United States Patent

Kintner

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[45] **July 18, 1972**

[54] **STORAGE COURIER BOUNDARY CONTROL SYSTEM**

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[73] Assignee: **Cutler-Hammer, Inc.**, Milwaukee, Wis.

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[52] **U.S. Cl.** ....214/16.4 A

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

[58] **Field of Search** 214/16.4, 16.42

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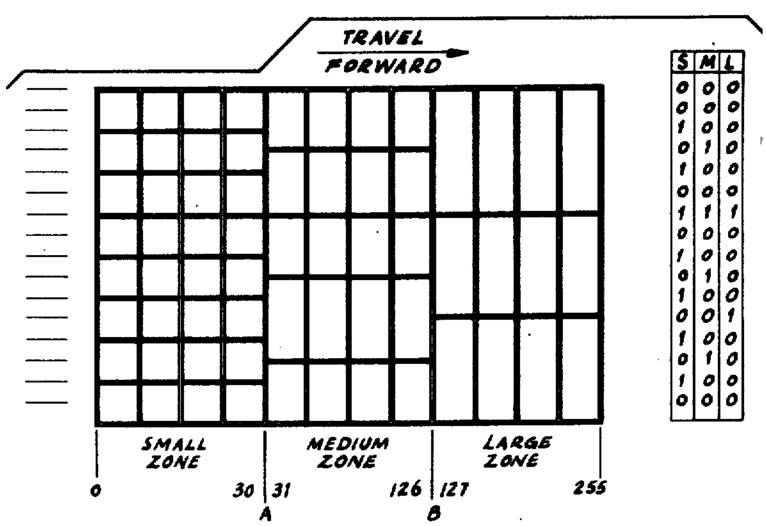
[57] **ABSTRACT**

In a warehouse having horizontal rows and vertical columns of bins in which packages are stored by a positive address code controlled courier (stacker crane), different size bins vary in height and are divided into zones of small, medium and large size bins. This system is arranged to check the size of the package. Subtraction of the read code from zone boundary codes provides information indicative of the zone of arrival. And comparison of the sizing information with the zone information will either allow the action to proceed or will return the package. Shelf error is handled by providing a code for each hoist address that defines the validity of the address for the several zones of different size bins. The integrated circuits send the package back to the pickup station if the validity code indicates that there is no shelf at the hoist address. In the event of a power failure, upon restoration, the integrated circuits automatically program for a large package sizing indication.

11 Claims, 15 Drawing Figures



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9 Sheets-Sheet 1

Fig. 1

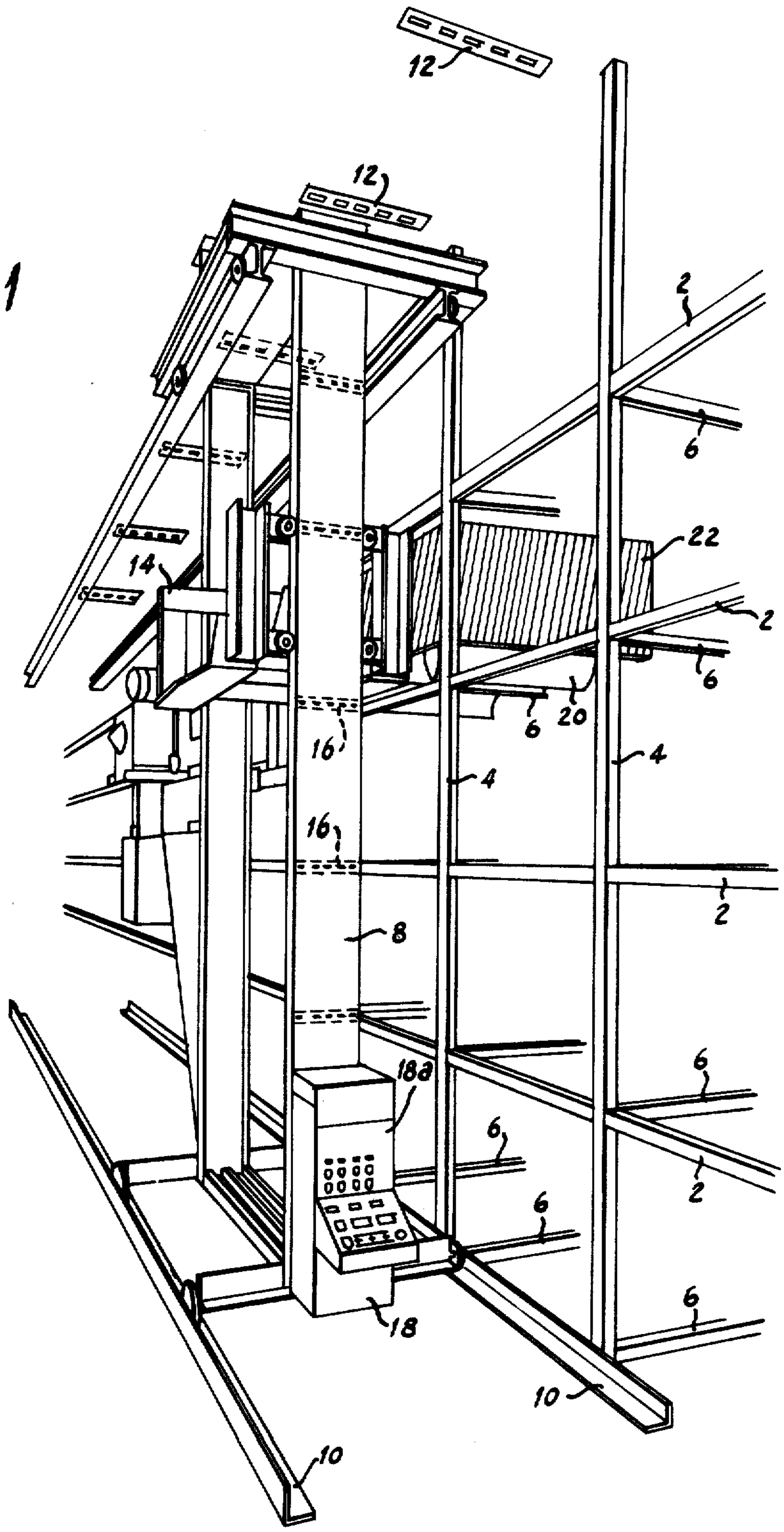


Fig. 2

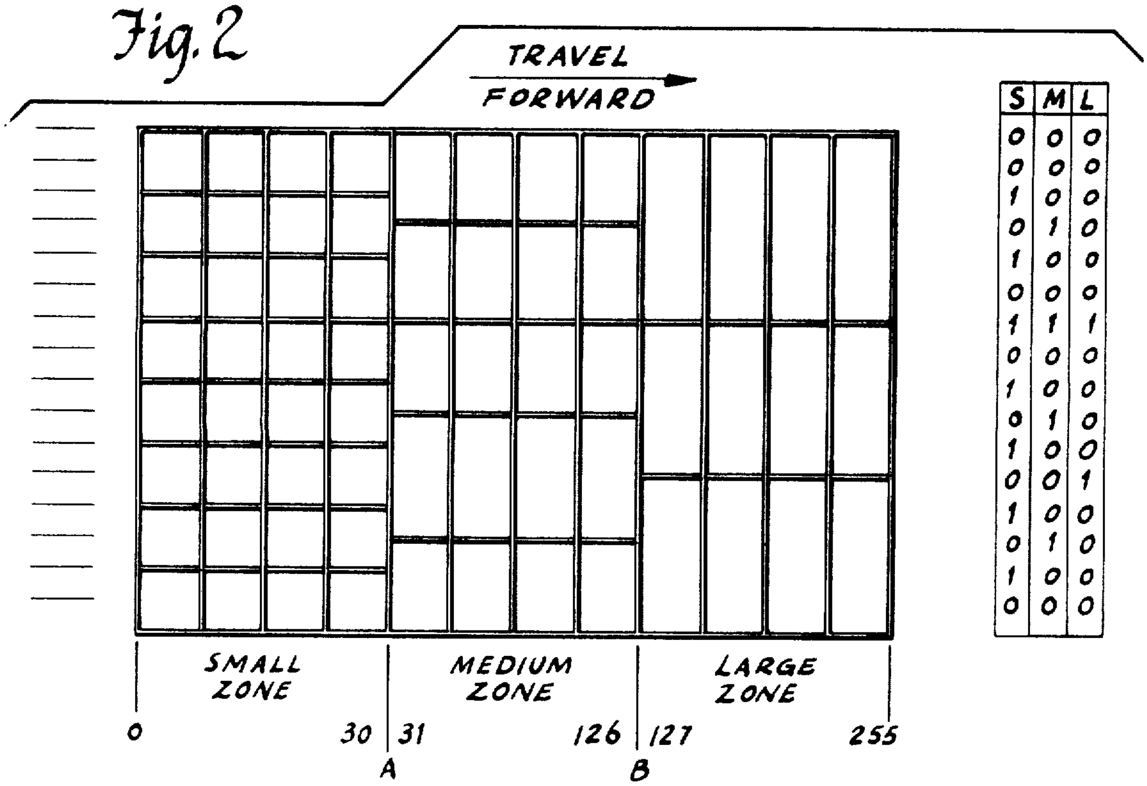
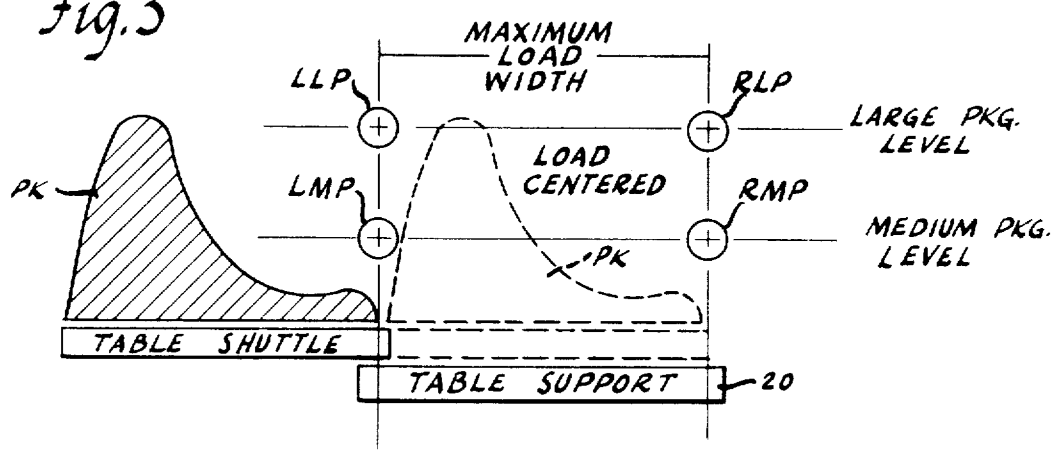


