United States Patent [19]

Hartman, III

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[54] **POSITION CONTROL SYSTEM FOR A WAREHOUSE APPARATUS**

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[21] Appl. No.: **306,862**

Related U.S. Application Data

[63] Continuation of Ser. No. 73,159, Sept. 17, 1970, abandoned.

[52] **U.S. Cl.** .... **214/16.4 A,** 318/603, 318/629

[51] **Int. Cl.** **B65g 1/06**

[58] **Field of Search**... 214/16.4 A, 16.4 B; 318/603, 318/629

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[57] **ABSTRACT**

An automatic stacker or load carrier has a trolley section movable down an aisle between a pair of storage racks, an elevator movable vertically on the trolley, and a retractable fork mechanism movable out of either side of the elevator to pick up a load from, or deposit a load into, a selected bin in one of the racks. A stationary console remote from the stacker is connected electrically to the stacker by a plurality of brush contacts on the stacker, which have sliding, electrical contact with a like plurality of conductors, which extend from the console down the aisle. By means of a computer connected to the console, an operator can program the stacker to perform a plurality of successive pick up and deposit operations to transfer loads between selected bins and a loading station at one end of the aisle, or between selected bins in the racks. At the end of each cycle, which comprises either a pick up or deposit operation, the stacker remains stationary until the computer enters the address of a new cycle.

12 Claims, 10 Drawing Figures

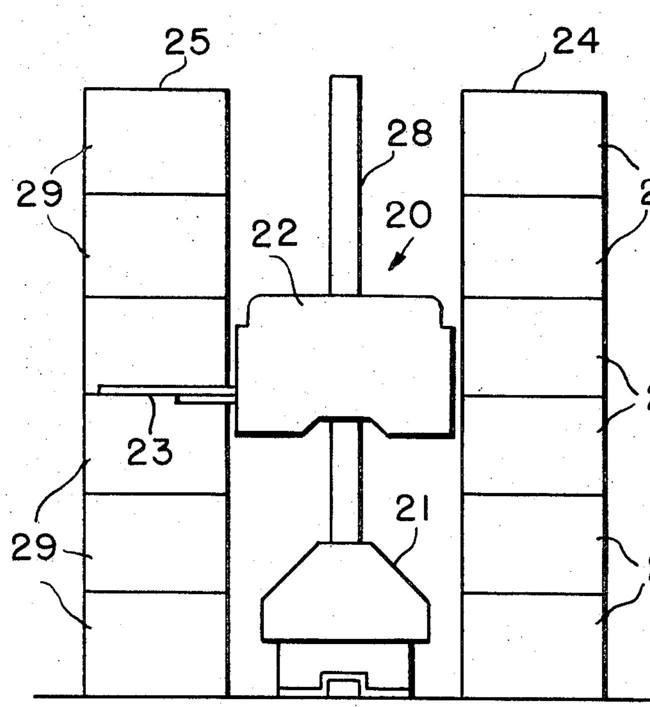


FIG. 1

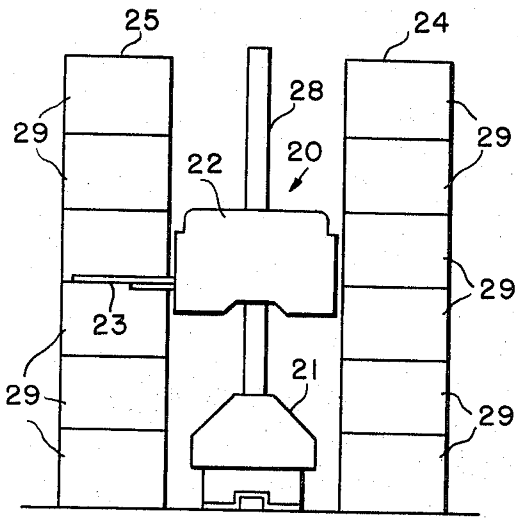
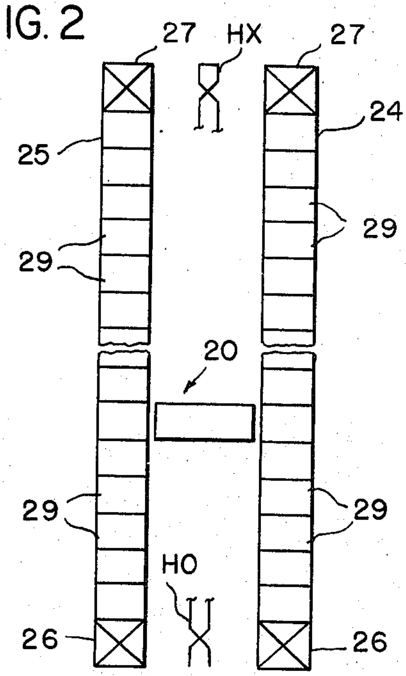


FIG. 2



CR1	CR2	CR3	CR4	VOLT AT 202
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
1	0	0	0	6
1	0	1	0	7
1	1	0	0	8
1	1	1	0	9

FIG. 5

CR5	CR6	CR7	CR8	CR9	CR10	CR11	VOLT AT 201
0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	1
0	0	0	0	0	1	0	2
0	0	0	0	0	1	1	3
0	0	0	0	1	0	0	4
0	0	0	0	1	0	1	5
0	0	0	0	1	1	0	6
0	0	0	0	1	1	1	7
0	0	0	1	0	0	0	8
0	0	0	1	0	0	1	9
0	0	0	1	0	1	0	10
0	0	0	1	0	1	1	11

FIG. 4

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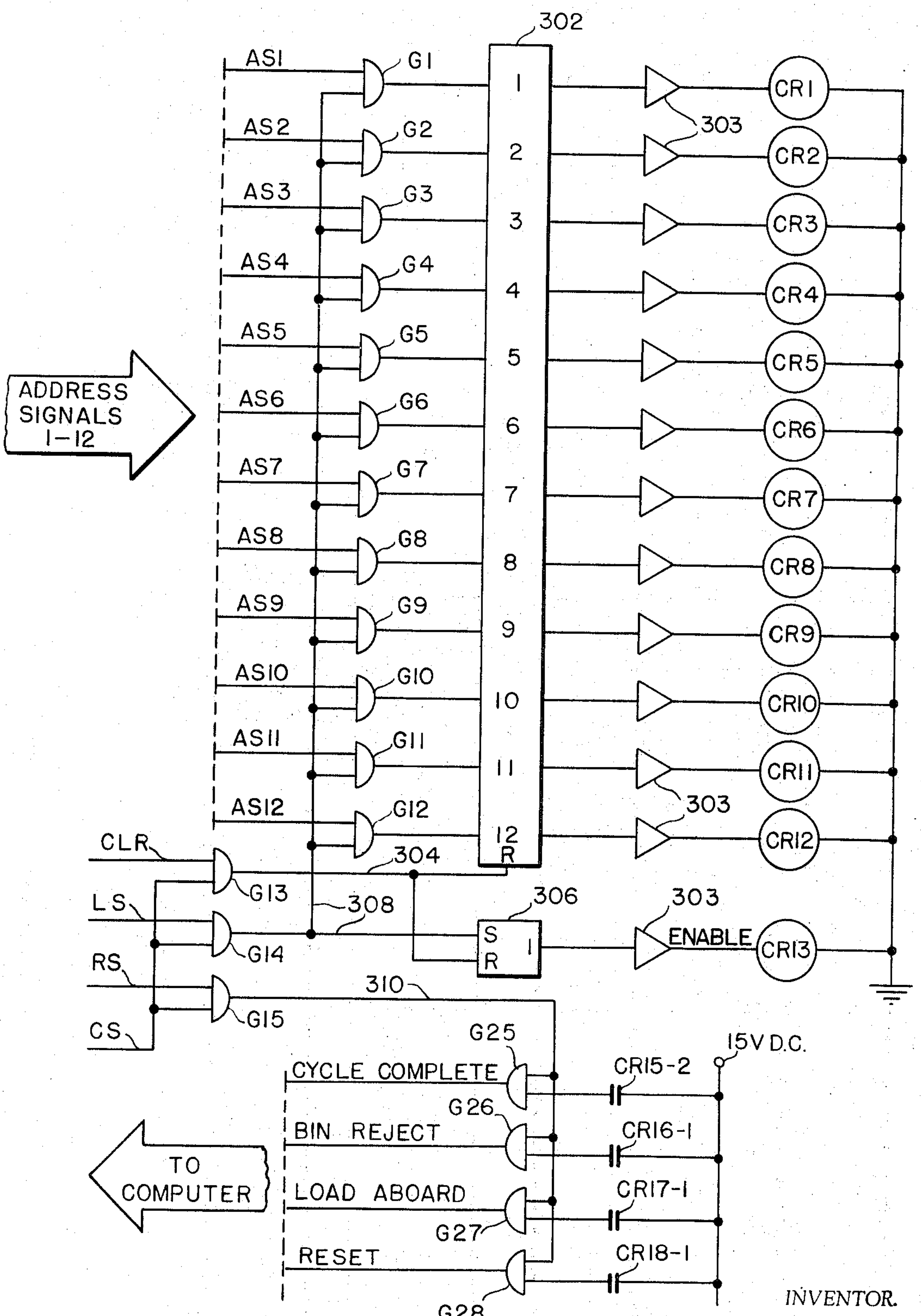

FIG. 3A

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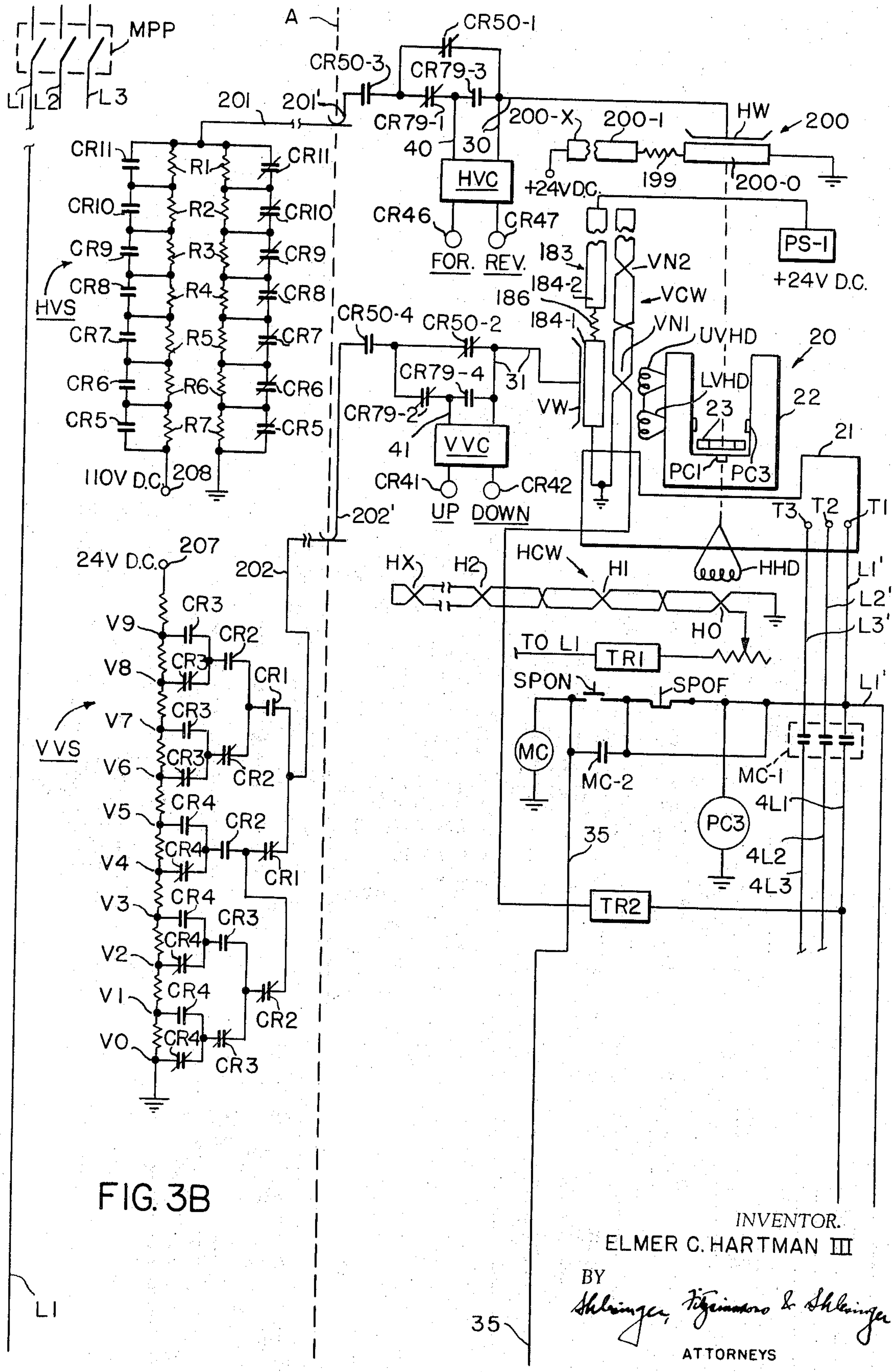

