 130 selects the desired stacker control board so that the output control command or the data input command go to or come from the desired sensors and controls through the control board. Vertical and horizontal drive bits are thus decoded through board 130 to monitor vehicle movement both horizontally and vertically.

FIG. 5 diagrammatically illustrates the carrier vehicle control logic representing the operational program of the control system. The program is initiated by a start command originating from 136 as shown in FIG. 5. The signal from 136 initiates one of two GET or PUT command cycles through component 138 from which signals are fed to an instruction sequencer 140.

Before a pallet table is extended into a rack, the rack condition sensors are checked for conditions which would conflict with the operation produced by signals from table position command 142. If rack conditions are acceptable, the table drive is activated from an out-

put of command 142 in response to an enable signal from the component 144 receiving inputs from the command storage 146 and the output of the instruction sequencer 140. Once the table is extended to a command depth, a time delay count is incremented. When the time delay reaches approximately one-half of a second, to allow for mechanical settling of the table, the table extension is given a confirmed position status through components 148, and 150 through sequencer 140.

The instruction sequencer 140 operates only when outputs are received from the horizontal and vertical difference zero component 152 to which zero inputs are fed from arithmetic units of the computer indicating alignment of the table with the rack. Vertical position confirmation is then removed and the vertical command address is altered by a constant distance. The constant vertical distance is upward if the command cycle is GET for load pick up and downward to lower the table for load deposit in the rack is the command cycle is PUT. Once vertically repositioned and the vertical position status reconfirmed, the table drive is allowed to retract to center. When the table is completely retracted, one cycle of a command is complete. If the command cycle was GET, the vehicle is initiated for the PUT cycle. If the command cycle was PUT, the vehicle is placed in the wait status to allow assignment of another command.

As hereinbefore indicated, every 32 milliseconds the program inputs a new set of vehicle addresses from the encoder and digital inputs from the other sensors. When valid readings have been inputted, through the activate component 154 as illustrated in FIG. 5, the permanent position addresses are subtracted from the command addresses to obtain a difference. If the difference is zero, the table is at the command address. This subtraction function is performed by the component 156 receiving address data from the activate component 154 through the enable component 160 added by component 162 to data from enable component 144 to feed a command position input into the subtract component 156 performing the function of subtracting the present position also inputted thereto, in order to supply appropriate signals to the drive control logic 164 producing a vertical positioning output. Similarly, the present position along the X-axis is inputted to subtract component 168 as well as the command position from enable component 144 to produce a horizontal positioning output. If the difference output from the subtract component 156 or 168 is zero, the drive is released and a time delay count is incremented. When the time delay reaches approximately one-half of a second and if the difference is still zero, the position along the associated axis is given a confirmed position status. The time delay allows for mechanical settling. If the difference is greater than zero, the direction of drive is selected. Also, if the difference is less than zero, the appropriate direction of drive is selected. Also, through the drive control logic 164 or 166 receiving the outputs from subtract components 156 and 168, a high or low speed drive is selected as explained in detail hereafter. The increment constant signal generated by address component 158 is operative through enable component 160 to effect the small vertical displacement of the pallet table in order to either pick up or deposit a load before the table is retracted from an extended position as aforementioned.

Each of the drive control logics 164 and 166 are similar as diagrammatically shown in FIG. 5 in order to provide the appropriate drive and brake apply signals. The difference output from the subtract component 156 or 168 is accordingly fed to the difference zero component 170 so that a brake apply signal will be dispatched through line 172 if the difference between the present position and command position is zero. If the difference is greater than zero, the output is fed by component 174 to comparison logic 178 to be compared with a braking distance constant from component 176. If the difference is less than zero, then the output is fed through 174 to comparison logic 190 for comparison with the braking constant. The output of logic 178 is fed to component 180 so that if it is greater than the braking constant a high speed signal is fed through line 182 to the vehicle for drive at a high speed in one directional sense. On the other hand, if the distance of the present position is less than the brake distance but greater than zero, as determined by the logic component 184, a low speed signal is fed through line 186 to the drive mechanism for drive in the same directional sense at a low speed. If the distance is zero, a brake apply signal is fed to the brake mechanism line 188.