Fig. 3



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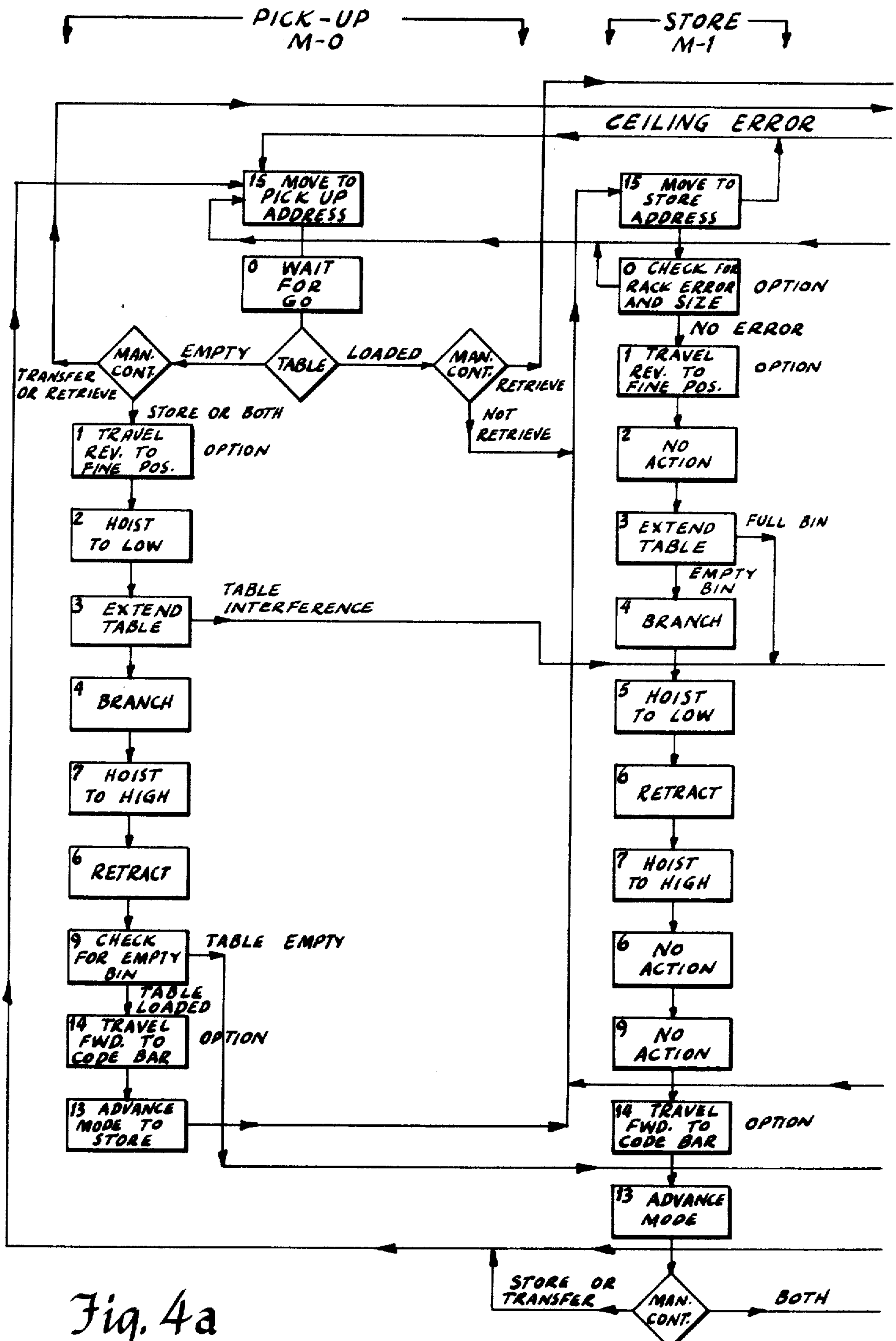

PICK-UP M-0
STORE M-1
CEILING ERROR
15 MOVE TO PICK UP ADDRESS
0 WAIT FOR GO
TABLE
EMPTY
LOADED
MAN. CONT.
TRANSFER OR RETRIEVE
STORE OR BOTH
MAN. CONT.
RETRIEVE
NOT RETRIEVE
1 TRAVEL REV. TO FINE POS.
OPTION
2 HOIST TO LOW
3 EXTEND TABLE
TABLE INTERFERENCE
4 BRANCH
7 HOIST TO HIGH
6 RETRACT
9 CHECK FOR EMPTY BIN
TABLE EMPTY
TABLE LOADED
14 TRAVEL FWD. TO CODE BAR
OPTION
13 ADVANCE MODE TO STORE
15 MOVE TO STORE ADDRESS
0 CHECK FOR RACK ERROR AND SIZE
OPTION
NO ERROR
1 TRAVEL REV. TO FINE POS.
OPTION
2 NO ACTION
3 EXTEND TABLE
FULL BIN
EMPTY BIN
4 BRANCH
5 HOIST TO LOW
6 RETRACT
7 HOIST TO HIGH
6 NO ACTION
9 NO ACTION
14 TRAVEL FWD. TO CODE BAR
OPTION
13 ADVANCE MODE
STORE OR TRANSFER
MAN. CONT.
BOTH

Fig. 4a

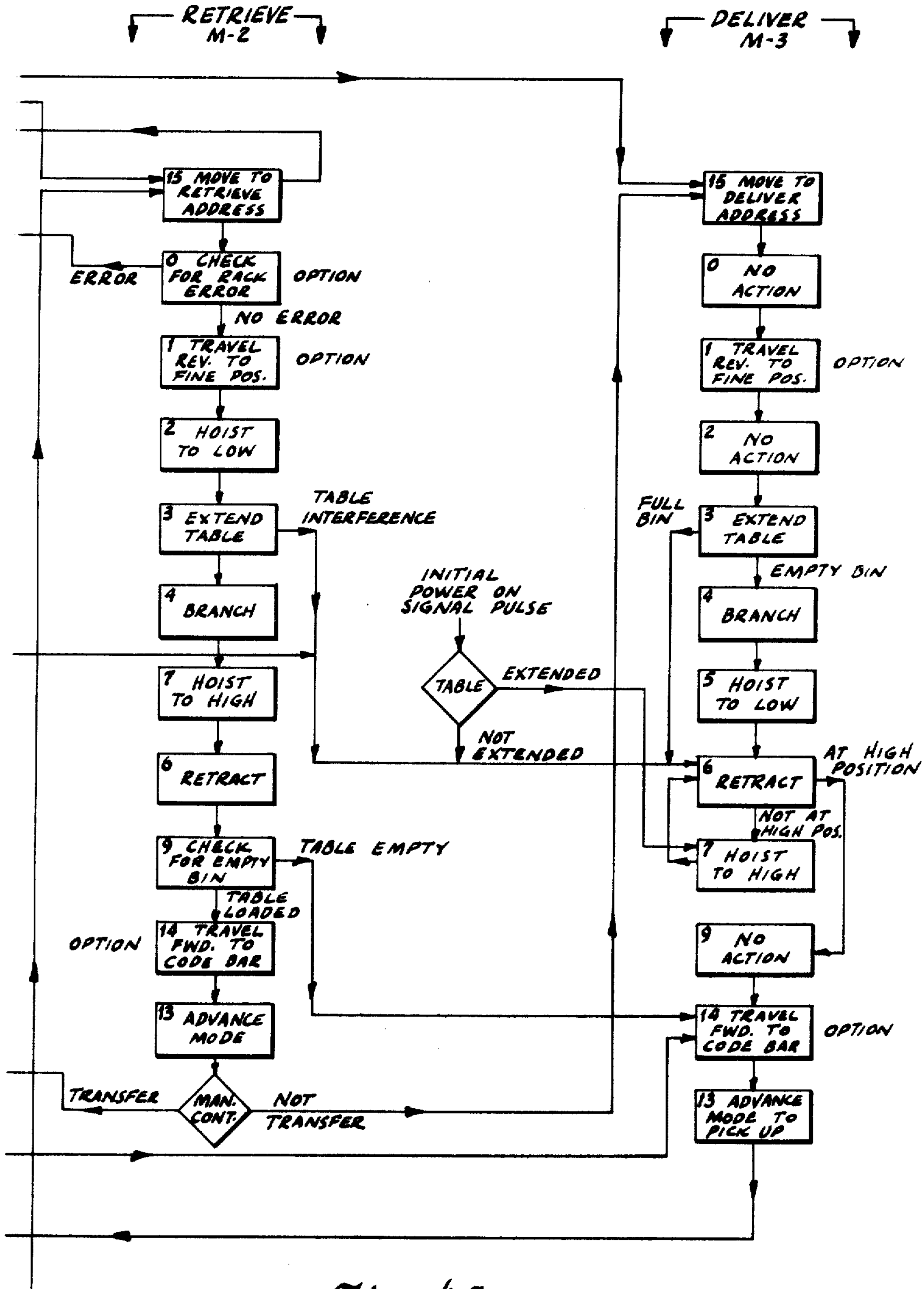

RETRIEVE
M-2
DELIVER
M-3
15 MOVE TO RETRIEVE ADDRESS
0 CHECK FOR RACK ERROR
ERROR
OPTION
NO ERROR
1 TRAVEL REV. TO FINE POS.
OPTION
2 HOIST TO LOW
3 EXTEND TABLE
TABLE INTERFERENCE
4 BRANCH
7 HOIST TO HIGH
6 RETRACT
9 CHECK FOR EMPTY BIN
TABLE EMPTY
TABLE LOADED
OPTION
14 TRAVEL FWD. TO CODE BAR
13 ADVANCE MODE
TRANSFER
MAN. CONT.
NOT TRANSFER
INITIAL POWER ON SIGNAL PULSE
TABLE
EXTENDED
NOT EXTENDED
15 MOVE TO DELIVER ADDRESS
0 NO ACTION
1 TRAVEL REV. TO FINE POS.
OPTION
2 NO ACTION
FULL BIN
3 EXTEND TABLE
EMPTY BIN
4 BRANCH
5 HOIST TO LOW
6 RETRACT
AT HIGH POSITION
NOT AT HIGH POS.
7 HOIST TO HIGH
9 NO ACTION
14 TRAVEL FWD. TO CODE BAR
OPTION
13 ADVANCE MODE TO PICK UP