FIG. 3B

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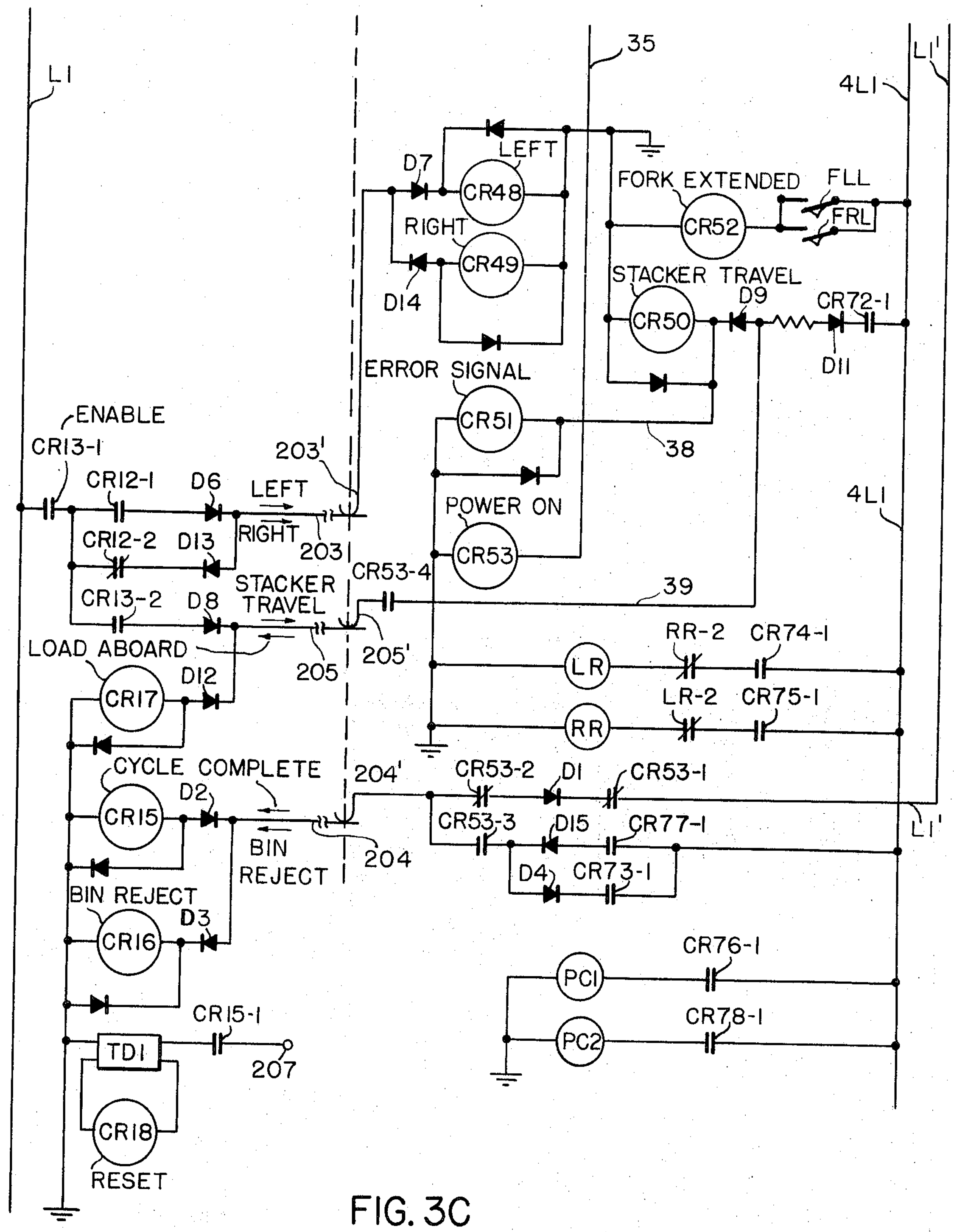

FIG. 3C

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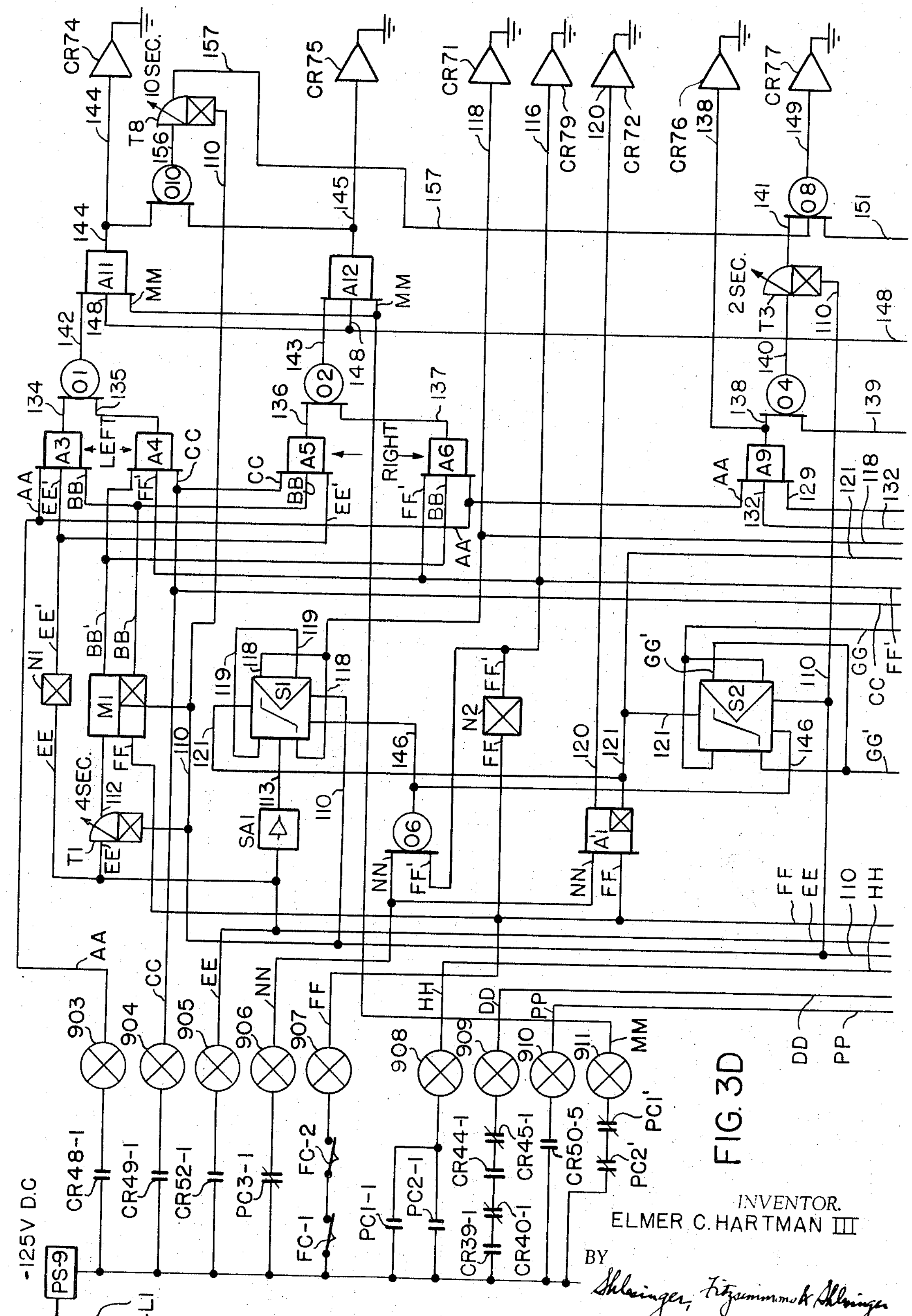

FIG. 3D

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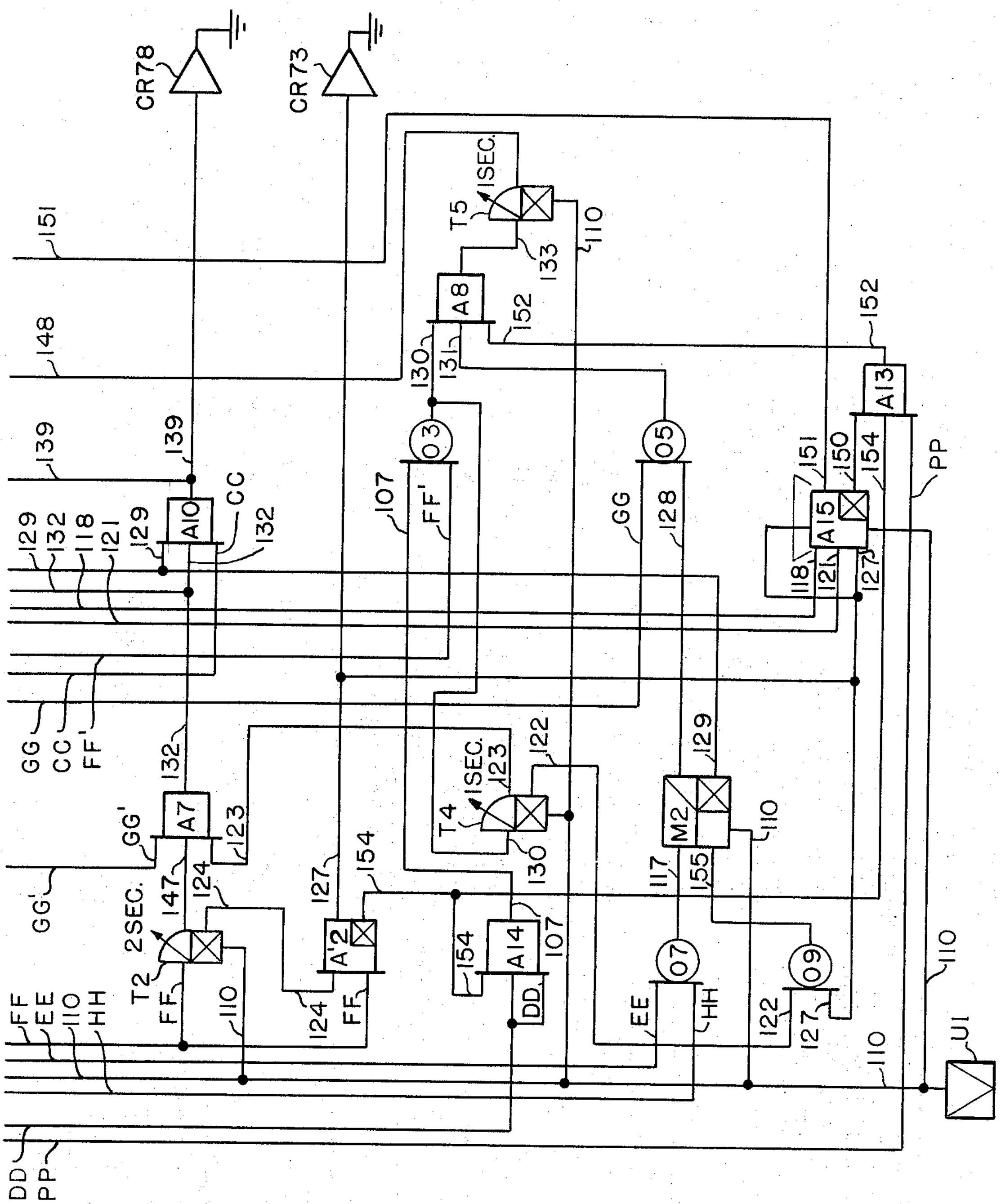