The braking distance constant generated by component 176 is also compared through logic component 190 with the difference between the command position and the present position in order to determine if it is less than the braking distance through logic component 192 to control drive in the directional sense opposite to that controlled by the output of logic 178. If the distance represented by the negative difference is greater than the braking distance, a high speed signal is fed through line 194. Similarly, if the distance is less than the braking distance, then a signal is fed to the velocity zero component 196 from which a low speed signal through line 198 is fed. The drive mechanism is accordingly of the reversible type as well as having a change speed capability. As in the case of component 184 if there is no output from component 196, a brake apply signal is transmitted through line 200 to the brake mechanism. Thus, the drive control logics are operative to control both the speed and the direction of the pallet table and would appropriately apply braking force in order to obtain precise stoppage of the table at positions aligned with the racks. When both the X and Y coordinates or horizontal and vertical positions are confirmed, the present addresses cannot deviate from the command addresses by more than one binary unit. Any discrepancies detected by the photo-cell detectors 18 will place the vehicle in maintenance status.

To summarize the foregoing programmed operations, the pallet table is propelled in a horizontal direction along an X axis by means of the carrier vehicle drive while in a vertical direction along the Y axis by an elevator drive mechanism. Angle shaft binary encoders monitor the position of the table while tachometers monitor the speed of the drive in each direction. Other sensors or detectors monitor the rack condition and depth of displacement of the table into the storage rack in a Z axis direction. The foregoing vehicle position data is transmitted to a computer, the program of which is interrupted every 32 milliseconds by a real time clock to receive this data or vehicle address inputs from the encoders and the other sensors. Inputs when accepted are subtracted from command addresses until equal to braking distance to change speed or until a

zero difference is obtained to release drive and apply brakes. A constant braking distance is subtracted from the distance of travel remaining to determine the speed of the drive before drive release and brake engagement. When the pallet table stops at the desired position along the X and Y axes and the storage rack condition is sensed, it is extended along the Z axis to a command depth, if the storage rack is empty. After a time delay and confirmation of position status, the extended table position is altered in a vertical direction by a constant amount in order to reposition it for retraction. When retracted from the storage rack, the command cycle is completed.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact arrangement and operation shown and described, and accordingly all suitable modifications and equivalents may be resorted to, falling within the scope of the invention as claimed.

What is claimed as new is as follows:

1. In combination with a load carrier propelled in two transverse directions by reversible change speed drives and displaced by preselected distances in a third direction by displacing mechanism for transfer of loads to and from a plurality of storage racks, a system for programming movement of the load carrier including position signalling means for registering the positions of the load carrier along said two transverse directions, command means for selecting one of the storage racks to which the load carrier is to be propelled, time-controlled means for intermittently comparing the position of the load carrier as indicated by the position signalling means with the position of the selected one of the racks relative to said two transverse directions, and means for controlling the change speed drives in accordance with the difference in position as indicated by the time-controlled comparing means.

2. The combination of claim 1 including means responsive to extension of the load carrier in said third direction into the selected one of the racks for displacement of the load carrier by a fixed amount in a vertical one of said two transverse directions.

3. The combination of claim 2 including a displacing mechanism responsive registration of zero difference by the time-controlled comparing means for displacing the load carrier along said third direction.

4. The combination of claim 3 wherein said load carrier is propelled in one of said two directions by a vehicle drive motor and in the other of said two directions by an elevator motor, said position signalling means including angle shaft encoders driven by said motors.

5. The combination of claim 1 including a displacing mechanism responsive registration of zero difference by the time-controlled comparing means for displacing the load carrier along said third direction.

6. The combination of claim 1 wherein said load carrier is propelled in one of said two directions by a vehicle drive motor and in the other of said two directions by an elevator motor, said position signalling means including angle shaft encoders driven by said motors.

7. In combination with a vehicle having powered means for movement thereof along predetermined paths between predetermined stations, a system for controlling movement of the vehicle comprising means for sensing position and motion of the vehicle and the

condition of the stations, a data processing computer having selectively controlled input command means and interface circuit means interconnecting the computer with the sensing means and the powered means for transmitting address and command data to control movement of the vehicle, said interface circuit means including clock means for periodically initiating a data processing cycle of the computer following receipt of address data from the sensing means, said clock means having a timing cycle greater than the duration of said data processing cycle.