Fig. 4b

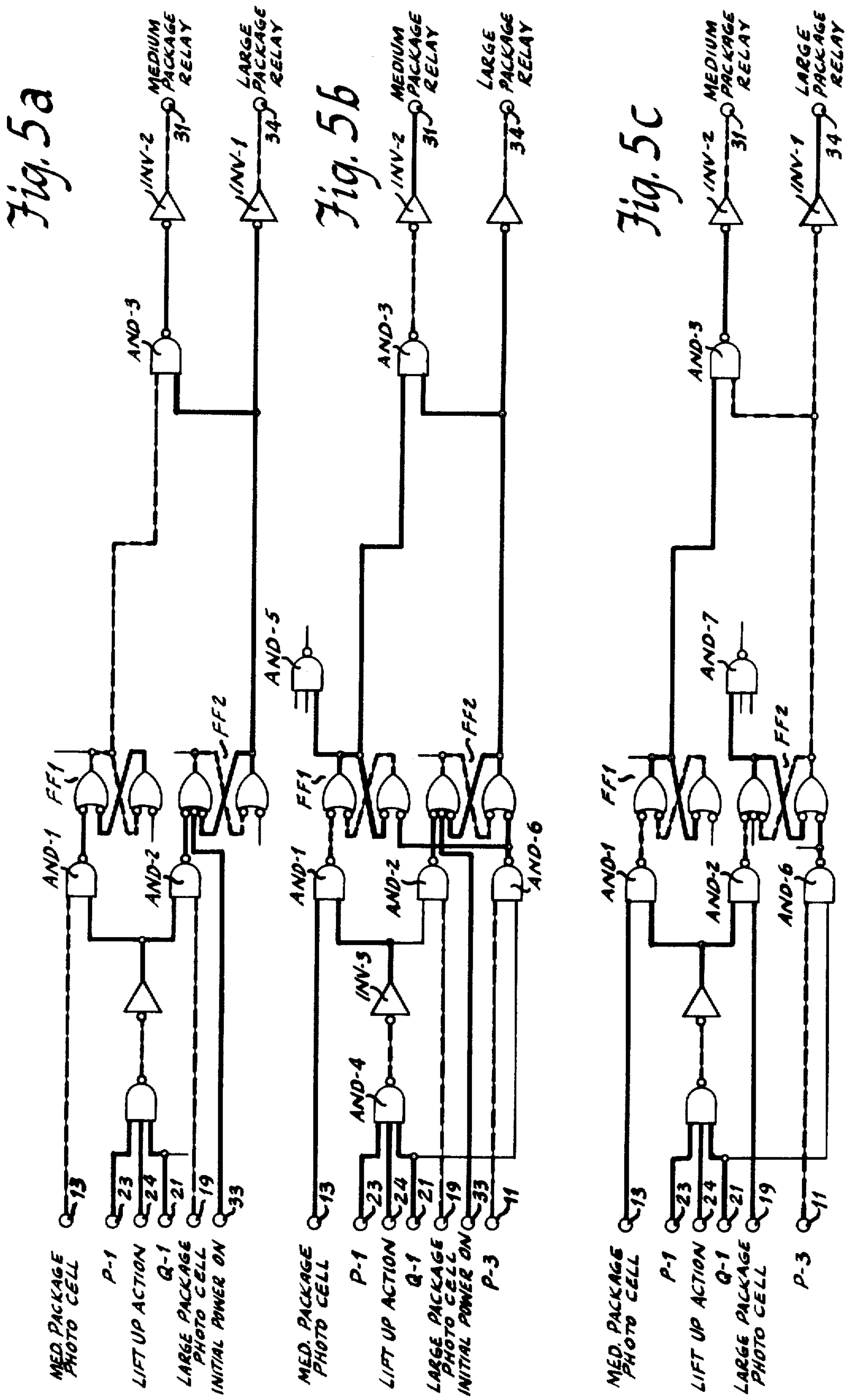


Fig. 5a
Fig. 5b
Fig. 5c
MEDIUM PACKAGE RELAY
LARGE PACKAGE RELAY
INV-1
INV-2
INV-3
AND-1
AND-2
AND-3
AND-4
AND-5
AND-6
AND-7
FF1
FF2
MED. PACKAGE PHOTO CELL
P-1
LIFT UP ACTION
Q-1
LARGE PACKAGE PHOTO CELL
INITIAL POWER ON
P-3
13
23
24
21
19
33
11
31
34

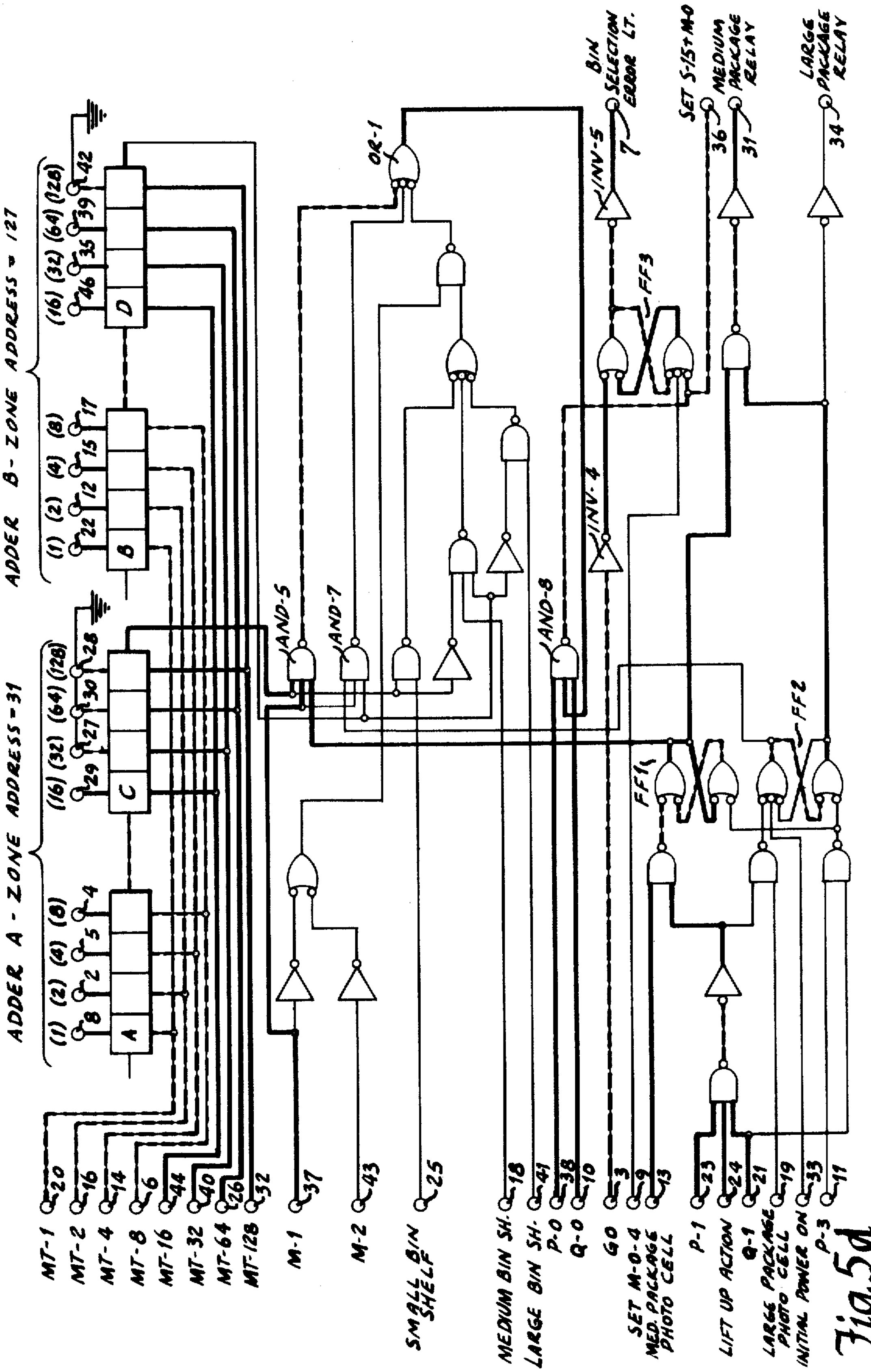

ADDER A - ZONE ADDRESS = 31
ADDER B - ZONE ADDRESS = 127
(1) (2) (4) (8)
(16) (32) (64) (128)
A
B
C
D
AND-5
AND-7
AND-8
OR-1
INV-4
INV-5
FF1
FF2
FF3
BIN SELECTION ERROR LT.
SET S-15 + M-0
MEDIUM PACKAGE RELAY
LARGE PACKAGE RELAY
MT-1
MT-2
MT-4
MT-8
MT-16
MT-32
MT-64
MT-128
M-1
M-2
SMALL BIN SHELF
MEDIUM BIN SH.
LARGE BIN SH.
P-0
Q-0
GO
SET M-0-4
MED. PACKAGE PHOTO CELL
P-1
LIFT UP ACTION
Q-1
LARGE PACKAGE PHOTO CELL
INITIAL POWER ON
P-3

Fig. 5d

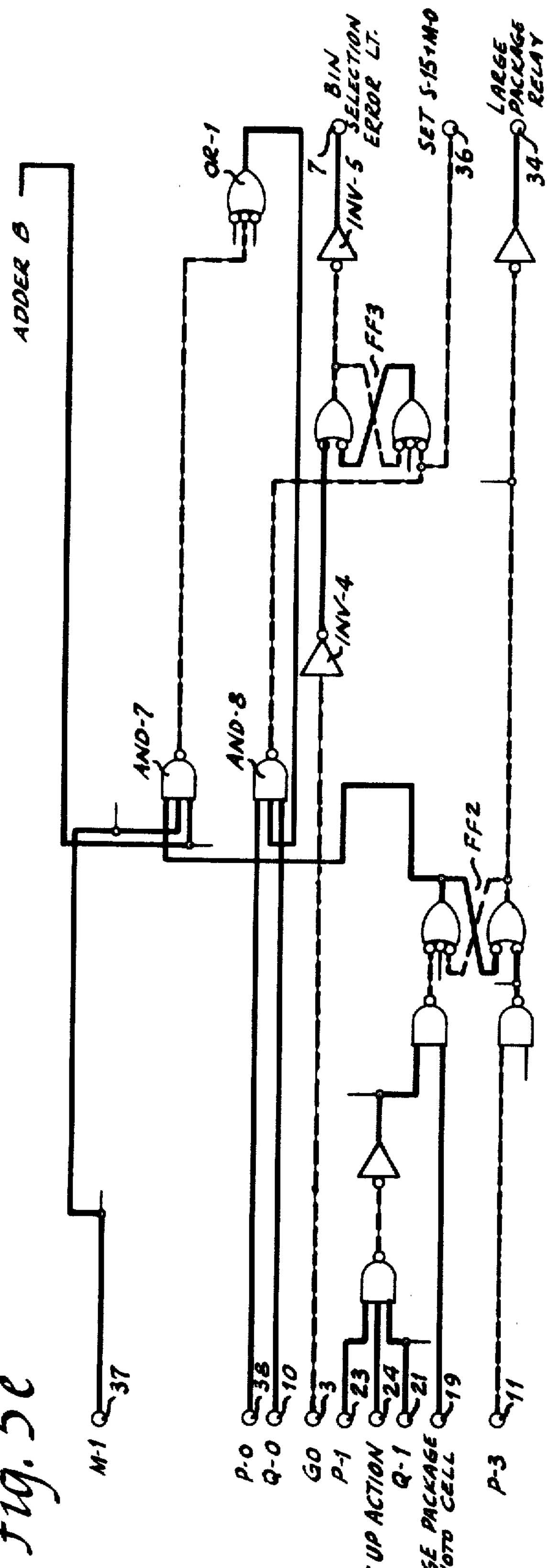

ADDER B
OR-1
BIN SELECTION ERROR LT.
7
INV-5
SET S-15+M-0
36
LARGE PACKAGE RELAY
34
FF3
INV-4
AND-7
AND-8
FF2
M-1
37
P-0
38
Q-0
10
GO
3
P-1
23
LIFT UP ACTION
24
Q-1
21
LARGE PACKAGE PHOTO CELL
19
P-3
11