FIG. 3E

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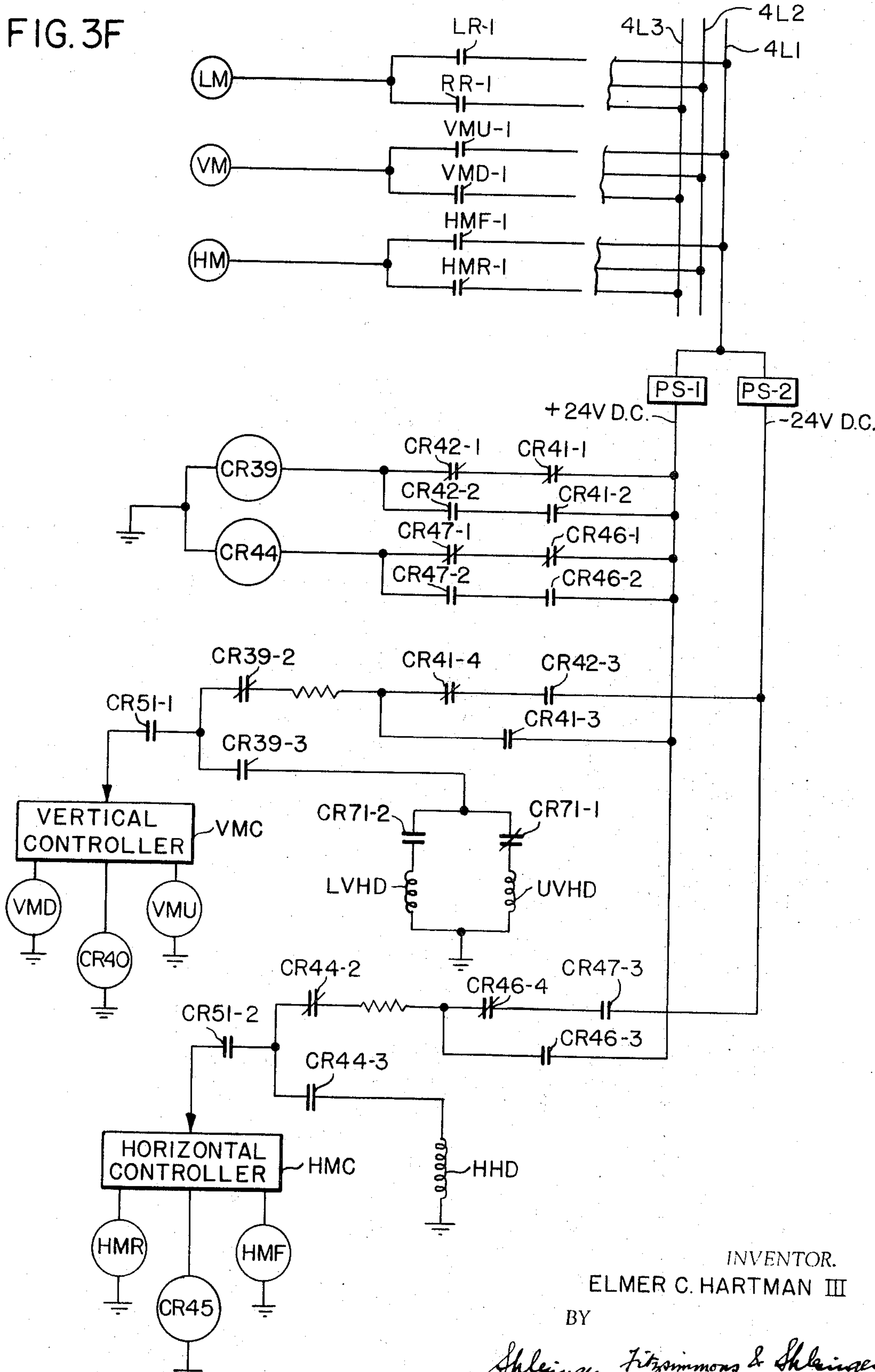
FIG. 3F



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POSITION CONTROL SYSTEM FOR A WAREHOUSE APPARATUS

This is a continuation of applicant's pending patent application Ser. No. 73,159, filed Sept. 17, 1970 now abandoned.

This invention relates to automated stackers or load carriers of the type employed in automatic warehouse systems, and more particularly to a stacker which can be programmed automatically to transfer loaded pallets between loading stations and selected bins in one or more storage racks. In a more specific aspect, this invention relates to an automatic stacker which can be programmed by a computer disposed remote from the stacker.

Conventional stackers can be programmed to effect a single or dual command - i.e., to effect automatic delivery of a load from a home loading station to a selected bin in a nearby storage rack, and/or to retrieve a load from a selected bin in the rack. Heretofore, however, with many types of stackers it has been necessary to cycle the stacker home after each command, whether single or dual, to enable the operator to program the stacker for a new command. The reason is that the address switches, which must be manually actuated to program a command, have been mounted on the stacker itself, and consequently it was essential that the stacker be returned to the head of the aisle at the completion of a command so as to be accessible to the operator for the programming of a new command.

Some stackers, though, have been built with remote controls; which in such cases may be located any desired distance from the stackers which they control, and from the racks served by the stackers. However, even where remote controls have been employed, it has been necessary heretofore in the case of certain dual command stackers to employ two separate sets of bin selector switches, one set for a storage command and another set for a retrieval command.

A further disadvantage of prior such stackers is that they are capable only of transferring loads between a loading station at one end of the aisle in which the stacker travels and any one of the bins in the associated racks; and they are not capable of transferring loads between bins in the racks.

It is an object of this invention to provide an improved remote controlled automatic stacker which does not have to return to any particular home or operating station in order to be programmed.

Another object of this invention is to provide a novel stacker of the type described which has only one set of selector switches programmable by a computer remote from the stacker to effect successive load pick up and deposit cycles for as long a period as the computer imparts program information to the stacker.

A further object of this invention is to provide an automatic stacker of the type described which is substantially more compact and versatile than prior such stackers.

Other objects of the invention will be apparent hereinafter from the specification and the recital of the appended claims, particularly when read in conjunction with the accompanying drawings.

In the drawings;

FIG. 1 is an end elevation and FIG. 2 is a schematic plan view of part of a warehousing system and a typical stacker therefor made in accordance with one embodiment of this invention;

FIGS. 3A, 3B, 3C, 3D, 3E and 3F are electrical wiring diagrams illustrating one manner in which this stacker may be wired for remote control operation, portions of the stacker also being illustrated schematically; and

FIGS. 4 and 5 are truth charts for the horizontal and vertical selector relays which control the corresponding motions of the stacker.

Referring now to the drawings by numerals of reference, 20 (FIGS. 1, 2 and 3B) denotes generally a stacker comprising a trolley portion 21, an elevator 22, which is mounted for vertical movement on a mast 28 carried by the trolley, and a reciprocable, load-bearing fork or shuttle mechanism 23, which is mounted on the elevator for telescopic movement selectively out of opposite sides thereof. Trolley 21 is mounted in a conventional manner for movement by a motor HM (FIG. 3F) longitudinally in an aisle between a pair of identical, spaced storage racks 24 and 25, and two pairs of loading stations 26 and 27, which are located at opposite ends of the aisle. The two racks 24 and 25 have their storage bins 29 arranged in confronting horizontal rows and vertical columns at opposite sides of the aisle. The elevator 22 is movable vertically on mast 28 by a motor VM (FIG. 3F); and the fork 23 is movable laterally out of either side of the elevator by a motor LM (FIG. 3F). Each of the motors HM, LM and VM has a brake (not illustrated), which normally is in its braking state, and which is released in a known manner, when the associated motor is energized.

Trolley 21 carries a horizontal sensing head HHD (FIG. 3B), which travels just above a pair of series-connected wires HCW, that are fixed to the floor beneath the stacker to extend longitudinally down the aisle between the racks. These wires, which cross and recross one another at spaced points along the aisle, from at alternate intersections thereof a plurality of stable nulls, or null points HO, H1, H2, etc. through HX, which are designed to develop in head HHD a control signal that is used to stop trolley 21 precisely at any one of a plurality of different horizontal positions in the aisle, in each of which positions the trolley will be in registry with a pair of confronting columns of bins of the racks. When the stacker 20 is properly positioned between one of the pair of loading stations 26 and 27 (FIG. 2), the head HHD will register with either the null point H0 or HX, respectively. The remaining horizontal null points correspond in number to, and register with, the columns of bins in each rack, and they are positioned so that as the stacker registers with successive pairs of confronting columns of bins during its movement in the aisle, its head HHD will register successively with the corresponding null points.

The elevator 22 carries a pair of vertically spaced heads UVHD and LVHD (FIG. 3B), which cooperate with a further pair of series-connected wires VCW mounted on the vertical mast 28 that projects upwardly from the trolley 21 for movement therewith. As in the case of the horizontal wires HCW, the vertical cross-over wires VCW cross and recross one another at vertically spaced intervals to form at alternate crossings a plurality of null points, two of which are illustrated at VN1 and VN2 in FIG. 3B. These null points correspond to successive, vertically spaced rows of storage bins in each rack, and are arranged so that point VN1 corresponds to the lowest row of bins in each rack, point VN2 corresponds to the second row of bins up from the bottom of each rack; and so on. In cooperation with the heads UVHD and LVHD these wires serve to position the elevator **22** in precise vertical alignment with any selected row of bins in the racks in a manner described in more detail below.

Mounted on the elevator for vertical movement therewith is a vertical wiper VW (FIG. 3B), which has sliding electrical contact with a vertical wiper track **183**. Wiper track **183** is mounted on the same mast **28** that supports the wires VCW, and comprises a plurality of vertical spaced conductor bars, two of which are designated as **184-1** and **184-2**, respectively. The number of conductor bars in track **183** equals the number of rows of bays or bins arranged vertically in each rack and, therefore, the number of null points in the vertical wires VCW. The confronting ends of the vertically spaced conductors **184-1, 184-2,** etc. are connected to one another by resistors **186**, which are selected to develop a predetermined, equal voltage drop (for example 1 volt) between adjacent conductors in the track, so that the uppermost conductor in the track will be at a higher voltage than the lowermost.

Fixed to a stationary support above the stacker **20** to extend down the aisle between the racks is a horizontal wiper track **200** (FIG. 3B), comprising a plurality of horizontally spaced conductor bars **200-0, 200-1,** etc. through **200-X**. The trolley **21** carries a horizontal wiper contact HW, which has sliding electrical contact with the conductors of track **200**. The bars in track **200** are two greater in number than the columns of bays in each rack, and are spaced along the aisle horizontally so that bar **200-0** registers with the loading stations **26** at one end of the aisle, the bar **200-X** registers with the loading stations **27** at the opposite end, and the remaining bars register with the columns of bays in the racks. As in the case of the vertical track **183**, confronting ends of adjacent conductor bars **200** are connected by like resistors **199**, which develop predetermined equal voltage drops (for instance 1 volt) between adjacent bars in the track **200**.

The potentials on the wipers HW and VW correspond, respectively, to the particular conductor bar of the tracks **200** and **183**, respectively, with which they are engaged at any particular moment. The voltages on the horizontal and vertical wipers HW and VW thus represent the actual position of the stacker **20** at any given instant. For example, when the stacker **20** is properly positioned between the loading stations **26**, the horizontal wiper HW (FIG. 3B) is at the ground potential of the bar **200-0**, while its vertical wiper VW is at the ground potential of the vertical conductor bar **184-1**.

The stacker carries both a horizontal voltage comparator HVC and a vertical voltage comparator VVC, each of which has a pair of input terminals. The voltage of the horizontal wiper HW is applied by a wire **30** to one of the input terminals of the horizontal comparator HVC; and the potential of the vertical wiper VW is applied by a wire **31** to one of the input terminals of the vertical comparator VVC.

The other input terminals of the comparators HVC and VVC, as represented by the wires **40** and **41**, respectively, are adapted to be placed selectively at different potentials corresponding to the positions to which it is desired to dispatch the stacker trolley **21** and

elevator **22**. When the input potentials (**40, 30**) to the horizontal comparator HVC are equal, the trolley **21** stops; but when these inputs are unequal, the trolley moves in a direction to equalize these inputs. Similarly the elevator **22** is moved vertically whenever the inputs (**41, 31**) to the vertical voltage comparator VVC are unequal, and its vertical movement is stopped, when the inputs **41, 31** are equal.

The dispatch signals to the comparator leads **40** and **41** are provided by a plurality of address selecting relays CR1 through CR11 (FIG. 3A), which are mounted in a stationary console (not illustrated) remote from the stacker, and which are energizable selectively by signals emanating from a conventional computer (not illustrated). The address relays CR1, CR2, CR3 and CR4 control the vertical position of the elevator **22** by operating a vertical voltage selector denoted generally at VVS in FIG. 3B; and the relays CR5, CR6, CR7, CR8, CR9, CR10 and CR11 control the horizontal position of the trolley portion **21** of the stacker through operation of a horizontal voltage selector denoted generally at HVS in FIG. 3B. In FIG. 3B the components to the left of the broken line A are located in the stationary console, while the apparatus and circuits carried by the stacker **20** are illustrated at the right of this line.

The horizontal voltage selector network HVS comprises two identical sets of series connected resistors R1 through R7 (FIG. 3B) corresponding, for example, to 10, 20, 40, 80, 100, 250 and 500 ohms, respectively. The resistors R1 to R7 of one set (the left hand set in FIG. 3B) are connected, respectively, in parallel with normally-open relay switches CR11, CR10, CR9, CR8, CR7, CR6 and CR5, respectively, between a line **201** and a direct current power source **208** of, for example, **100** volts. The resistors R1 to R7 of the other set (the right hand set in FIG.3B) are connected, respectively, in parallel with normally-closed relay switches CR11, CR10, CR9, CR8, CR7, CR6 and CR5, respectively, between the line **201** and ground. Consequently, when switches CR5 through CR11 are in the positions illustrated in the drawing (FIG. 3B), line **201** will be placed at ground potential, and **100** ma. flows in the circuit, with the full 100 volt potential on terminal **208** being dropped across the left hand set of resistors R1 to R7. When, however, the positions of these switches are reversed, line **201** will be at the potential of terminal **208**, or at 100 volts. By selective energization of the relays CR5 to CR11 as illustrated in part by the chart in FIG. 4, the potential applied by the selector HVS to line **201** can be made to be any-where from zero to 100 volts.