8. The combination of claim 7 wherein said interface circuit means further includes surveillance means normally receiving a signal pulse during each data processing cycle for disabling the powered means in the absence of timely receipt of the signal pulse.

9. The combination of claim 8 wherein said sensing means includes angle shaft encoders driven by the powered means.

10. The combination of claim 9 wherein said powered means includes a change speed drive mechanism for propelling the vehicle at high and low speeds and brake means for stopping movement of the vehicle.

11. The combination of claim 10 wherein said computer includes subtracting means for determining the difference between data received from the sensing means and data received from the input command means to periodically register the distance between the vehicle and a preselected station, means responsive to a registered distance of zero for generating a brake applying signal, means responsive to a registered distance greater than a predetermined braking constant for generating a high speed signal and means responsive to a registered distance less than the braking constant for generating a low speed signal, said braking applying signal and speed signals being transmitted by the interface circuit means respectively to the brake means and the drive mechanism of the powered means.

12. The combination of claim 7 wherein said powered means includes a change speed drive mechanism for propelling the vehicle at high and low speeds and brake means for stopping movement of the vehicle.

13. The combination of claim 12 wherein said computer includes subtracting means for determining the difference between data received from the sensing means and data received from the input command means to periodically register the distance between the vehicle and a preselected station, means responsive to a registered distance of zero for generating a brake applying signal, means responsive to a registered distance greater than a predetermined braking constant for generating a high speed signal and means responsive to a registered distance less than the braking constant for generating a low speed signal, said brake applying signal and speed signals being transmitted by the interface circuit means respectively to the brake means and the drive mechanism of the powered means.

14. In combination with a vehicle having powered means for movement thereof along predetermined paths between predetermined stations, a system for controlling movement of the vehicle comprising means for sensing position of the vehicle, a data processing computer, selectively controlled input command means and interface circuit means interconnecting the computer with the sensing means and the powered means for transmitting data, said computer including subtracting means for determining the difference be-

tween data received from the sensing means and data received from the input command means to periodically register the distance between the vehicle and a preselected station, means responsive to a registered distance of zero for generating a brake applying signal, means responsive to a registered distance greater than a predetermined braking constant for generating a high speed signal and means responsive to a registered distance less than the braking constant for generating a low speed signal, said brake applying signal and speed signals being transmitted by the interface circuit means to the powered means.

15. The combination of claim 14 wherein said vehicle includes a load supporting platform and said powered means includes means for propelling the vehicles in a first horizontal direction, elevator means for moving the platform in a second vertical direction and a displacing mechanism for moving the platform in a third horizontal direction by a predetermined amount, and detector means for indicating alignment between the platform and said preselected station to initiate operation of the displacing mechanism.

16. The combination of claim 15 wherein said computer further includes means for generating a signal in response to said movement of the platform by said predetermined amount to operate the elevator means thereby vertically displacing the platform by a fixed amount.

17. In combination with a vehicle having an elevator, a carrier mounted on the elevator, propelling means mounted by the vehicle for movement of the carrier along predetermined paths from a starting position, sensing means carried by the vehicle for continuously measuring distance travelled by the carrier from said starting position along said paths, drive control means operatively connected to said propelling means for stopping movement of the carrier at another position preselected by input command data, time-control means for sampling distance measurements of the sensing means at fixedly spaced intervals of time, computer means for comparing each of said sampled measurements with the input command data to produce difference signal outputs and interface means operatively connecting the sensing means and the drive control means to the computer means for transmitting the sampled measurements to the computer means and the outputs from the computer means to the drive control means thereby controlling movement of the carrier in accordance with each of said outputs of the computer means.

18. The combination of claim 17, wherein the computer means includes means responsive to successful processing of the sampled measurements and input data for producing a cycle signal at a frequency higher than the frequency of said fixedly spaced intervals of time; and surveillance means responsive to the absence of said cycle signal for disabling the drive control means.

19. The combination of claim 18, wherein the propelling means includes displacing means for imparting fixed incremental movement to the carrier prior to movement thereof toward the other preselected position.

20. The combination of claim 17, wherein the propelling means includes displacing means for imparting fixed incremental movement to the carrier prior to movement thereof toward the other preselected position.