Fig. 5e

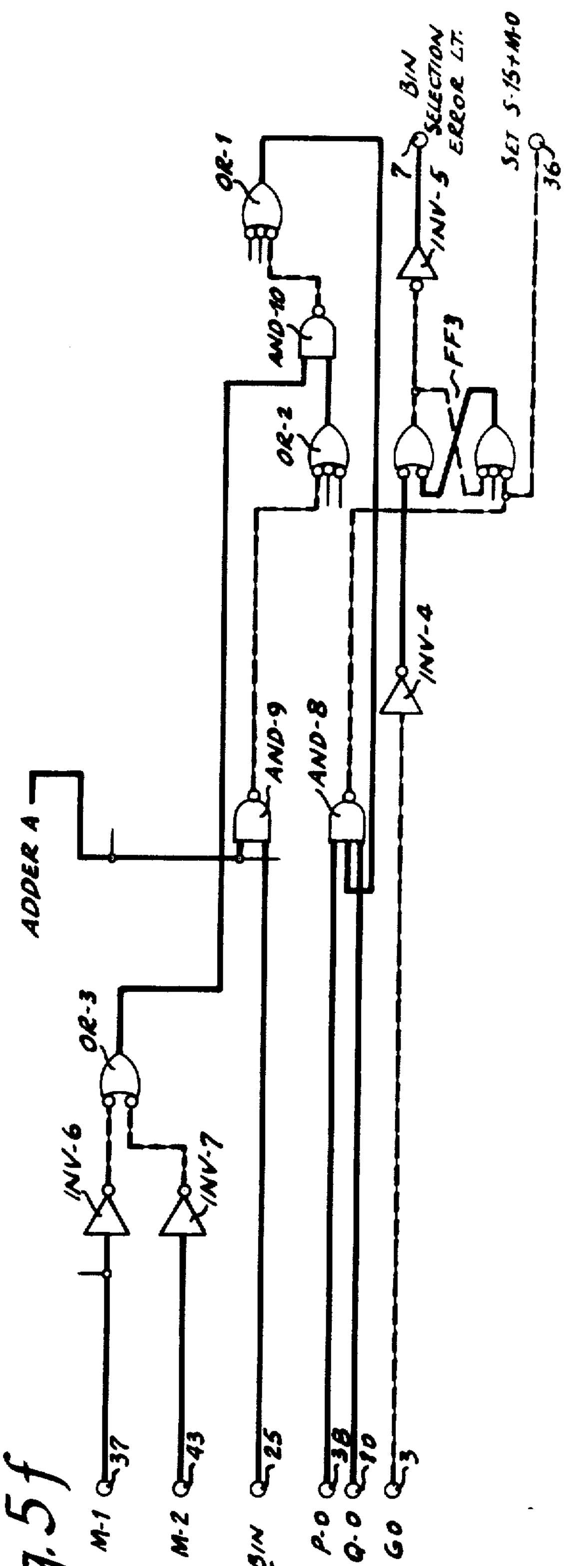

OR-1
BIN SELECTION ERROR LT.
7
INV-5
SET S-15+M-0
36
AND-10
FF3
OR-2
INV-4
AND-9
AND-8
ADDER A
OR-3
INV-6
INV-7
M-1
37
M-2
43
SMALL BIN SHELF
25
P-0
38
Q-0
10
GO
3

Fig. 5f

Fig. 5g

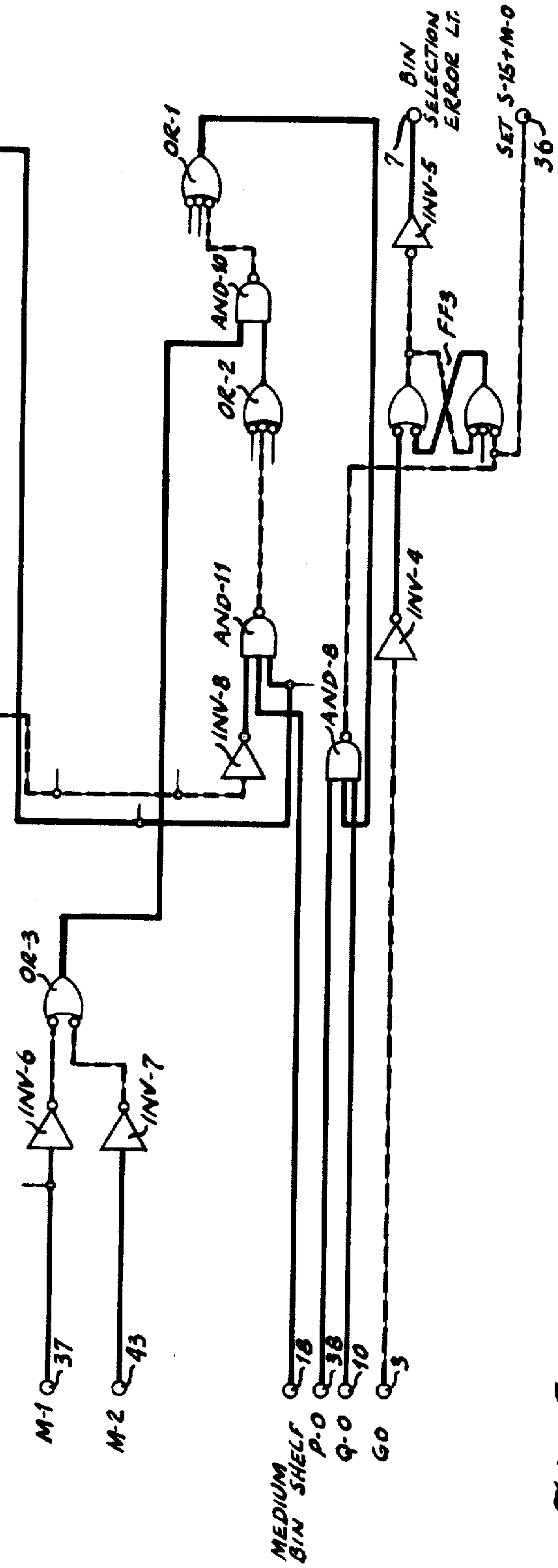
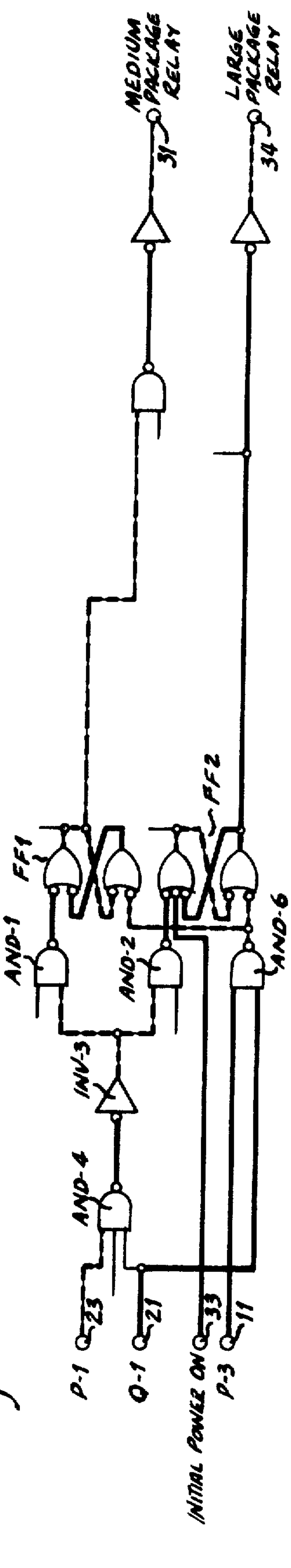
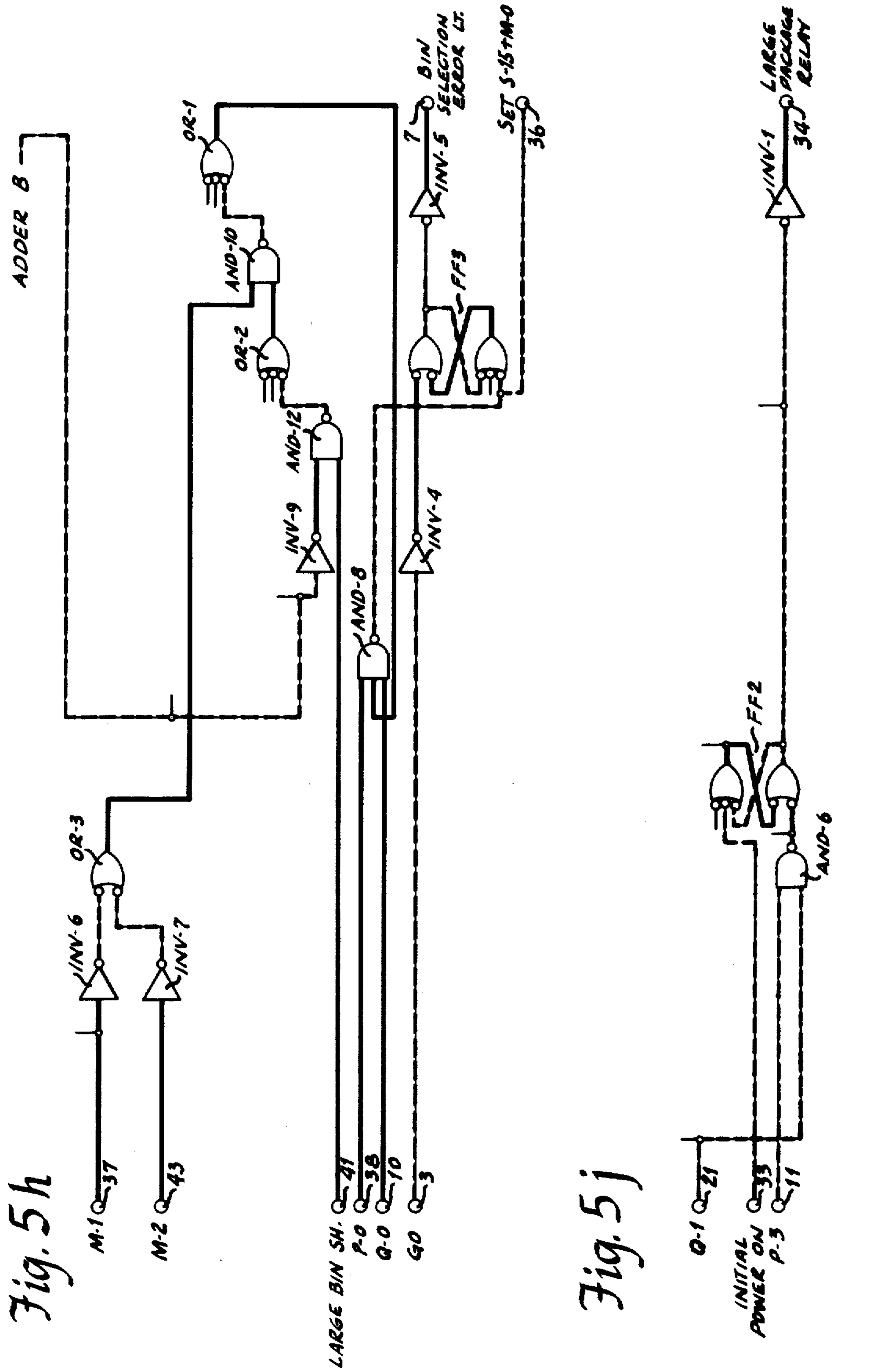