The vertical voltage selector VVS (FIG. 3B) comprises ten terminals VO through V9 separated from one another by like, series connected resistors, each of which may have a value, for example, of 20 ohms. Terminal V0 is connected to ground potential, and terminal T9 to a direct current power source **207** (e.g. **24** volts) which is operative to maintain terminals VO through V9 at voltage potentials of zero through 9 volts, respectively. These terminals are adapted to be connected selectively to a line **202** by a bank of relay switches CR1, CR2, CR3 and CR4, some of which are normally open, and some of which are normally-closed. When these switches are in the positions shown in FIG. 3B, the zero voltage or ground potential of terminal VO is applied to line **202**. By selective operation of the relays CR1 to CR4 in the manner indicated by the chart in FIG. 5, the terminals VO to V9 may be connected selectively to line 202 thereby to apply anywhere from zero to nine volts to line 202.

Line 201 extends down the aisle between the racks 25 and 24, and is slidingly engaged by a wiper contact 201' carried by the stacker, and connected through a normally-open relay switch CR50-3 and a normally-closed switch CR79-1 to horizontal comparator input 40. Line 202 also extends down the aisle between racks 25 and 24, and is slidingly engaged by another wiper contact 202', which is mounted on the stacker for movement therewith, and which is connected through normally-open switch CR50-4 and normally-closed switch CR79-2 with the vertical comparator input 41. It is therefore possible to apply preselected horizontal and vertical address signals to the comparators HVC and VVC regardless of where the stacker is located in the aisle.

As shown in FIG. 3C, additional wiper contacts 203', 204' and 205' are carried by the stacker 20 for transmitting signals between the console and the stacker along lines 203, 204 and 205, respectively. These signals are controlled, at least in part, by solid state logic circuitry (FIGS. 3D and 3E), which is mounted on a stacker control panel for movement with the stacker.

The address signals AS1 through AS11 (FIG. 3A) for controlling the address relays CR1-CR11 originate at the computer with a twelfth address signal AS12, which determines which rack (left or right) is to be serviced by the command represented by the stacker dispatching signals AS1-AS11. Each of the twelve address signals AS1-AS12 is applied to one of the inputs of twelve dual input AND gates G1 through G12, respectively, the outputs of which are applied in parallel to the inputs 1 to 12 of a twelve bit register 302 (FIG. 3A). The outputs 1 to 12 of register 302 are applied through conventional DC amplifiers 303 to the relays CR1-CR12, respectively; relay CR12 being operable, as noted hereinafter, to determine from which side of the elevator 22 the fork or shuttle 23 will advance, when the stacker reaches its programmed destination.

The computer also develops at certain times a "clear" signal CLR (FIG. 3A), which is applied to one of the inputs of an AND gate G13; a "load" signal LS which is applied to the input of AND gate G14; and a "read" RS signal, which is applied to the input of an AND gate G15. The other input to each of gates G13, G14 and G15 is a "code" signal CS, which is developed at the computer to supply signals, for example, selectively to one of a plurality of stackers similar to stacker 20, and which is decoded at the stationary console by a conventional decoding device (not illustrated) before being applied as an enabling signal to gates of the type denoted at G13, G14 and G15. When gate G13 is enabled, it produces at its output a signal 304, which resets register 302, and resets a flip flop 306, which controls an "enabling" relay CR13. When G14 is gated it produces at its output a signal 308, which is applied to gates G1 through G12, and to flip flop 306 to set the latter and energize CR13. When G15 is gated, its output signal 310 is applied to one of the inputs of AND gates G25, G26, G27 and G28, which will be described hereinafter.

Power for operating the console and stacker circuits, including the stacker motor control circuits of FIG. 3F, is supplied from a conventional three phase alternating current power source through a manually operable power switch MPP (FIG. 3B) to power lines L1, L2 and L3. Line L1 supplies power to the console (FIG. 3C), while all three of these lines are connected (for example by conventional wiper contacts, not illustrated) to the input terminals T1, T2 and T3 (FIG. 3B) of a control panel on the stacker 20.

To avoid unnecessary repetition, it will be assumed hereinafter that the switch MPP has been closed to apply power to the system.

With switch MPP closed, the hot terminals T1, T2 and T3 (FIG. 3B) on the stacker energize the stacker power lines L1', L2' and L3', respectively. Line L1' energizes a photo cell unit PC3, which is mounted on the stacker elevator 22 to detect the presence or absence of a load on the fork or shuttle 23. If a load is present the load will prevent light from a lamp on the elevator from falling on the photo cell PC3, and consequently will permit its associated switch PC3-1 (FIG. 3D) to return to its normally-closed position. If on the other hand there is no load on the elevator, the photo cell PC3 will be actuated by the light from its associated lamp, and switch PC3-1 will be held open.

On the negative half-cycle of the voltage applied to line L1' upon the closing of switch MPP, a "cycle complete" relay CR15 (FIG. 3C) in the stationary console is energized from line L1' through the normally-closed relay switch CR53-1, the diode D1, the normally-closed switch CR53-2, the wiper contact 204' on the stacker, conductor 204, diode D2 and relay CR15 to ground. A diode D3 and a bin reject relay CR16 are connected in parallel with the diode D2 and relay CR15, but diode D3 is oriented oppositely with respect to the diodes D1 and D2, so that it prevents current flow in the bin reject relay CR16, when the cycle complete relay CR15 is energized. The now energized relay CR15 closes its switch contacts CR15-1 (FIG. 3C) and CR15-2 (FIG. 3A), thereby sending a "cycle complete" signal to one of the inputs of the dual input AND gate G25 (FIG. 3A), and energizing a time delay unit TD1 (FIG. 3C), which momentarily delays the energization of a reset relay CR18. This relay is used to indicate the absence of power in the stacker logic. At this time the stacker-power-on switch SPON (FIG. 3B) has not yet been closed, so that after a brief delay the relay CR18 is energized by TD1 and closes its switch CR18-1 (FIG. 3A) to send a "power off" or "reset" signal to one of the inputs of the AND gate G28.

At this time, assuming that the signals from the computer are intended for stacker 20, the decoder (not illustrated) on the console will produce the code signal CS (FIG. 3A), which partially enables gates G13, G14 and G15. At this time also the computer applies a "read" signal RS to gate G15 to determine the present mode of the stacker. Gate G15 is therefore enabled and produces an output signal 310 which is applied to one of the inputs of each of the AND gates G25, G26, G27 and G28, which when gated, send signals to the computer. Since switches CR15-2 and CR18-1 are closed at this time, gates G25 and G28 are enabled and send "cycle complete" and "reset" signals, respectively, to the computer. It will be assumed that there is no load on elevator 22 at this time, so that switch CR17-1 (FIG. 3A) is open and G27 is not gated.

The computer responds to the "cycle complete" signal by sending a "clear" signal CLR together with the code signal CS to the gate G13 so that the latter is enabled and produces an output signal in line 304, which resets the twelve bit "Address" register **302** and the "enable" flip flop **306.** Normally, when a plurality of successive commands are being fed to the stacker by the computer, the "cycle complete" signal appears only momentarily, each time the fork mechanism retracts back onto the elevator **22** after a pickup or deposit operation, or just long enough to reset the register **302** and the flip flop **308.** At this time, however, power has not yet been applied to the stacker logic circuitry, (i.e., switch SPON (FIG. 3B) has not yet been pushed closed) so that the energizing voltage for relays **CR15** and **CR18** continues to be applied through switches **CR53-1** and **CR53-2** (FIG. 3C). The prolonged energization of relay **CR15,** and the consequent energization of relay **CR18,** indicates to the computer that the stacker power must be "reset" or turned on by pushing switch SPON. This reset condition, which may be indicated at the computer by a print out or other visual indicator means, will occur whenever relay **CR18** is energized.

For purposes of explanation, it will be assumed that the empty stacker is positioned between the load stations **26,** and that it is desired to pick up a loaded pallet from the left hand station **26** (FIG. 2), and to place this pallet in the right hand rack **24** in a bin **29** which is the fourth bin up from ground level in the fourth column of bins down the aisle from stations **26.** To perform these operations, the computer is programmed to instruct the stacker to perform two successive cycles; the first cycle comprising picking up the load from the left station **26,** and the second comprising depositing the load in the selected bin. A "cycle complete" signal is generated at the end of each of these cycles.

The operator now closes the stacker Power On switch SPON to energize the main control relay MC from the line L1' through the normally-closed stacker Power On switch SPOF and switch SPON. This closes a holding switch **MC-2** to maintain the relay MC energized upon release of the switch SPON, and closes switch **MC-1** to supply power to the stacker logic through leads **4L1, 4L2** and **4L3.** These leads then remain energized until relay MC is deenergized, for example by the manual opening of switch MPP, or by a conventional safety circuit (not ilustrated). Instantly the Power On relay **CR53** (FIG. 3C) is energized from line L1' through the holding switch **MC-2,** line **35** and relay **CR53** to ground, thereby opening the switches **CR53-1** and **CR53-2** and removing the signal from wiper contact **204'.** This deenergizes the "cycle complete" relay **CR15,** thereby opening switches **CR15-2** (FIG. 3A) and **CR15-1** (FIG. 3C) and deenergizing reset relay **CR18-1** so that both the cycle complete and reset signals are removed from the computer input.

When the "cycle complete" and "reset" signals are removed , the computer initiates the first of the two above-noted cycles by applying a "load" signal LS together with a code signal CS to the inputs of gate **G14** (FIG. 3A), at the same time that it applies the programmed address signals to selected ones of the gates G1-G12. Gate **G14** is thus enabled, producing a signal in line **308,** which simultaneously "enables" those of gates G1 through **G12** which are receiving address signals from the computer, and sets flip flop **306** to energize the "stacker enabling" relay **CR13.** Relay **CR13** then closes its switches **CR13-1** and **CR13-2** (FIG. 3C).

At this time, since the stacker is already in position to pick up a load from station **26,** it need not be moved before picking up the load; and consequently no signals are present on any of the address signal lines **AS1** through **AS11,** whereby relays **CR1** through **CR11** remain deenergized. However, at this time the computer does apply a signal to line **AS12** (FIG. 3A) to energize relay **CR12** to program the forks **23** for movement left. Relay **CR12** closes switch **CR12-1** (FIG. 3C) and opens **CR12-2** to energize the "forks left" relay **CR48** on the positive half cycle of the voltage in line **L1** through **CR13-1, CR12-1** diode **D6,** line **203,** wiper **203',** diode **D7** and **CR48** to ground. With relay **CR48** energized, its switch **CR48-1** (FIG. 3D) will be closed to energize converter **903.** Since at this time there is no load on the elevator **22,** switch **PC3-1** (FIG. 3D) will be open, and converter **906** deenergized.

Also at this time the switches which are illustrated as controlling motors LM, VM and HM (FIG. 3F) are open, so these motors remain in their deenergized, braked mode. Moreover, the now-energized line **4L1** energizes a transformer **TR2** (FIG. 3B), and direct current power supplies **PS-1** and **PS-2** (FIG. 3F) and **PS-9** (FIG. 3D). The output of the transformer **TR2** supplies power for the vertical crossover wires VCW (FIG. 3B); the power supplies **PS-1** and **PS-2** provide, respectively, positive and negative 24 volt power supplies for the stacker motor circuits (FIG. 3F); and the power supply **PS9** supplies a negative 125 volts DC for the stacker logic illustrated in FIGS. **3D** and E. The power supply **PS-1** also has its output connected to the vertical wiper track **183** as shown in FIG. 3B.

The now-energized power supply **PS-9** applies an input signal through a pair of normally-closed switches **PC1'** and **PC2'** (FIG. 3D) to a converter **911** in the stacker solid state logic. This produces an output signal MM in the logic to indicate that the bin testing system is ready. Switches **PC1'** and **PC2'** are controlled by photoelectric cell units **PC1** and **PC2** (FIG. 3C), which are adaptd to be energized selectively through normally-open relay switches **CR76-1** and **CR78-1** from line **4L1.** These units, which are conventional, are mounted on the left and right hand sides, respectively, of elevator **22** to detect the presence or absence of a load in a selected bin, or on one of the loading stations, to prevent the stacker from attempting to deposit a load in a filled bin or station. Whenever either unit **PC1** or **PC2** is energized from line **4L1** to perform a testing operation, the corresponding switch **PC1'** or **PC2',** respectively, is opened. The normally-open switches **PC1-1** and **PC2-1,** however, which are in parallel with one another, and in series with the converter **908** (FIG. 3D), are closed only when the light from the lamp associated therewith is reflected onto the photoelectric cell of the particular unit during conduction of a test.

At this time the power On relay switches **CR53-3** (FIG. 3C) and **CR53-4** are closed to enable the transmission of signals between the stacker and console through the wipers **204'** and **205'.** Also, as previously noted, relay **CR13** has been energized by signals from the computer, so that its switches **CR13-1** and **CR13-2** (FIG. 3C) are closed. Consequently, on the positive half cycle of the voltage in line **L1,** power is applied through these switches, a diode **D8,** line **205,** wiper **205',** switch **CR53-4,** line **39,** diode **D9** and both relays **CR50** and **CR51** to ground. Relay **CR51** then closes its switches **CR51-1** and **CR51-2** (FIG. 3F) so that signals may be sent the horizontal and vertical motor controllers HMC and VMC as noted hereinafter. Also, since the stacker travel enabling relay CR50 is now energized, its normally-closed switches CR50-1 and CR50-2 (FIG. 3B) are opened; its switches CR50-3 and CR50-4 are closed to enable address voltages to be applied from selectors HVS and VVS to the inputs 40 and 41 of the horizontal comparator HVC and vertical comparator VVC through the normally-closed switches CR79-1 and CR79-2, respectively; and switch CR50-5 (FIG. 3D) is closed to energize converter 910.

At this time, however, none of the address relays CR1-CR11 are energized, so that lines 201 and 202 apply ground potential to the comparator inputs 40 and 41. Since the stacker is between stations 26 with its elevator in its lowermost position (FIG. 3B), the inputs 30 and 31 of the comparators HVC and VVC are also at ground potentials.

The comparators HVC and VVC (FIG. 3B) operate in known manner to control relays CR46, CR47 and CR41, CR42, respectively, which are connected to their outputs. When the inputs to either comparator are equal, there is no signal at the output of the comparator, and consequently neither of its relays CR46, CR47 or CR41 or CR42 is energized. If the inputs to a comparator HVC or VVC are different, an output signal is produced to energize one of its output relays. For the horizontal comparator HVC, if the address signal or voltage on input 40 is greater than (more positive with respect to) the signal on input 30, the relay CR46 will be energized to energize the horizontal or trolley motor HM (FIG. 3F) in a direction to drive the stacker 20 away from stations 26 and toward stations 27. Merely for purposes of description, this will be referred to as the forward direction of travel of the stacker. Conversely, if the voltage on line 30 is greater than on the input line 40, the relay CR47 will be energized and the stacker will travel in a reverse direction (toward stations 26).

When the address voltage on the vertical comparator input 41 (FIG. 3B) is greater than that on line 31 the relay CR41 is energized to cause the elevator to be driven upwardly; and when the voltage on line 31 exceeds the voltage on line 41, the relay CR42 is energized to drive the elevator downwardly.

Referring now to FIG. 3F, CR39 and CR44 represent two relays, which control what may be defined as the "coarse" and "fine" feed operations of the vertical and horizontal motors VM and HM. When the two relays CR39 and CR44 are deenergized, the horizontal and vertical motors HM and VM are in "coarse" control and will operate at high speeds to move the stacker and elevator, respectively, rapidly toward a selected designation; and when these two relays are energized, the motors HM and VM are switched from "coarse" to "fine" control mode in which they operate slowly to bring the stacker and elevator precisely to the desired destination. During "coarse" control predetermined direct current voltages are applied to the horizontal and vertical motor controllers HMC and VMC (FIG. 3F); but during "fine" control variable signals are applied to the inputs of the controllers from the sensing heads HHD and UVHD, LVHD (FIG. 38) on the stacker. These heads develop signals only when moved relative to their associated wires HCW and VCW, and during "coarse" control they have no effect on the controllers HMC and VMC. When input signals, either "coarse" or "fine," are applied to the controllers HMC and VMC, the reversible motors HM (FIG. 3F) and VM are rotated in one direction or the other, depending upon the polarity of the input signals. Moreover, whenever the horizontal motor HM is energized, the controller HMC energizes a horizontal tachometer relay CR45;and when the motor VM is energized, controller VMC energizes a vertical tachometer relay CR40. Relays CR45 and CR40 control normally-closed switches CR45-1 and CR40-1 (FIG. 3D) in a zero center control circuit.

At this time relays CR39 and CR44 (FIG. 3F) are energized from the power supply PS-1 through the normally-closed switches CR41-1 and CR42-1, and the normally-closed switches CR46-1 and CR47-1, respectively, and relays CR40 and CR45 are deenergized. Consequently, the switches CR39-1, CR40-1, CR45-1 and CR44-1 (FIG. 3D) are closed, so that voltage is applied from PS-9 to the input of the stacker converter 909. Also switches CR39-2 and CR44-2 (FIG. 3F) are open to isolate controllers VMC and HMC from the DC power supplies PS-1 and PS-2, and switches CR39-3 and CR44-3 are closed to enable signals developed by the head HHD to be applied through switches CR44-3 and CR51-2 to the input of controller HMC and to enable signals from head UVHD to be applied through CR71-1, CR39-3 and CR51-1 to the input of controller VMC. Since the stacker 20 is now motionless in the position illustrated in FIG. 3B, its horizontal head HHD registers with the null HO of the horizontal wires HCW, and its upper vertical head UVHD is in registry with the lowermost null VNL of the vertical wires VCW. As a result, no sensing signals are developed in these heads by the associated wires, and consequently at this time there are no input signals to the horizontal and vertical controllers HMC and VMC. The vertical and horizontal motors VM and HM therefore remain deenergized.

At this time the fork mechanism 23 is in its retracted or centered position on elevator 22, where it holds closed two limit switches FC-1 and FC-2 (FIG. 3D), which therefore complete a signal input circuit from the power supply PS-9 to the converter 907. At this time, therefore, the converters 903, 907, 909 910 and 911 (FIGS. 3D and 3E) are receiving input signals. Converter 903 produces the signal in line AA, which indicates to stacker 20 that its fork mechanism 23 is to be moved to the left, when actuated. Converter 911 produces the signal MM, which indicates that the bin sensor device is ready. Converters 907 and 909 now produce the forks-centered signal FF and the stacker-centered signal DD, respectively (FIGS. 3D and E).

Signal FF is applied to the input of a memory element M1, which controls the mode of the fork mechanism 23 by preparing it for either a "retract" or an "extend" operation. Although signal FF tends to place M1 in its "extend" mode, it is already in this mode as a result of having received an initial setting signal on line 110 from a unit reset device U1, which is energized from the power supply PS-9 when the stacker switch SPON (FIG. 3B) is depressed. Each time it is pulsed, the reset U1 (FIG. 3E) also resets the step memories S1 and S2, the memory M2, the sealed AND element A15 to produce the output signals in lines 119 (FIG. 3D), GG, 129 and 150, respectively. The timer elements of the logic illustrated in FIGS. 3D and E are also reset upon the appearance of the signal 110 to produce signals in lines 124 and 122 at the output of the timers T2 and T4, respectively.

At this time unit S1 (FIG. 3D), which controls the energization of the upper and lower heads UVHD and LVHD (FIGS. 3B and 3F) by the solenoid CR71 (FIG. 3D), has its output signal along line **118** blocked, which therefore prevents the energization of the relay CR71, so that its normally-closed switch CR71-1 (FIG. 3F) remains closed to maintin the upper vertical head UVHD energized, while the switch CR71-2 remains open to deenergize the lower vertical head LVHD. With the upper head energized, the elevator **22** is maintained in its lower position with respect to the two different positions it assumes for picking up and depositing, respectively.

Signal FF also blocks the output of the NOT element N2 (FIG. 3D) and gates the AND/NOT element A'1 to produce the output signal in line **121**. For the first two seconds after the stacker switch SPON (FIG. 3B) is closed, the resulting signal FF combines with the input signal **124** at the AND/NOT unit A'2 (FIG. 3E) to produce an output signal in line **127** that momentarily energizes the "cycle complete" relay CR73. Signal FF is also applied to the input of the two-second time delay element T2, so that approximately two seconds after T2 is actuated, the latter is gated to produce the output signal in line **147**, and to block the output signal from line **124**. This removes the signal from line **124** to the input to element A'2, and causes this element to switch its mode, thus blocking any output signal to line **127** and deenergizing relay CR73, and producing instead at A'2 an output signal through line **154**. This pulsing of the "cycle complete" relay CR73 occurs each time that the forks-centered signal FF is generated at the completion of a cycle, when the forks retract back onto the center of the elevator. This pulse causes the momentary closing of the switch CR73-1 (FIG. 3C) so that a "cycle complete" signal can be transmitted from line 4L1, upon the negative half cycle of its voltage, through switch CR73-1, diode D4, the now-closed switch CR53-3, the brush contact **204'** and its associated conductor **204**, the diode D2 and the relay CR15 to ground. This, as noted above, momentarily closes switch CR15-2 (FIG. 3F) to send a cycle complete signal to the computer.

The output signal in line **154** (FIG. 3E) from the element A'2 is applied with the signal DD (FIGS. 3D and 3E) to the AND element A14 (FIG. 3D) to produce an output signal in line **107**, which gates the OR element **03** to produce an output signal in line **130**. The "pick up" signal GG is applied to the input of the OR element **05** to produce an output signal in line **131**, which appears with the signal in line **130** at the input of the AND element A8. The energized converter **910** is producing the stacker enabling signal PP in the stacker logic, thereby completing the input signals (**150, 154,** PP) to the AND element A13, thus gating this element and producing a signal in line **152**. Signal **152** completes the input signals (**130, 131, 152**) to element A8, which is thus gated to produce the input signal **133** for the timer T5. Approximately 5 seconds later this timer is gated producing an output signal in line **148**, which is applied to the inputs of the AND elements A11 and A12. Since at this time the forks are not extended, there is no input signal EE for the NOT element N1, so that this element has an output signal EE', which completes the input signals AA, BB, and EE' to the AND element A3, thus gating this element and producing an output signal in line **134**, which gates the OR element **01**. This produces an output signal in line **142**, which is applied to the input of the element A11. At this time the bin sensor ready signal MM is applied to the inputs of the AND elements A11 and A12. This completes the input signals (**142, 148,** MM) to element A11, which is therefore gated producing the output signal **144**, which energizes the forks left relay CR74 in the stacker logic.

The stacker now begins to operate because relay CR74 closes switch CR74-1 (FIG. 3C) to energize the forks left relay LR from the line 4L1 through switches CR74-1, to normally closed right relay switch RR-2, and relay LR to ground. The relay LR closes the switch LR-1 (FIG. 3F) to energize the reversible motor LM in a direction to drive the associated fork mechanism **23** out of the left hand side of the elevator **22** and beneath the load on the left hand loading station **26**.

As the fork mechanism **23** moves out of the left side of the elevator, it allows the fork center switches FC-1 and FC-2 (FIG. 3D) to open, thus removing the input to the converter **907** and blocking the output signal FF, so that during the time that the forks are not centered on the elevator **22**, the NOT element N2 has an output signal FF', which energizes the relay CR79, reversing its associated switches CR79-1, CR79-2, CR79-3 and CR79-4 from the positions illustrated in FIG. 3B and holding these switches in their reversed positions. This shunts the two input signals to each of the horizontal and vertical voltage comparators HVC and VVC to prevent energization of any of the relays CR41, CR42, CR46 and CR47 during the lateral movement of the fork mechanism.

The signal FF' also is applied to the inputs of elements A4 and A6, neither of which is gated at this time; and signal FF' also gates the OR elements **06** and **03** to produce signals in lines **146** and **130**, respectively. The signal in line **130** already exists at this time because of the presence of a signal in line **107**, which is not blocked upon the removal of signal FF from elements T2 and A'2. The reason for this is that although signal **124** now reappears at the input to A'2, the latter is not gated because signal FF is missing, therefore signal **154** remains to keep element A14 gated.

When the fork mechanism **23** has extended completely under the load it closes the forks-left limit switch FLL (FIG. 3C) to energize the forks-extended relay CR52 from of said carrier relative to said supports, through switch FLL and relay CR52 to ground. The relay switch CR52-1 (FIG. 3D) is thus closed to apply an input signal from the power supply PS-9 to the converter **905** in the stacker logic. This produces the fork-extended signal EE, which blocks the signal EE' to deenergize element **01** to A11, and the relays CR74 and LR. This stops the fork mechanism **23** in its extended position.