ADDER B
ADDER A
OR-1
AND-10
OR-2
AND-11
INV-8
AND-8
INV-4
INV-5
FF3
7
BIN SELECTION ERROR LT.
SET S-15+M-0
36
OR-3
INV-6
INV-7
M-1
37
M-2
43
MEDIUM BIN SHELF
18
P-0
38
Q-0
10
GO
3

Fig. 5i


MEDIUM PACKAGE RELAY
31
LARGE PACKAGE RELAY
34
FF1
FF2
AND-1
AND-2
AND-6
INV-3
AND-4
P-1
23
Q-1
21
INITIAL POWER ON
33
P-3
11



ADDER B
OR-1
AND-10
OR-2
AND-12
INV-9
AND-8
INV-4
INV-5
FF3
7
BIN SELECTION ERROR LT.
SET S-15+M-0
36
LARGE PACKAGE RELAY
34
INV-1
FF2
AND-6
OR-3
INV-6
INV-7
M-1 37
M-2 43
LARGE BIN SH. 41
P-0 38
Q-0 10
GO 3
Q-1 21
INITIAL POWER ON 33
P-3 11

Fig. 5h

Fig. 5j

STORAGE COURIER BOUNDARY CONTROL SYSTEM

BACKGROUND OF THE INVENTION

Automatic stacker crane control systems have been known heretofore. Such systems have used either a counting system or a positive address, binary code system for controlling movements of and stopping of the article carrier in front of the bin. In a counting system, numbers proportional to the distances to be traveled are put into the system and each number or count is counted out as the crane moves from column to column or from bin to bin and stops at a zero count. In the positive address, binary code system, as for example, that disclosed in R. K. Cotton et al. copending application Ser. No. 498,326, filed Oct. 20, 1965, now U.S. Pat. No. 3,504,245, dated Mar. 31, 1970, a horizontal-vertical code representing the destination bin is put into the system and a magnetic code is read and subtracted therefrom at each column and bin to obtain difference codes indicative of the remaining distances and polarity codes indicative of the directions of travel-forward, reverse, up or down. Neither of these systems provides for variable bin size self error detection or automatic programming for a large bin following power failure, nor does the positive address system take into account any error that might occur in sending an article to a wrong size bin.

SUMMARY OF THE INVENTION

This invention relates to improvements over prior automatic stacker crane positive address control systems whereby provision is made for a plurality of different size bins to accommodate different sizes of articles.

An object of the invention is to provide a courier control system with improved means for sizing an article and for activating error detection and control apparatus if an article is sent to a wrong size bin.

A more specific object of the invention is to provide positive address courier control system with improved means for storing package sizing data and for operating error control apparatus when a package is sent to a too small bin.

Another specific object of the invention is to provide a stacker crane control system with error control apparatus that programs the crane for return to the point of origin in response to detection of bin size or wrong shelf error.

Another specific object of the invention is to provide such system with improved means for sizing a package during retraction of the article supporting table and for storing the sizing data in integrated circuit means for later use when the package arrives in front of the bin.

Another object of the invention is to provide a courier control system with improved means for sizing an article and for activating error detection and control apparatus if the courier is sent to the wrong shelf in a zone of given bin size.

A more specific object of the invention is to provide a stacker crane control system with zones of variable size bins and a code for each hoist address that defines the validity of the address for each zone.

Another object of the invention is to provide such system with improved means for resetting the package sizing data storing means prior to the program step during which retraction of the table takes place.

Another object of the invention is to provide such system with improved means effective upon power restoration following power failure when an article is on the table for automatically programming the sizing data storing integrated circuits to large package indication to prevent any erroneous attempt to put a package already on the table into a bin too small for it.

Other objects and advantages of the invention will hereinafter appear.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a rack of bins and a stacker crane (courier) mounted for movement past the front of the the bins for storing articles therein;

FIG. 2 is a front elevational view of storage bins arranged in three zones of small, medium and large size bins, respectively, and indicating at the left by short horizontal lines the required hoist code addresses and showing at the right horizontal alignment therewith the shelf validity codes;

FIG. 3 is a schematic side view of the article supporting table, an irregular shaped article thereon and the article sizing photocells;

FIGS. 4*a–b* show a flow diagram depicting the operating modes and program steps for each such operating mode of the courier control system; and

FIGS. 5*a–j* show an integrated circuit logic system for controlling package sizing and variable bin size and shelf error detection and control of the courier.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, there is shown a rack structure including a plurality of bins in which articles such as pallet supported boxes or packages may be stored. This rack structure is made from steel members such as angle members, channel members and the like, and includes horizontal members 2, vertical members 4 and lateral support members 6. These support members may have flanges projecting into the bin from opposite sides thereof in known manner onto which a load may be deposited after it has been extended between the horizontal and vertical members.

While only a right rack is shown, it will be apparent that there is a similar left rack on the other side of the aisle in which the courier travels.

The courier shown in FIG. 1 comprises a frame 8 (or mast) that runs on horizontal tracks 10 along the aisle, driven by an electric motor, and guided by rails 11. This horizontal movement is controlled by a code reader mounted on the top or bottom of the frame. This code reader reads a series of sets of horizontal code bars 12, there being one set of magnetic code bars for each vertical column of bins. While the code bars 12 are shown at the top, they could as well be at the bottom near the floor of the warehouse.

This courier also comprises a hoist 14 mounted on the frame for vertical movement. The hoist is driven by an electric motor up and down along the frame. Vertical code bars 16 are mounted along the frame. These vertical code bars are magnetic code bars that are arranged to be read by a code reader to control vertical movement of the hoist to the selected bin in a selected column.

A control cabinet 18 is also mounted on the frame and houses electronic controls and supports a control panel 18*a* whereby the input codes may be put into the system when the courier is at a pickup station at an end of the aisle.

The hoist 14 comprises a table 20 that supports a load or package 22 and can be driven in opposite directions to reach into the right or left bins on opposite sides of the aisle. This table is driven by an electric motor from either of two vertical positions at each bin. When it is extended from a lower position it will be raised within the bin to pick up the load and then retracted to retrieve the load as indicated by program steps 3–6 of the retrieve mode in FIG. 4*b*. When it is extended from the upper position, it will be lowered within the bin to deposit the load and then retracted to store the load in the bin as indicated by program steps 3–6 of the store mode in FIG. 4*a*. A similar retrieve operation is performed at the pickup station as indicated by program steps 3–6 of the pickup mode in FIG. 4*a*. A similar store operation is performed at the delivery station as indicated by program steps 3–6 of the deliver mode in FIG. 4*b*.

The integrated circuit logic system shown in FIGS. 5*a–j* will be primarily concerned with sizing of the packages and detection of bin size and shelf errors and return of the courier to the pickup station when such error is detected.

The zones of variable bin sizes, their boundary codes and shelf validity codes with which the logic circuits operate are shown in FIG. 2. As shown in FIG. 2, the bins are arranged in zones of small, medium and large bins. For exemplary purposes, the small bin zone extends from zero through the horizontal binary code equivalent to decimal number 30. The medium bin zone extends from horizontal binary code 31 through 126. And the large bin zone extends from horizontal binary code 127 through 255.

The boundaries between the zones are indicated in FIG. 2 as boundary A and boundary B. The code of boundary A is 31 since any horizontal code less than this is in the small bin zone and any code equal to or larger than this is in the medium or large zones. The code of boundary B is 127 since any code less than this is in the small or medium bin zones and any code equal to or larger than this is in the large bin zone.

These boundary codes provide a simple and convenient way of determining what zone the courier arrives at. These boundary codes are wired into adders A and B shown in FIG. 5*d*. By subtracting (by inversion and adding) the "read" code at the destination bin from the boundary codes, the "carry" accompanying the difference codes indicates the zone as hereinafter more fully described.

FIG. 2 also shows at the right the shelf validity codes hereinafter more fully described. Briefly, a "1" bit in the left or S bit position indicates that this hoist address is valid for the small bin zone. A "1" bit in the middle or M bit position indicates that this hoist address is valid for the medium bin zone. And a "1" bit in the right or L bit position indicates that this hoist address is valid for the large bin zone. A "0" bit indicates lack of validity. This shelf validity code is read by the magnetic code reader along with the hoist code and operates the error control integrated circuits as hereinafter described.

FIG. 3 shows the means provided for sizing the package while the table is being retracted at the pickup station and at the bin when a load is being retrieved. As shown therein, a package PK rests on table 20. Scanning means is provided for detecting a large load when the table is retracted. This means comprises a left large load photocell LLP and a right large load photocell RLP, one at each side of the table so that a large load even if it is irregular in shape will interrupt the light beam thereto. Photocell LLP will function when a large load is retracted from the left bin or pickup station and photocell RLP will function when a large load is retracted from the right bin or pickup station.