Signal EE also appears simultaneously at the input to the timer T1 and the amplifier SA1 (FIG. 3D). There is a delay of four seconds before the timer T1 is gated, and during this period the amplifier SA1 applies an output signal to line **113**, which gates the step memory S1 to block its output signal to line **119**, and to produce instead an output signal in line **118**, which energizes the head control relay CR71 to open switch CR71-1 (FIG. 3F) and to close switch CR71-2, so that the upper vertical head UVHD becomes deenergized, and the lower vertical head LVHD is instead energized. Since it is not precisely in registry with the vertical null V1, the lower head now develops a signal which, causes the elevator

22 to move slightly upwardly in a known manner unitl the lower vertical head LVHD registers with the null VH, at which time the elevator stops. This slight upward movement, which takes slightly less than four seconds, is sufficient to cause the fork mechanism 23 to engage and lift the loaded pallet slightly off of the loading station 26.

Shortly after the load is lifted, the timer T1 times out, and is gated to produce an output signal in line 112 (FIG. 3D), which switches the mode of the memory M1 to block its output signal BB, and to produce the "retract" signal BB', which is applied to the inputs of the AND elements A4 and A6. This causes the AND element A6 to be gated, therefore producing an output signal in line 137, which gates the OR element 02 to produce an input signal in line 143 to element A12. This completes the input signals (143, 148, MM) to the element A12, which therefore energizes the forks-right relay CR75 (FIG. 3D), thus closing the switch CR75-1 (FIG. 3C) to energize the fork right relay RR from line 4L1 through switch CR75-1, switch LR-2 and relay RR. This closes switch RR-1 (FIG. 3F) in the lateral motor circuit to energize motor LM from the lines 4L1, 4L2 and 4L3 in the reverse direction. The now-loaded fork mechanism 23 then begins to retract toward the right onto the elevator.

As shown in FIG. 3D, during travel of the forks either to the left or to the right in response to the output signals in line 144 or 145, the OR element 010 is gated to produce an output signal in line 156, which is applied to the input of a time delay element T8, which has a delay of approximately ten seconds before it is gated to produce an output signal in line 157. Under normal operation this output signal is not generated. If, however onstruction such as a misplaced load should prevent the fork mechanism 23 from completing its movement either outwardly, or rearwardly back onto the elevator, within the ten second period, the timer T8 will be gated to produce a signal in line 157, which will gate an OR element 08 to energize a bin-reject realy CR7 in a manner which will be described in more detail below.

After the load is picked up from the loading station, and during the retraction of the load back onto the elevator, and switch FLL (FIG. 3C) reopens to remove signal EE (FIG. 3D); and the lamp for the photoelectric cell PC3 (FIG. 3B) is blocked, therefore deenergizing the photocell and permitting its switch PC3-1 (FIG. 3D) to close to complete the input signal to the converter 906 from the power supply PS9. This produces the signal NN indicating the presence of a load on the fork mechanism but at this time (during retraction) the input signal FF to the element A'1 is missing, so that the latter element is not gated. The signal NN does gate at this time the OR element 06 to maintain the signal in line 146 at the inputs to the step memory units S1 and S2; but this has no effect on these units at this time.

When the fork mechanism finally returns in loaded condition to the center of the elevator, it once again closes the fork center switches FC-1 and FC-2 (FIG. 3D) to apply an input signal to the converter 907, thereby producing an output signal FF, and blocking the output signal FF' of the NOT element N2. This removes the input signal FF'from the element A6, thereby deenergizing the forks-right relay CR75 to stop the lateral motor LM. The removal of signal FF' also deenergizes the relay CR79 so that the inputs to the horizontal and vertical voltage comparators HVC and VVC are no longer shunted. Also at this time the cycle-complete pulse or signal in line 127 (FIG. 3E) is triggered by the application of the fork-centered signal FF simultaneously to the unit T2 and the element A'2.

As noted above, during the two second interval it takes before the timer T2 is gated, the element A'2 is momentarily gated to block its output signal 154, and to produce an output signal in line 127, which momentarily energizes the cycle-complete relay CR73. Also, since the load-present signal NN is present, when the loaded fork mechanism returns to the center of the elevator, the AND/OR element A'1 is also gated to remove the output signal from line 121, and to develop instead an output signal in line 120. Signal 121 is removed in time to prevent the gating of the sealed AND element A15. Also, the removal of signal 121 from the input to the step memory S1 has no effect on the latter, which is already in the mode that produces a signal in line 118. The blocking of signal through line 121 to the input of the step memory S2, on the other hand, switches the mode of this element from "pickup" to "deposit", by blocking the output signal GG, and producing instead a signal GG. The signal in line 120 energizes the load present relay CR72; and the signal FF switches the memory M1 to block its output signal BB' and to produce instead the output signal BB.

When the relays CR72 and CR73 are thus energized, they send signals from the stacker to the remote console to indicate that the stacker is loaded and ready to travel to the selected bin into which the load is to be deposited. The relay CR72 closes switch CR72-1 (FIG. 3C) to apply the voltage of line 4L1, on the negative half cycle thereof, through the switch CR72-1, a diode D11, the line 39, the now-closed switch CR53-4, the brush 205' and its associated conductor 205, the diode D12, and through the load-present or load-aboard relay CR17 in the console to ground, thus energizing relay CR17.

Also on the negative half cycle thereof, the voltage in line 4L1 is applied through the now-closed switch CR73-1 (FIG. 3C), the diode D4, now-closed switch CR53-3, the brush 204' and its associated conductor 204, and through the diode D2 and the cycle-complete relay CR15 in the console to ground.

Relays CR15 and CR17 close their associated switches CR15-1, CR15-2 and CR17-1 (FIGS. 3A and 3C), to energize the timer unit TD1 (FIG. 3C) and to apply "cycle complete" and "load aboard" signals to gates G25 and G27 (FIG. 3A). The computer then sends the clear signal CLR (FIG. 3A), which resets or clears the register 302 and the enable flip-flop 306. By this time the time-delay period for element T2 (FIG. 3E) has expired, and a signal in line 147 appears at its output, thereby blocking the signal in line 124 so that element A'2 is no longer gated, thereby blocking a signal from line 127 so that the cycle-complete relay CR73 is deenergized. This opens switch CR73-1 and deenergizes CR15 to remove the cycle-complete signal to the computer before TD1 times out, thus preventing energization of the reset relay CR18.

When the register 302 has been cleared, and the "cycle complete" signal has expired, the computer sends the next address to the register 302 (FIG. 3A) to instruct the stacker 20 to deposit its load in the right hand rack 23, fourth bin up in the fourth column of bins down the aisle from stations 26. This address includes the load signal LS and code signal CS to enable gate G14, plus the address signals AS1, AS2 (vertical) and AS9 (horizontal). Since the forks are to be extended to deposit in the right hand rack, the signal AS12 is not present. Since the enabling signal in line **308** is present, gates G1, G2 and G9 are enabled and cause relays CR1, CR2 and CR9 to become energized, thereby reversing the positions of their associated switches in the vertical and horizontal selectors VVS and HVS (FIG. 3B), and as indicated by the charts in FIGS. **4** and **5**, producing a potential of three volts on line **202**, and four volts on line **201**.

The enabling signal in line **308** has again set flip flop **306** so that relay CR13 is energized, and so that its switches CR13-1 and CR13-2 (FIG. 3C) are closed. Since relay CR12 is not energized at this time, on its negative half cycle the voltage in line L1 will energize the forks-right relay CR49 from the line L1 through the now-closed switches CR13-1 (FIG. 3C), CR12-2, the diode D13, the conductor **203** and its associated brush **203'** on the stacker **20**, the diode D14 and the relay CR49 to ground. This closes the associated switch CR49-1 (FIG. 3D) to energize the stacker converter **904** from the power supply PS-9, thus producing the output signal CC in the stacker logic. Similarly the stacker travel relay CR50 will be energized through switch CR13-2, etc., so that signals may be applied from the voltage selector HVS and VVS to the comparator inputs **40** and **41**.

Since the voltage which is applied through line **201** to the comparator input line **40** (FIG. 3B) is approximately four volts greater than, or positive with respect to, the ground potential, which is at this time applied by the horizontal wiper HW to the other input lead **30** of the comparator HVC, this positive voltage differential causes the "forward" relay CR46 of this comparator to be energized. Also, since the voltage applied by the conductor **202** and its associated wiper contact **202'** to the input lead **41** of the vertical voltage comparator VVC also is approximately three volts greater than the ground potential which is presently applied to the other input terminal **31** of this comparator by the vertical wiper VW, the "up" relay CR41 of the vertical comparator VVC is energized.

The now-energized relays CR46 and CR41 cause their associated switches CR46-1, CR46-2, CR41-1 and CR41-2 to be reversed from the positions illustrated in FIG. 3F, thereby deenergizing the relays CR39 and CR44. These latter relays in turn permit their switches CR39-1 and CR44-1 (FIG. 3D) to return to their normally-open positions, thereby opening the zero center circuit, and removing the input to the converter **909** in the stacker logic. Also at this time switch CR41-3 (FIG. 3F) is closed, and CR41-4 is open, so that a positive, coarse, twenty-four volt signal is applied from the power supply PS-1 through the now-closed switches CR41-3, CR39-2 and CR51-1 to the input of the vertical controller VMC. This positive voltage energizes the vertical motor "up" relay VMU. Also at this time switch CR46-3 is closed and CR46-4 is open, so that a positive, coarse, twenty-four volt signal is applied from power supply PS-1 through switch CR46-3, CR44-2 and CR51-2 to the horizontal controller HMC, which in turn energizes the horizontal motor "forward" relay HMF. At this time, and whenever the stacker is in "coarse" control (i.e., relays CR44 and CR39 deenergized), the switches CR44-3 and CR39-3 are open so that the signals developed by the heads HHD and UVHD or LVHD, cannot be applied to the associated controller HMC or VMC. The relay switches VMU-1 and HMF-1 now close to energize the vertical and horizontal motors VM and HM in the up and forward directions, respectively. Accordingly, the trolley and elevator sections of the stacker travel simultaneously toward the selected bin (4X4). During this stacker movement the tachometer relays CR40 and CR45 (FIG. 3F) are energized so that their switches CR40-1 and CR45-1 (FIG. 3D) are held open.

When the carriage or trolley **21** has moved far enough down the aisle to register approximately with the fourth column of bins in each rack, its horizontal wiper HW (FIG. 3B) moves into contact with the fourth conductor away from the conductor **200-0** in the horizontal wiper track **200**, so that the wiper HW will apply through the line **30** a voltage that is equal to the four volts then being applied by the address selector HVS through line **40** to the other input of the comparator HVC. Consequently the forward relay CR46 once again becomes deenergized. Similarly, when the elevator **22** has traveled upwardly far enough to register approximately with the fourth row of bins, its wiper VW engages the third conductor up from the lowermost conductor **184-1** in the vertical wiper track **183**, whereby the input voltage supplied by the line **31** to the vertical voltage comparator VVC will be identical with the voltage then being applied by the line **41** to the other input terminal of this comparator from the address selector VVS. At this time the "up" relay CR41 will therefore become deenergized. Consequently the relays CR39 and CR44 (FIG. 3F) once again become energized so that the coarse, positive, 24 volt inputs to the horizontal and vertical controllers HMC and VMC are removed by the opening of the switches CR45-3, CR41-3, CR44-2 and CR39-2.

At this moment both the trolley and elevator sections of the stacker are moving so that signals are developed in the heads HHD (FIG. 3B) and LVHD by the associated wire systems HCW and VCW. Moreover, since relays CR39 (FIG. 3F) and CR44 are energized, these signals are fed through the now-closed switches CR39-3 and CR51-1 to the input of the vertical motor controller VMC, and through switches CR44-3 and CR51-2 to the input of the horizontal motor controller HMC so that the horizontal and vertical motors HM and VM are now controlled by the head signals as in U. S. letters Pat. No. 3,349,303, issued Oct. 24, 1967 to Burch and Burnight. The heads HHD and LVHD cause the carriage and elevator to stop in exact registry with the selected bin (4X4) in rack **24**. Moreover, since the motors HM and VM have stopped, the associated tachometer relays CR45 and CR40 have become deenergized.

The preceding operations of the motors HM qnd VM need not, of course, always terminate simultaneously. I.e., either motor HM or VM may halt in advance of the other, assuming the associated trolley or elevator section reaches its destination in advance of the other section.

At this time switches CR39-1, CR44-1 and CR45-1 (FIG. 3D) are closed, so that power is applied to converter **909**. This developes the zero-center signal DD, and initiates a test to determine whether or not the selected bin is empty. The signal DD completes the input signals in lines **154**, DD to element A14 which therefore is gated to produce the signal in line **107**, which gates element 03. This produces a signal in line 130, which is applied to the inputs of elements A8, and T4. Element A4 is not gated at this time, but after approximately one second delay, T4 is gated to block the signal from line 122 and generate a signal in line 123. The removal of the signal from line 122 blocks the output signal in line 155 from element 09; and the signal in line 123 completes the input signals (GG', 147, 123) needed to gate the AND element A7, which produces the output signal in line 132 that is applied to the input of the AND element A10. The memory M2 is still producing the signal in line 129 (until its mode is switched by an input signal in line 117), so that the input signals (129, 132, CC) to A10 are completed, and A10 is gated to produce the test signal in line 139.