Similar scanning means is provided for detecting a medium load when the table is retracted. This means comprises a left medium load photocell LMP mounted at the left side of the table below photocell LLP and a right medium load photocell RMP mounted at the right side of the table below photocell RLP for detecting a medium size load or package PK that may be irregular in shape as shown by the broken line in FIG. 3.

Light beams from suitable lamps (not shown) impinge on these photocells and interruption of one of these beams by a load causes a signal to be provided as hereinafter described in connection with FIGS. 5*b–c*.

No interruption of a light beam is indicative of a small load.

The overall system operation or program is shown in the flow diagram in FIGS. 4*a* and 4*b*. The rectangles represent program steps and are arranged in four vertical columns according to the four modes of operation. These modes are the pickup mode M–O, the store mode M–1, the retrieve mode M–2, and the delivery mode M–3. These modes are selected by setting M program flip-flops into different operating states in a manner shown in the following mode program table to provide the mode signals hereinafter described.

Each mode has a plurality of program steps. The numbers in the upper left corner of the rectangles in FIGS. 4*a–b* indicate the program steps. These steps are selected by setting flip-flops into different operating states, that is, P and Q program flip-flops, as hereinafter more fully described. To this end, two P program flip-flops and two Q program flip-flops, each having two states, will give 16 steps in accordance with 16 possible combinations of the flip-flop states as shown in the following step program table. All of these steps are not used in each mode as will be apparent in FIG. 4*a–b*. The legends within the rectangles describe generally the functions performed at the respective steps and these will be referred to later on in connection with the specific operations described hereinafter.

VARIABLE BIN SIZE

The normal warehouse arrangement is for all the bins to have the same size. Sometimes, however, the material being stored can be classified into general groups of different size packages and it is then advantageous to have different size bins, small bins for small packages, medium size bins for medium packages and large bins for large packages. This will enable use of the available space most efficiently.

There are a number of ways of doing this, one of which is to divide the warehouse into three zones, characterized as small, medium and large zones. FIG. 2 shows how this is done. While the variation in bin size is in the vertical direction, and the horizontal dimensions or widths are the same for all bins, other variations could readily be used. The zones are arranged in order as shown in FIG. 2 with the small zone at the left, the medium zone at the middle and the large zone at the right. The small zone corresponds to the small numbered travel addresses with increasing travel address proceeding to the right through the medium and large zones in the forward direction of horizontal travel.

The main effect of variable bin size as shown in FIG. is to increase the number of possible hoist or vertical movement stopping positions. For example, there would be only eight hoist positions if the warehouse consisted of only small bins. However, the variable bin arrangement requires establishment of 16 stopping positions with the arrangement shown in FIG. 2 where the medium and large bin heights are not multiples of small bin heights.

The integrated circuit logic system for variable bin size error control is shown in FIG. 5*d* whereas FIGS. 5*a–c* and 5*e–j* show portions thereof to depict the various operations thereof generally entitled as follows.

FIG. 5*a* —Sizing small package.
FIG. 5*b* —Sizing medium package.
FIG. 5*c* —Sizing large package.
FIG. 5*d* —Bin selection error-store medium package in small bin.
FIG. 5*e* —Bin selection error-store large package in not large bin.
FIG. 5*f* —Bin selection error-small zone and not small bin shelf.
FIG. 5*g* —Bin selection error-medium zone and not medium bin shelf.
FIG. 5*h* —Bin selection error-large zone and not large bin shelf.
FIG. 5*i* —Reset package sizing flip-flops.
FIG. 5*j* —Force package sizing flip-flops to large indication in response to power-on.

THE AND/OR LOGIC SYMBOLS

The logic operations generated by the circuits, or more precisely, the logic operations that the circuits are being asked to perform, are shown in FIGS. 5*a–j* by shapes. The symbols prefixed AND and OR therein show the two shapes that correspond to the inverting AND and OR (NAND and NOR) logic operations, respectively. The symbol prefixed INV performs an inversion or NOT logic operation. These are the shapes that are in prevalent use for switching circuits based on integrated circuits.

The next task of the symbol is to show what signal value, or signal values, are significant. The symbols in FIGS. 5*a–j* show this also. A "high" value is significant if there is no circle (small circle at the inputs or outputs) and a "low" value is significant if there is a circle. The high value of signal is a positive voltage and the low value of signal is at or near ground potential.

The symbols in FIGS. 5*a–j* show what to look for. If the circuit is supposed to behave as an AND circuit, one looks for high on all inputs and low on the output. If the circuit is supposed to behave as an OR circuit, one looks for low on one or more inputs and high on the output.

If the proper signals are in place for a given operation, that operation is activated. Actually this can be given in terms of only the output. The circuit is an activated AND when the output is low. It is an activated OR when the output is high. It is therefore evident that if the circuit is an activated AND, it is an inactivated OR and vice versa.

The logic diagrams may be understood by tracing down through the active portions thereof. For this purpose, the active parts are shown in FIGS. *5a–j* as follows. An active line that has a high signal is shown as a heavy dark line superimposed on the usual interconnecting line. An active line that has a low signal is shown as a heavy dashed line superimposed on the connecting line. The lines that are not active are assumed to be inactive.

If one of the inputs to the logic circuit is allowed to float or is connected to a plus five volt supply, the circuit becomes an inverter as far as the output is concerned. That is, the output signal value is the opposite of the input signal value. The symbol for the inverter is prefixed by INV. The significance circles are customarily placed on the inverter symbol in order to match the circles of an element connected to the inverter as shown in FIGS. *5a–j*.

BIN SELECTION ERROR PROGRAM

One of the options that is available in the courier control system is rack adjustability whereby the warehouse can be divided into three zones where the bin heights vary as shown in FIG. 2.

This rack adjustability increases the possibilities of errors and these must be prevented. One of these errors is attempting to store a package in a zone where the bins are too small for it. For example, a large package cannot be stored in either the medium or small bin zones. A medium size package cannot be stored in the small bin zone. Another error is directing the courier to the wrong zone (in the horizontal direction) for a given shelf position (vertical direction). This is a shelf selection error.

All of these error prevention controls are combined into one error program, the bin selection error program. Bin selection errors can occur only in the Store Mode or in the Retrieve Mode where the courier is operating in the rack structure. The program exits directly from these modes to the Pickup Mode that brings the courier directly back to the home station as shown in the flow diagram in FIGS. *4a–b*.

The integrated circuit shown in FIG. *5d* is mounted on a single board. This is an option board that may be plugged into its slot when it is desired to have bins of different sizes and to control the storage of proper size articles therein. The receptacle wiring is in place whether this option is used or not. If this option board is removed, the terminal to which error output terminal **36** normally connects will be floating voltagewise which is the same as a high signal indicative of no bin selection error.

The main function of the integrated circuit on this board is to detect bin select errors. For example, the bin to which a package is set must be of a size, small, medium or large, capable of receiving the package.

The bins are divided into small, medium and large bin zones. Each zone has a distinctive address. Once the zone is known, this must be compared with the actual package size to see if the bins in that zone are capable of receiving the package, that is, to insure that a small, medium or large package is addressed to a small, medium or large bin, respectively.

The integrated circuit shown in FIGS. *5a–d* also contains the logic and memory elements for the sizing of packages. For this purpose, classification is based on a set of photocells at two levels. One level corresponds to the boundary between small and medium packages and the other level corresponds to the boundary between medium and large packages as shown in FIG. 3.

It might be thought that two such photocells could be placed in the center of the table and load size determined in that manner. However, this would only determine the size of the center of the load and would not detect an outsize dimension because of load irregularity.

To determine the maximum size of the load regardless of its irregularity requires scanning the load. This is done by mounting photocells displaced from the center of the table toward the side by the amount of the widest load to be carried. The actual sizing operation is then carried out as the load is retracted. Any protrusion on the load placing it into a particular size classification will then trip a corresponding photocell as the load moves past it.

As shown in FIG. 3, two sets of photocells are provided, one at the left extremity of the centered load and another at the right extremity of the centered load. When the large load is retracted from its left-hand position toward the right to its center position, the large photocell at the left will trip although such a cell if it had been located at the center of the table would not have detected the large dimension.

The classification of the package as based on the tripping of photocells (breaking of light beams) is performed by the integrated circuit logic in FIGS. *5a–d*. It is apparent that the actions of the photocells must be remembered because they might trip only momentarily during the scanning action. Therefore, two flip-flops FF1 and FF2 are provided as shown at the bottom portion of FIG. *5d*.

These flip-flops are reset to "0" condition sometime before the scanning takes place and are set to "1" condition in the following combinations by photocell trip signals (low value) during retract movement.

Medium Package Flip-Flop	Large Package Flip-Flop	Package Size Indication
0	0	Small
1	0	Medium
1	1	Large

SMALL PACKAGE

Referring to FIG. *5a*, it will be seen that when the package is a small one, a low signal will appear on left-hand terminal **13** designed MEDIUM PACKAGE PHOTOCELL Land a low signal will appear on left-hand terminal **19** designated LARGE PACKAGE PHOTOCELL. These low signals are applied to inputs of logics AND–1 and AND–2, respectively. As a result, these AND logics apply high signals to the set to "1" inputs of flip-flops FF1 and FF2, keeping these flip-flops in their "0" states. That is, these flip-flops require low signals on their set to "1" inputs to flip to their "1" states. Consequently, under present conditions they will remain in their "0" states.

From the foregoing, it will be seen that determination of the size of a small package is one of no action since there is no change in the state of the flip-flops.

Under these conditions, as shown in FIG. *5a* flip-flop FF1 applies a low signal to the upper input of logic AND–3. Flip-flop FF2 applies a high signal to logic INV–1 and the lower input of logic AND–3. This causes logic INV–1 to provide a low signal to terminal **34** designated LARGE PACKAGE RELAY, this low signal indicating that the package is not a large package.

With high and low signals at the two inputs, logic AND–3 provides a high signal that is inverted in logic INV–2 to a low signal. This low signal is applied to terminal **31** designated MEDIUM PACKAGE RELAY to indicate that the package is not a medium size package.

MEDIUM SIZE PACKAGE

When a medium size package is on the table, the medium package photocell is actuated during retraction of the table. This is done by the package interrupting the light beam. As a result, a high signal is applied to left-hand terminal **13**, designated MEDIUM PACKAGE PHOTOCELL in FIG. **5***b*. This high signal goes to the upper input of logic AND–1.

Left-hand terminals **21**, **23** and **24** in FIG. **5***b* have high signals during the package scanning operation for the following reasons. This scanning takes place during the table retract operation. It will be seen from the flow diagram in FIG. **4** that the retract operation occurs on step **6** of the program in each of the four modes, pickup, store, retrieve and deliver. This step **6** is the step program corresponding to P–1 and Q–1, meaning that the P and Q flip-flops are in their "1" state as shown below.