The signal in line 139 gates the OR element 04 to apply an input signal through line 140 to the time delay unit T3, and simultaneously energizes the right-bin-test relay CR78. Relay CR78 immediately closes switch CR78-1 (FIG. 3C) to energize the reflex photoelectric cell PC2 (FIG. 3C) at the right side of the elevator from line 4L1 through switch CR78-1 and the unit PC2 to ground. This opens switch PC2' (FIG. 3D) to deenergize converter 911 and to remove signal MM from the stacker logic to prevent actuation of the fork mechanism during the test period. There is approximately a two second time delay before the signal in line 140 gates the unit T3 to product a reject signal in line 141. During this interval the selected bin is tested by the unit PC2. If the selected bin is already occupied by a loaded pallet, the light from the lamp in unit PC2 is not reflected onto the associated photo cell, and consequently the unit PC2 is not actuated at this time; but if the selected bin is empty, the reflected light from the associated lamp does actuate the cell PC2 to close its associated switch PC2-1 as noted in more detail below.

Assuming that the selected bin (4X4) is full, and that the photocell unit PC2 is not actuated, the time delay element T3 will be gated after the expiration of the two second time interval, producing the reject signal in line 141, which gates the OR element 08 to apply an actuating signal through line 149 to the bin-reject relay CR77. Relay CR77 now closes its switch CR77-1 (FIG. 3C) to apply a reject signal from the stacker to the console on the positive half cycle of the voltage in the line 4L1 through the switch CR77-1, a diode D15, switch CR53-3, the wiper contact 204' and its associated conductor 204, and through the diode D3 and the bin-reject relay CR16 in the console to ground. Relay CR16 closes switch CR16-1 (FIG. 3A) to apply an input signal to gate G26, which at this time also receives a signal through line 310 so that a bin reject signal is sent to the computer.

When the computer receives the reject signal it indicates to the operator in any desired manner (e.g. by operating a reject lamp or printing out a reject notice) that the selected bin is loaded, and that the computer must be reprogrammed to send the loaded stacker to another bin. At this time the computer is still receiving the "load aboard" signal from the output of gate G27 (FIG. 3A), memory S1 (FIG. 3D) is still in the mode in which it energizes relay CR71 to maintain the lower vertical head LVHD energized, and memory S2 is still in its "deposit" mode producing signal GG'. Thus, assuming that a new program is entered in the computer calling, for example, for the load to be deposited in the left rather than the right bin, the computer would send, together with the code signal CS, first the clear signal CLR to reset the register 302 and the flip flop 306. As soon as the enable flip flop 306 is reset, it deenergizes relays CR77 and CR78 so that the photo cell unit PC2 is deenergized, and the cycle reject relay CR16 is consequently deenergized. Then the computer sends the load signal LS together with the new address signals, which would include signal AS12 to effect energization of relay CR12 (FIG. 3A), and consequent energization of the "left deposit" relay CR48 in a manner that will be apparent from the above disclosure. Since the stacker is already at its newly programmed destination, the bin test photo cell unit PC1 is energized to check whether or not the left bin is loaded. If the new address had necessitated movement of the stacker to a new bin, this movement would, of course, occur before the bin testing step.

Assuming that when the stacker reached the originally programmed bin 4X4 the bin was empty, and that no reject signal was developed in the logic, the photocell PC2 would have been energized by light reflected back from the selected bin before the time delay element T3 had had an opportunity to be gated. In this case the switch PC2-1 (FIG. 3D) closes before timer T3 is gated. This applies an input signal to the converter 908, which produces the bin-empty signal HH in the stacker logic, thereby gating the OR element 07 to produce a signal in line 117, which reverses the mode of the memory M2 to block the signal from line 129, and to produce instead a signal in line 128. The blocking of the signal from line 129 removes the input signal in line 140 from timer T3 before the latter is gated, and also effects the deenergization of relay CR78 and the photo cell unit PC2.

The signal in line 128 now gates the OR element 05 to produce the input signals (130, 131, 152) to element A8, which is gated to produce the input signal through line 133 for the time delay element T5, which has a one second delay to permit stabilization of the logic signals before the forks are advanced. The time T5 thus is gated to produce a signal in line 148, which is applied to the input of the AND element A12. Since the photocell unit PC2 is deenergized, switch PC2' has reclosed so that the bin-sensor-ready signal MM (FIG. 3D) is also present at the input to A12. At this time, the AND element A5 is gated by the input signals in lines CC, BB and EE', thereby producing the output signal in line 136, which gates the OR element 02. This produces a signal in line 143, which completes the input signals (143, 148, MM) to the element A12, which is gated to produce the signal in line 145, which energizes the forks right relay CR75. The loaded forks are thus extended out of the right side of the elevator into the empty bin.

When the forks are fully extended, they close the forks-right limit switch FRL to energize the forks-extended relay CR52 (FIG. 3C) from line 4L1. This closes switch CR52-1 (FIG. 3D) to apply a signal to the converter 905, thus developing the signal EE in the stacker logic. This blocks the NOT element N1 to remove signal EE', therefore blocking element A5 and deenergizing relay CR75 to stop the forks. The signal EE then actuates the signal amplifier SA1 to switch the mode of memory S1 and deenergize relay CR71. The fork 23 then deposits the load in the selected bin. After the elevator has dropped slightly to deposit the load in the bin, the reenergized head UVHD "homes" out at the selected null point on wires VCW, and the timer T1 is gated to effect return of the empty fork mechanism to the center of the elevator. When the shuttle **23** is fully retracted it momentarily develops the cycle-complete signal in line **127.**

At this time, there is no load aboard the elevator so that the photo cell unit PC3 is energized and switch PC3-1 (FIG. 3D) is held open, therefore deenergizing converter **906** and removing signal NN from the stacker logic. This deenergizes relay CR72 and opens switch CR72-1 (FIG. 3C) so that the load aboard relay CR17 is deenergized, thereby blocking gate G27 and removing the "load aboard" signal from the computer. Since the stacker is motionless, converter **909** is energized; the forks are centered so that converter **907** is energized; the bin sensors are ready so that converter **911** is energized, and the momentary application of the cycle complete signal to the computer from gate G25 signals the computer to send another address to the stacker.

In a manner that will be apparent from the above description, the computer then transmits another address to the register **306** (FIG. 3A). Since the stacker is unloaded at this time, the new address must, of course, amount to an instruction to pick up a load from one of the bins or from one of the loading stations **26** or **27.** Assuming that the new address is to pick up a load from the bin which is the second bin up in the second column of bins down the aisle from the loading stations **26,** the relays CR4 (vertical) (FIG. 3A) and CR10 (horizontal) will be energized to apply, for example, two volts to the input lead **40** of the horizontal comparator HVC, and one volt to the input line **41** of the vertical comparator VVC.

Since at this time the horizontal and vertical wipers HW and VW engage the four and three volt conductors, respectively, in the horizontal and vertical wiper tracks **200** and **183,** respectively, the voltage inputs in the lines **30** and **31** are greater than, or positive with respect to, the voltages applied to the respective comparators by the leads **40** and **41.** Consequently the reverse and the down relays CR47 and CR42 (FIG. 3B), respectively, are energized by the comparators to open switches **CR42-1** (FIG. 3F) and **CR47-2,** thus deenergizing the relays CR39 and **CR44.** This applies a coarse, negative voltage from the power supply **PS-2** through the now-closed switches **CR47-3, CR46-4, CR44-2** to the horizontal motor controller HMC, and through the switches **CR42-3, CR41-4, CR39-2** and **CR51-1** to the vertical controller VMC, respectively. These negative input voltages cause the energization of the reverse and down relays HMR and VMD, thereby closing switches HMR-1 and VMD-1 in the horizontal and vertical motor circuits, respectively, so that the motors HM and VM are energized to cause the trolley **21** and elevator **22** to move simultaneously in the reverse and down directions, respectively.

When the stacker elevator **22** is in proper registry with the selected bin (2X2), the zero center circuit is once again energized to provide a zero center signal DD in the stacker logic. This again gates the AND element A14, but does not result in the gating of the element A7, and the consequent energization of one of the bin testing relays CR76 and CR78, because at this time the step memory S2 is in its "pickup" mode, wherein it blocks the signal GG', which is necessary for the gating of element A7. Output signal GG, however, is present and gates the OR element **05** to complete the input signals to the element **A8,** which therefore actuates the timer unit T5 in a manner similar to that described above. Shortly thereafter the signal **148** appears at element **A12,** which is already receiving the bin-sensory-ready signal MM, because neither bin testing photoelectric cell PC1 nor PC2 are energized at this time. Also the signals CC, BB, and EE' are present at this time to gate the element **A5,** which in turn gates the OR element **02** to complete the input signals **(143, 148,** MM) to element **A12,** which therefore energizes the forks-right relay **CR75.** The empty fork mechanism **23** then extends into the selected bin in the right hand rack to pick up the load and to return to the center of the elevator in the usual manner.

After the fork mechanism **23** has returned to the center of the elevator, a test is made to determine whether or not it picked up a load from the selected bin. This test is triggered by the pulsing of the cycle-complete relay **CR74,** which occurs each time the fork mechanism **23** is retracted onto the elevator.

Assuming that the fork mechanism did not pick up a load, the load present signal NN is not present when the fork mechanism has centered on the elevator. Consequently the element A'1 is not gated to produce the load-present signal in line **120.** Instead a signal through line **121** is produced simultaneously with the production of the cycle complete output signal **127** from the element **A'2.** Also at this time, since the forks are elevated, the step memory **S1** is producing an output signal in line **118,** which appears momentarily with the signals in lines **121** and **127** at the input to the sealed AND element **A15.** This gates A15 to produce a signal in line **151,** which gates the OR element **08** to energize the bin-reject relay **CR77.**

The appearance of the forks centered signal FF at the input of the NOT element **N2** removes the output signal FF', and consequently blocks the output signal in line **146** from the OR element **06,** since the other input signal NN (load-present signal) is not present at the element **06** at this time. The blocking of the signal from line **146** switches the mode of the step memory S1 to block the output signal in line **118** and to produce a signal in line **119,** but not before the signal in line **118** has gated the sealed AND element **A15.** This deenergizes the head control relay **CR71** so that the upper vertical head UVHD once again becomes energized through the now-closed switch **CR71-1** (FIG. 3F). The elevator **22** is thus lowered slightly until the upper vertical head UVHD registers with the adjacent vertical null point VN2, corresponding to the bin (second bin up in the second column of bins) from which the fork mechanism **23** had attempted to remove a load. The elevator is thus automatically reset to a position in which the fork or shuttle will pass beneath a load to pick it up, the next time that the shuttle **23** is advanced out of the elevator.

With the last-mentioned energization of the bin reject relay **CR77,** a reject signal is transmitted in the usual manner from the stacker **20** through its wiper contact **204'** (FIG. 3C) to' energize the reject relay CR16 in the console. This closes CR16-1 (FIG. 3A) and enables gate G26, which then sends a reject signal to the computer. Any conventional means is then employed to alert the operator that the stacker failed to pick up a load and that a new "pick up" program is required.

Assuming that a load had in fact been retrieved from the second bin up in the second column of bins in the right hand rack (bin 2X2), the bin-empty reject signal would not have been produced by the logic. In such case, as the loaded forks return to the center of the elevator the forks-centered signal FF (FIG. 3D) is generated to cause momentary energization of the cycle complete relay **CR73**, and consequent gating of gate G25 (FIG. 3A) to send a cycle complete signal to the computer. Also now, the load present signal NN (FIG. 3D) is present in the stacker logic so that the OR element **06** is gated to maintain the input signal in line **146** for the step memories S1 and S2. At this time, however, the load-present and fork-centered signals NN and FF cause element A'**1** to be gated to block the signal from line **121**, thereby maintaining the memory S1 in the mode to produce an output signal in line **118**, which holds the head control relay CR71 energized and the fork mechanism **23** in its "upper" position. The removal of the signal from line **121** also switches unit S2 into its deposit mode to block the output signal GG, and to produce instead the output signal GG'. Element A'**1** now produces the signal **120**, which energizes the load-present relay CR72 so that gate G27 is enabled to advise the computer that there is a load aboard the stacker.

After the computer receives the "cycle complete" and "load aboard" signals, it transmits a "deposit" address to the register **302** (FIG. 3A) in a manner that will be apparent from the preceding discussion. If the computer has not been programmed for another address, the loaded stacker will remain motionless until a new address is entered in register **302.** If there is another address in the computer ready for entry into the register **302,** the new address will enter the register in the usual manner and cause the loaded stacker to travel to the new bin address. After arriving at the new bin, the bin testing step will occur to determine whether or not the bin is empty. If so the stacker will deposit the load in the usual manner. On the other hand if the new bin is full, the bin reject gate G26 will be enabled to pass the reject signal to the computer, and to suspend operation of the stacker until a new address is received.