STEP PROGRAM

Step P	Flip-Flops P & Q Position PQ	Outputs A	B	Q C	D
0	0 0	0	0	0	0
1	1 0	1	0	0	0
2	2 0	1	1	0	0
3	3 0	0	1	0	0
4	3 1	0	1	1	0
5	2 1	1	1	1	0
6	1 1	1	0	1	0
7	0 1	0	0	1	0
8	0 2	0	0	1	1
9	1 2	1	0	1	1
10	2 2	1	1	1	1
11	3 2	0	1	1	1
12	3 3	0	1	0	1
13	2 3	1	1	0	1
14	1 3	1	0	0	1
15	0 3	0	0	0	1

MODE PROGRAM

Mode	Flip-Flop M Position M	Outputs E	F
Pick-up	0	0	0
Store	1	1	0
Retrieve	2	1	1
Deliver	3	0	1

Consequently, the P and Q program flip-flops will apply high signals to terminals **23** and **21**, marked **P–1** and **Q–1**, respectively, in FIG. 5b. These high signals go to two inputs of a three-input logic AND–4.

The third input of logic AND–4 receives a high signal under the following alternative permissive conditions. The power must be turned on and the system must be either in the pickup or retrieve mode. Under either of these two conditions, a high signal is applied to terminal **24** designated LIFT-UP ACTION and goes to the third input of logic AND–4 to activate this logic.

This high signal is preferably developed in the following manner. A power-on signal and a pickup mode (M–0) signal are applied through a two-input AND logic to one of two inputs of an OR logic. This power-on signal and retrieve mode (M–2) signal are applied through a two-input AND logic to the other input of the OR logic. The output of the OR logic is applied to terminal **24** in FIG. **5***b*. In this manner either pair of conditions will supply a high signal to terminal **24**.

All three inputs of logic AND–4 now having high signals, a low signal is applied to logic INV–3 and inverted therein to a high signal. This high signal is applied to the lower input of logic AND–1.

Both inputs now having high signals, logic AND–1 applies a low signal to the set to "1" input of flip-flop FF1. As a result, this flip-flop goes to its "1" state and applies a high signal to the upper input of logic AND–3 and the lower input of logic AND–5 as shown in FIGS. **5***b* and **5***d*.

Both inputs now having high signals, logic AND–3 applies a low signal that is inverted in logic INV–2 to a high signal and applied to terminal **31** marked MEDIUM PACKAGE RELAY. The high signal to logic AND–5 constitutes a registration or remembering of the fact that the package is of medium size. This information will be used later to prevent erroneously placing it in a different size bin as hereinafter described.

The medium package relay will set up a limit switch circuit that will stop the hoist to prevent a medium package from hitting the ceiling if sent to a small bin at the top of the column.

During the time that the medium size package photocell signal is received, terminal **19** of FIG. **5***b* has a low signal since the large package photocell has not been activated. This low signal is applied to one input of logic AND–2 to maintain its output at a high signal value. This high signal is applied to the set to "1" input of flip-flop FF2 to maintain it in its "0" state. Also, terminal **11** marked P–3 has a low signal, meaning that the program is not in step (P program step 3 in position 3 in accordance with above step program). This prevents sensing the load size during the time that the table is being extended. This low signal is applied to one input of logic AND–6 whereby a high signal is applied from its output to the set to "0" inputs of flip-flops FF1 and FF2. This conditions these flip-flops for setting to their "1" state.

LARGE PACKAGE

When a large package is on the table, the large package photocell is activated during retraction of the table in the pickup or retrieve modes of operation. This is done by the package interrupting the light beam as before. As a result, a high signal is applied to left-hand terminal **19** marked LARGE PACKAGE PHOTOCELL in FIG. **5***c*. This high signal goes to the lower input of logic AND–2.

Terminals **21**, **23** and **24** have high signals and terminal **11** has a low signal as described in connection with medium size package scanning. And since a large package will also trip the medium package photocell, terminal **13** will have a high signal.

As a result of this, logics AND–1 and AND–2 will have high signals on both inputs to provide low signal outputs. Logic AND–6 will provide a high signal output to the set to "0" inputs of the flip-flops to allow operation thereof. The low signals from logics AND–1 and AND–2 are applied to the set to "1" inputs of flip-flops FF1 and FF2, respectively, to change both of them to their "1" states.

This gives a large package indication only although both medium and large package photocells are tripped. A high signal is applied from flip-flop FF1 to the upper input of logic AND–3. A high signal is applied from flip-flop FF2 to logic AND–7. A low signal is applied from flip-flop FF2 to the lower input of logic AND–3 and to logic INV–1. As a result, logic INV–1 provides a high signal to terminal **34** marked LARGE PACKAGE RELAY. The high and low inputs to logic AND–3 cause it to provide a high signal that is inverted in logic INV–2 to a low signal at terminal **31** marked MEDIUM PACKAGE RELAY. Thus, only a large package indication has been registered. For this purpose, the high signal to logic AND–7 constitutes a registration or remembering of the fact that the package is large size. The large package relay will set up a limit switch circuit that will stop the hoist before it reaches the end of hoist movement to prevent the large package from hitting the ceiling if sent to a small or medium size bin at the top of the column.

BIN SELECTION ERROR

When the code reader stops the courier in front of a bin during the store or retrieve modes of operation, a check is made for variable bin selection error. This is done by comparing the package size signal (as registered during the table retraction operation hereinbefore described) with a resultant "arrived position" signal obtained by subtracting the address read by the code reader from the zones boundary addresses wired into the logic system of FIG. **5d** as hereinafter more fully described. This subtracting is done by the two adders in FIG. **5d** marked ADDER A ZONE ADDRESS =**31** and ADDER B ZONE ADDRESS =**127**.

For this purpose, it may be assumed that the bin zones have been selected as follows with respect to the code addresses of the bins in the horizontal travel direction.

Small zone — addresses 1 through **30**
Medium zone — addresses **31** through **126**
Large zone — addresses **127** through **255**

As will be apparent, there are two boundaries between these three zones, one between the small and medium zones and another between the medium and large zones. The first boundary is designated the A zone boundary and the second boundary is designated the B zone boundary. The A zone boundary address that is 31 is wired into the A ZONE ADDRESS ADDER by jumper wires connecting pins **27**, **30** and **28** to ground as represented in FIG. **5d**. These pins are actually in the receptacle into which the integrated circuit board is inserted. This leaves the remaining five pins having binary values of 1, 2, 4, 8 and 16 unconnected which puts in the binary value equivalent to decimal value 31.

In a similar manner, the B zone boundary address that is **127** is wired into the B ZONE ADDRESS ADDER by a jumper wire connecting pin **42** to ground. These pins are actually in the receptacle into which the integrated circuit board is inserted. This leaves the remaining seven pins having binary values of 1, 2, 4, 8, 16, 32 and 64 unconnected which puts in the binary value equivalent to decimal value 127.

As a result of the above, the two adders have the following values at first inputs thereof:

	(128) (2)	(64)	(32)	(16)	(8)	(4)		(1)	
A ZONE	0 0		0	1	1	1	1	1	– 31
B ZONE	0 1		1	1	1	1	1	1	– 127

It is now possible to determine where the courier has stopped by determining if the code read by the reader is larger or smaller than the numbers wired into the adder. If the read address is smaller than both A and B zone addresses, the courier is in the small zone. If the read address is equal to or larger than the A zone address and smaller than the B zone address, the courier is in the medium zone. And if the read address is larger than the A zone address and equal to or larger than the B zone address, the courier is in the large zone. We will now see how this functions to detect error.

For purposes of description of error detection, let it be assumed that the following travel addresses are read by the code reader:

TRAVEL ADDRESSES READ

Zone	Decimal Value	32 128	26 64	40 32	44 16	6 8	14 4	16 2	20 1 (Pin No.) (Binary)
Small	15	0	0	0	0	1	1	1	1
Medium	63	0	0	1	1	1	1	1	1
Large	255	1	1	1	1	1	1	1	1

Since binary subtraction is performed by inversion of the subtrahend and adding, this inversion is taken care of by providing signal values on the above pins of low for "1" and high for "0. " In other words, the input (read) address is presented to the adder as inverted.

The sum outputs of the adders are not used, only the carry-out signals because we wish to determine only if a given input or read address is equal to or greater than, or less than the A and B boundary (zone) addresses. From this carry-out signal it is readily determined which of the zones the courier is in.

To illustrate how the carry-out changes as the input address changes with respect to the boundary address, let it first be assumed that the preset (wired in) boundary address is **100** (decimal 4) and that the input (read) address changes from decimal 3 to 4 and to 5. The following table shows the results.

SUBTRACTION TABLE

Preset	Input	Input Inverted	Sum	Carry-out
100	011	100	000	1
100	100	011	111	0
100	101	010	110	0

From this it can be concluded that if the input address is less than the preset boundary address, the carry-out is "1." If the input address is equal to or greater than the preset boundary address, the carry-out is "0."

Three cases can be tabulated for each adder, where N is the input address and A and B are the respective preset boundary addresses:

CARRY-OUT TABLE

A ADDER Zone	Inputs	Carry-out	B ADDER Inputs	Carry-out
Small	N < A	1	N < B	1
Medium	N ≥ A	0	N < B	1
Large	N ≥ A	0	N ≥ B	0

This table shows that the small, medium and large zones can be defined by carry-out values of 1 and 1, 0 and 1, 0 and 0, respectively.

Specific error detection will now be described.

STORE MEDIUM PACKAGE IN SMALL BIN

This operation is the detection of the error when an attempt is made to store a medium size package in a small bin. The result of this detection is to send the courier back to the pickup station as hereinafter described.

Four signals are used, namely, medium packages, store mode M–1, small bin zone and program step **0**.

For this purpose, the size of the package has been determined as hereinbefore described. Being a medium size package, its size is indicated by the "1" state of flip-flop FF1 as shown in the above table whereby it applies a high signal to the lower input of logic AND–5 in FIG. **5d**.

The system being in the store mode (M–1), that is, the courier loaded with a medium size package having arrived in front of a small bin, a high signal is applied to left-hand terminal **37** in FIG. **5d** that is designated M–1. This high signal goes to the middle input of logic AND–5.

Let it now be assumed that the code reader has reached the small bin and has read its travel address shown in the above table and corresponding to decimal 15. This binary code is applied to the terminals **20**, **16**, **14**, **6**, **44**, **40**, **26** and **32** at the upper left-hand portion of FIG. **5d** designated MT–1, MT–2, MT–4, MT–8, MT–16, MT–32, MT–64 and MT–128, respectively. The letter prefix stands for Maitrol that is the type of code reader used and the suffix number indicates the binary bit value. A "1" bit low signal will be applied to terminals MT–1, MT–2, MT–4 and MT–8, and a "0" bit high signal will be applied to terminals MT–16, MT–32, MT–64 and MT–128. It will be seen that this binary code comes in inverted form since subtraction is to be performed by inversion of the subtrahend and adding.