After the load has been deposited in one of the bins, or on one of the load stations **26** and **27,** the load aboard gate **G27** is disenabled, and the cycle complete gate **G25** is once again enabled to inform the computer that the stacker is empty and ready for a "pick up" operation.

From the foregoing it will be apparent that the computer-controlled stacker disclosed herein is designed to develop a "cycle complete" signal each time the forks **23** retract to their fully centered positions on the elevator **22.** Each time this signal occurs the computer sends another address or command to the register **302,** and hence to the stacker logic. These commands merely instruct the stacker to move to a particular bin or loading station, and initially to move the forks either to the right or left. The command does not include an instruction to "pick up" a load or to "deposit" a load at the destination. This "pick up" or "deposit" operation is determined by the mode of the stacker at the time it reaches its addressed destination. If the stacker is already loaded it attempts to deposit the load by first testing the new bin to see if it is empty. If not, the "reject" signal is sent by gate **G26** to the computer, indicating that the loaded stacker must be readdressed to an empty bin. Moreover, if the stacker attempts to "pick up" a load from an empty bin or loading station **26** or **27,** the reject signal is produced and the elevator is automatially dropped slightly to its "pick up" mode to be ready to pick up a load when a new address is received from the computer.

With this form of control the stacker can transfer loads directly from one bin to another, in the racks; or between the bins and loading stations, or can transfer loads directly between the loading stations **26** and **27** without first placing the load in one of the storage bins. This type of control also permits the stacker to remain in the aisle between the racks at the completion of a "pick up" or "deposit" command rather than requiring the stacker to return to a "start" position. Since the stacker can remain down the aisle between the racks after depositing a load in one of the racks, rather than having to return to the head of the aisle there is a saving in time of operation achieved, for the stacker does not have to return to a load station, and then travel away from that station again to pick up or deposit a load; it is already down the aisle, ready for a new pick-up or deposit operation. Thus, also, a considerable amount of wear and tear on the stacker is avoided.

A still further advantage of this type of control is that much information can be stored in the computer and retrieved when desired. For example, if certain loads are to be removed from the racks and delivered to a transport vehicle, for instance, at some future time, the information may first be recorded in the computer, and at a future time when the transport arrives, the information can be transferred out of the computer to the register **302** to effect the necessary retrieval operations.

Another advantage is that, merely by using the five sliding brush contacts **201'** through **205'** on the stacker, together with their associated conductors **201** through **205,** it is possible to program the stacker from any points remote therefrom — even, for example, from a control room separate from the room containing the stacker **20** and the associated racks. At no time, after having pushed the stacker power-on button SPON, need the operator approach the control circuitry on the stacker itself in order to manipulate any of the switches manually, as was the case in most prior stackers. Moreover, by sending more than one signal in opposite directions through the wiper contacts on the stacker to the associated conductors that lead to the remote console, both the cost and the complexity of the stacker control circuitry is reduced. Also, whenever power is removed from the logic circuitry on the stacker, for example by pushing button SPOF (FIG. 3B), or by triggering a conventional safety circuit (not illustrated) designed to deenergize relay MC (FIG. 3B), the Power On relay **CR53** is instantly deenergized, thereby causing switches **CR53-1** and **CR53-2** to reclose. This will, as noted above, result in energization of both the cycle complete and reset relays **CR15** and **CR18** to signal the computer operator that power is missing from the stacker logic.

Although the invention has been described in connection with the use of ten rows and 100 columns of bins in each rack, it will be apparent that a different number of bins may be employed if desired. Moreover, although the loading stations **26** and **27** have been selected to register with the lowermost row of bins in each rack, it will be apparent that the height of the loading stations may be altered merely by applying a different vertical address voltage to line **41**, when the stacker is between a pair of loading stations.

Having thus described my invention, what I claim is:

1. In an automatic warehousing system having a plurality of load supports,

a load carrier movable selectively into different transfer positions in which it registers with one of said supports,

a transfer device on said carrier extensible selectively out of either side thereof to pick up a load from, or to deposit a load onto, the registering support, control apparatus comprising

means remote from said carrier for developing control signals therefor, including a pair of address signals for selecting the transfer position of the carrier, and a third signal for selecting the direction in which the transfer device is to extend during a transfer operation,

a first pair of conductors for transmitting said address signals from said remote means to said carrier,

drive means on said carrier connected to said conductors and responsive to signals thereon to move said carrier to the transfer position represented by said address signals,

a third conductor for transmitting said third signal to said carrier,

said remote means including means for causing said third signal to have selectively one of two different polarities depending upon from which side of the carrier the transfer device is to be extended during a transfer operation, and

means on said carrier connected to said third conductor and operative during each transfer operation to cause said transfer device to be extended from one side of said carrier, when said third signal is positive, and to be extended from the opposite side of said carrier, when said third signal is negative.

2. An automatic warehousing system as defined in claim **1**, including

a fourth conductor connecting said remote means to said carrier,

means on said carrier for developing a cycle complete signal of predetermined polarity each time said transfer device moves from one to the other of its pick-up and deposit positions, respectively,

means on said carrier operative, prior to movement of said transfer device from its pick-up to its deposit position, to test for the presence of a load on the registering load support,

means to develop a reject signal having a polarity opposite to that of said cycle complete signal, when a load is detected on the last-named support by said testing means, and

means for transmitting both said cycle complete and said reject signals to said remote means on said fourth conductor.

3. An automatic warehousing system as defined in claim **2**, including

means on said carrier for sensing the presence of a load on said transfer device, and operative to generate a load aboard signal of predetermined polarity, when a load is present on said device,

a fifth conductor for transmitting said load aboard signal to said remote means,

said remote means including means for applying to said fifth conductor a stacker travel signal having a polarity opposite to that of said load aboard signal, and

means on said carrier for preventing transmission of said address signals to said carrier except when said stacker travel signal is applied to said fifth conductor.

4. Automatic storage apparatus, comprising

a plurality of load supports,

a load carrier mounted to move selectively into different transfer positions in which it registers with one of said supports,

means on said carrier for developing a pair of position signals corresponding to the actual position of said carrier relative to said supports,

means remote from said carrier including

signal storage means connected at one side to a computer intermittently to receive and store sets of coded command signals from the computer,

a plurality of relays connected to the opposite side of said storage means selectively to be energized in accordance with command signals from said storage means upon receipt of cycle complete signals from said carrier,

means controlled by said relays to convert said command signals into pairs of address signals, each pair of said address signals corresponding to a different desired position

a pair of conductors for transmitting said address signals to said carrier,

means on said carrier for comparing each pair of address signals with said position signals,

drive means on said carrier operative, when the compared address and position signals disagree, to move said carrier toward said desired position until the compared address and position signals agree,

means for stopping said drive means, when the compared address and position signals agree, and said carrier is in said desired position,

a load transfer device on said carrier movable automatically between pick-up and deposit positions each time said carrier has reached the transfer position determined by the last-transmitted pair of address signals, to transfer a load between said carrier and the registering support,

a third conductor connecting said carrier to said computer,

means on said carrier operative, each time said transfer device is moved from one to the other of its pick-up and deposit positions, to apply a cycle complete signal of predetermined polarity to said third conductor for transmission thereby to said computer, thereby again to enable said relays selectively to be energized to produce the next pair of address signals corresponding to the next desired position of said carrier, and

reject means on said carrier operative to apply to said third conductor a reject signal having a polarity opposite to that of said cycle complete signal, when the support onto which a load is to be deposited by said transfer device is already occupied by another load.

5. Automatic storage apparatus as defined in claim **4**, including load sensing means on said carrier operative to transmit said reject signal on said third conductor to the computer, when said transfer device moves from its deposit to its pick-up position without picking up a load.

6. Automatic storage apparatus as defined in claim **5**, including

a fourth conductor connecting said carrier to said computer,

said computer being operative to apply an enabling signal of one polarity to said fourth conductor during movement of said carrier from one transfer position to another, and

means on said carrier for detecting the presence of a load on said transfer device, and for applying to said fourth conductor a load aboard signal having a polarity opposite to that of said enabling signal, when a load is present on said transfer device.

7. Automatic storage apparatus as defined in claim **4**, wherein said means controlled by said relays comprises

a first plurality of switches responsive to certain of said relays selectively to apply to one of said pair of conductors a first voltage corresponding to one address signal of a pair thereof,

a second plurality of switches responsive to the remainder of said relays selectively to apply to the other of said pair of conductors a second voltage corresponding to the other of the last-named pair of address signals,

each of said first and second pluralities of switches being divided into two equal groups, the switches of one group of each plurality being normally-closed normally to apply ground potential to said pair of conductors, and the switches of the other group of each plurality normally being open, and

means operable upon selective energization of said relays and consequent selective changes in the positions of said switches to apply different voltages to said pair of conductors.

8. Automatic storage apparatus comprising

a plurality of load supports,

a movable load carrier,

a load transfer device on said carrier movable selectively out of either side thereof between pick-up and deposit positions, respectively, to pick up a load from or to deposit a load onto a load support,

signal-responsive drive means for moving said carrier selectively to different positions to register with different load supports, respectively,

control means remote from said carrier for developing address signals to actuate said drive means to move said carrier selectively into registry with different load supports,

means for actuating said load transfer device, when the carrier is in registry with a load support, to pick up a load from or to deposit a load onto the registering load support,

a computer connected to said control means and capable of storing a plurality of different programs, so that said control means is actuated to cause said drive means to move said carrier into registry with different load supports on successive operations of said control means,

means connecting said load transfer device to said computer to cause actuation of said control means after each pick-up and after each deposit operation of said load transfer device,

a storage rack containing certain of said supports,

means mounting said carrier for movement in an aisle adjacent said rack, and

said control means including means for moving said carrier successively from registry with one to another of said supports in said rack in response to successive actuations of said control means,

said control means further including means for applying, through said connecting means to said transfer device, a control signal having selectively different polarity, depending upon the side of the carrier from which the transfer device is to move to execute a pick-up or deposit operation, and

said actuating means including means for moving said device out of one side of said carrier, when the last-named signal is of one polarity, and for moving said device out of the opposite side of the carrier when said last-named signal is of the opposite polarity.

9. Automatic storage apparatus as defined in claim **8**, wherein

said connecting means comprises a plurality of stationary, electrical conductors extending down said aisle adjacent said rack,

sliding electrical contacts on said carrier engaging said conductors,

one of said conductors is used to transmit said last-named signal through one of said contacts to said transfer device, and

other of said conductors are used to transmit between said control means and said carrier additional pairs of control signals, the pair of control signals on each of said certain other conductors being of opposite polarity.

10. In an automatic warehousing system having a plurality of load supports,

a load carrier movable selectively into different transfer positions in which it registers with one of said supports,

a transfer device on said carrier reciprocable from a retracted position on said carrier selectively out of either side thereof to pick up a load from, or to deposit a load onto, the registering support, control apparatus comprising

means remote from said carrier for developing control signals therefor, including a first pair of signals for selecting the transfer position of the carrier,

a first pair of conductors for transmitting said first pair of signals from said remote means to said carrier,

drive means on said carrier connected to said first pair of conductors and responsive to signals thereon to move said carrier to the transfer position represented by said first pair of signals,

a third conductor for transmitting from said remote means to said carrier a third signal having selectively one of two different polarities depending upon from which side of the carrier the transfer device is to be extended during a transfer operation, and

means on said carrier connected to said third conductor and operative during each transfer operation to cause said transfer device to be extended from one side of said carrier, when said third signal is positive, and to be extended from the opposite side of said carrier, when said third signal is negative, and

a fourth conductor for transmitting from said carrier to said remote means a fourth signal each time said transfer device returns to its retracted position on said carrier,

said remote means including means operative to change said first pair of signals each time said fourth signal is applied to said fourth conductor.

11. An automatic warehousing system as defined in claim **10,** including

means mounting said transfer device for movement upwardly and downwardly on said carrier between pick-up and deposit modes during a transfer operation, respectively, to pick up a load from, or deposit a load onto, the registering support,

a fifth conductor for transmitting from said carrier to said remote means a fifth signal whenever a load is present on said transfer device, and

means operative, when said transfer device has returned to its retracted position in its pick-up mode, automatically to move said device down on said carrier to its deposit mode unless said fifth signal is present on said fifth conductor.

12. An automatic warehousing system as defined in claim **11,** including

means for transmitting a sixth signal on said fifth conductor from said remote means to said carrier to enable application of said first pair of signals to said drive means,

means on said carrier for developing a reject signal, when said transfer device attempts to transfer a load to an already occupied load support, and

means for transmitting said reject signal from said carrier to said remote means on said fourth conductor.

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