This binary code 15 that has been read will be applied to both A and B adders. It will be recalled that the code 31 was wired into the A adder and the code 127 was wired into the B adder. As described in connection with the above subtraction table, it will be apparent that since the read code is smaller than the preset code, the A adder will provide a carry-out of "1," that is, a high signal to the upper input of logic AND-5.

The B adder will also provide a carry-out of "1" since the read code 15 is smaller than the preset code 127 but this will have no effect at this time since logic AND-7 has not been gated by flip-flop FF2.

Logic AND-5, having now three high signal inputs, provides a low signal to logic OR-1, causing it to apply a high signal to the middle input of logic AND-8.

Since the system is at step 0 of the store program, indicative of having completed the movement to the front of the bin, high signals will be present on terminals 38 and 10 designated P-0 and Q-0, respectively, in FIG. 5d. These high signals go to the upper and lower inputs of logic AND-8.

To allow operation of flip-flop FF3 by a low signal at its set to "0" input, a high signal must be present at its set to "1" input. This is obtained from logic INV-4 which inverts the low signal it receives from terminal 3 marked GO. This GO signal is low after the system leaves step O of the pickup program.

With high signals on all three inputs, logic AND-8 applies a low signal to the set to "0" input of flip-flop FF3 and to output terminal 36 marked SET S-15 and M-0. This flip-flop applies a low signal that is inverted in logic INV-5 to a high signal and applied to terminal 7 designated BIN SELECTION ERROR LIGHT. This high signal energizes the light to indicate that a bin selection error has occurred. Also, the low signal at terminal 36 is applied to the step program flip-flops to set the pair of P flip-flops to "0" state and to set the pair of Q flip-flops to "0" and "1" states, respectively, indicative of step 15 as shown on the above step program table. This low signal at terminal 36 is further applied to the mode program flip-flops to set the pair of M flip-flops "0" state, indicative of the pickup program as shown on the above mode program table. It will now be seen from the flow diagram in FIG. 4 that the system has been changed from step 0 of the store program to step 15 of the pickup program that causes the courier to move to the pickup station as indicated by the legend thereon.

STORE LARGE PACKAGE IN NOT LARGE BIN

This operation is the detection of the error when an attempt is made to store a large package in other than a large bin, that is, in a small or medium bin. The result of this error detection will be that the courier will be sent back to the pickup station.

Four signals are used, namely, large package, store mode, not large bin zone and program step 0.

From the foregoing package sizing description, it will be recalled that the large package size has been remembered by both flip-flops FF1 and FF2 in FIG. 5c having been set in their "1" states. The high signal from flip-flop FF2 to one input of logic AND-7 constitutes the large package indication. Also flip-flop FF1 applies a high signal to logic AND-5 at one input thereof as shown in FIG. 5*d*.

A second input of each logic AND-5 and logic AND-7 receives a high signal from store mode (M-1) terminal 37 as hereinbefore described.

Now if the courier goes to the small zone so that the read code is less than 31, both adders A and B will provide a carry-out of 1 as shown in the above carry-out table. If the courier goes to the medium zone so that the read code is from 31 through 126, adder B will provide a carry-out of 1. In the first case, both logics AND-5 and AND-7 will be operated. In the second case, only logic AND-7 will be operated as shown in FIG. 5*e*. In either case of error, one or two low signals will be applied to logic OR-1, causing it to apply a high signal to one input of logic AND-8. This causes the courier to be moved back to the pickup station and the bin selection error light to be lit as hereinbefore described.

SHELF ERROR

This operation is the detection of an error when the courier goes to valid travel (horizontal) address but to an invalid hoist (vertical) address. This is an error possibility because some of the small, medium and large bin shelves do not coincide as shown in FIG. 2.

This error is detected by virtue of a code assigned to each hoist address that defines the validity of the hoist address for the various zones of different size bins. These codes are shown at the right-hand portion of FIG. 2. Since a given hoist address can be valid for one, two or three zones, a three-position code is used. As shown in FIG. 2, wherein S, M and L designate small, medium and large bin zones, respectively, a "1" is placed in the proper position in the three bit code if the address is valid for the corresponding zone. For example, an address that is valid for only the small zone is coded 100, an address valid for only the large zone is coded 001, and an address that is valid for both small and medium zones is coded 110, etc.

This code is obtained from three bits added to the hoist address as read by the magnetic code reader. This code is applied to left-hand input terminals 25, 18 and 41 in FIG. 5*d*, these terminals being designated SMALL BIN SHELF, MEDIUM BIN SHELF, and LARGE BIN SHELF, respectively. This code is applied in such a manner that a high signal at the given terminal 25, 18 or 41 means that there is no bin shelf at that hoist address. A low signal, of course, is the opposite indication, that is, no error. The code bits can be applied directly to these terminals if "0" in FIG. 2 is a high signal and "1" in FIG. 2 is a low signal or inverted if they are the opposites.

SMALL ZONE AND NOT SMALL BIN SHELF

This operation is the detection of an error when the courier arrives at a hoist address in the small bin zone and the code read by the code reader indicates that the hoist address selected is not valid for that zone.

Four signals are used, namely small bin zone, invalid hoist address, store or retrieved mode and program step 0.

Let it be again assumed that the courier goes to travel address 15 and that when this is subtracted from the preset address 31 in the A adder (FIG. 5*d*), it provides a carry-out of "1" to apply a high signal to one input of logic AND-9 in FIG. 5f. Since the hoist address at which the courier stopped is not valid for the small bin zone, a high signal is applied from terminal 25 to the other input of logic AND-9. As a result, this logic applies a low signal to logic OR-2. This logic then applies a high signal to one input of logic AND-10.

This logic AND-10 will be gated provided the system is in either the store (M -1) or retrieve (M-2) program. This condition is indicated by a high signal on terminal 37 or 43, respectively. Such high signal is inverted in logic INV-6 or INV-7 to a low signal at one of the inputs of logic OR-3. As a result, this logic applies a high signal to the other input of logic AND-10 to indicate that the system is in either the store or retrieve program. Such interlock limits this shelf error checking to those situations when the table is about to be extended into the bin.

This causes activation of logic AND-10 to apply a low signal to one input of logic OR-1, causing it to apply a high signal to one input of logic AND-8. This logic will now be gated provided the program is at step 0 whereby high signals appear at terminal 38 (P-0) and terminal 10 (Q-0). These high signals are applied to the other two inputs of logic AND-8 to cause it to apply a low signal to the set to "0" input of flip-flop FF3 and to terminal 36 (SET S-15 and M-0). The low signal at terminal 3 (GO) is inverted by logic INV-4 to a high signal at the set to "1" input of flip-flop FF3 allowing the low signal to flop it to its "0" state shown in FIG. 5*f*. This causes it to apply a low signal that is inverted by logic INV-5 to a high signal at terminal 7 to light the bin selection error light. The low signal at terminal 36 shifts the system back to step 15 of the pickup mode due to the error as hereinbefore described.

MEDIUM ZONE AND NOT MEDIUM BIN SHELF

This operation is the detection of an error when the courier arrives at a hoist address in the medium bin zone and the read code indicates that this hoist address is not valid for that zone.

Five signals are used, namely, not large zone, not small zone, invalid shelf address, store or retrieve mode and program step 0.

Assuming that the travel address is 63 as shown in the table above, the B adder (FIG. 5*d*) provides a carry-out "1" that is applied as a high signal to one input of logic AND—11 in FIG. 5*g*. The A adder doe s not provide a carry-out "1" since 63 is larger than preset code 31 therein so that its carry-out terminal has a low signal. This does inverted in logic INV–8 to apply a high signal to another input of logic AND–11. The third high signal comes to logic AND–11 from terminal 18 marked MEDIUM BIN SHELF since the medium bin zone does not have a shelf at the hoist level as hereinbefore described.

This causes logic AND–11 to apply a low signal to logic OR–2 which in turn applies a high signal to one input of logic AND–10. The remainder of the operation is similar to that described in the last section, resulting in a high signal at terminal 7 to ignite the bin selection error light and further resulting in a low signal at terminal 36 to shift the program to step 15 in the pickup mode. This causes the courier to be returned to the pickup station.

LARGE ZONE AND NOT LARGE BIN SHELF

This operation is the detection of an error when the courier arrives at a hoist address in the large bin zone and the read code indicates that this address is not valid for that zone.

Four signals are used, namely, large zone, invalid shelf code, store or retrieve mode and program step 0.

Assuming that the travel address is 255 as shown in the above table, the B adder (FIG. 5*d*) does not provide a carry-out "1", so that a low signal is applied therefrom as shown in FIG. 5*h*. This is inverted in logic INV–9 to a high signal and applied to one input of logic AND–12. The other input of this logic receives a high signal from terminal 41 designated LARGE BIN SHELF since the large bin zone does not have a shelf at that hoist level as hereinbefore described.

This causes logic AND–12 to apply a low signal to logic OR–2 which in turn applies a high signal to one input of logic AND–10. The remainder of the operation is similar to that described in the last two sections, resulting in ignition of the bin selection error light and return of the courier to the pickup station.

Flip-flop FF3 is reset by the GO signal, a high signal, at terminal 3 of FIGS. 5*d*–*h* at the start of the next operation.

INITIAL SIZING PRESET

The purpose of this function is to take care of the situation where there is a load on the table and there is no way to ascertain its size in order to direct it to the proper size of bin. In such case, the system will automatically program for a large bin.

It will be recalled that the load size is normally determined by scanning the load as it is being retracted to the center of the courier. Therefore, if there is a load on the table initially when the power comes on, the scanning action has been skipped. This creates a potentially dangerous situation in that a load can be dispatched without any sizing information being present to control its destination.

This difficulty will actually occur only for one condition, the initial application of power with a load on the table. Any sizing information previously obtained will have been lost when the power was off since the memories of this information are flip-flops FF1 and FF2 in FIG. 5*d*. The problem then is to protect against bin selection error when there is no sizing information available.

This is done by forcing the sizing logic to large bin indicative condition with the initial power-on signal. This makes the system fail safe. At worst then, there can be only an unnecessary rejection action such as would occur if the package on the table was actually small. However, the system is protected against the attempted storage of a large or medium package in a bin that is too small for the package. In case of this type of rejection, it is necessary for the operator manually to control depositing of the load onto the pickup station. Normal action can then be initiated in which the load is picked up and scanned for sizing information.

FORCE TO LARGE INDICATION

Programming for a large bin upon power restoration is done by an initial power-on signal.

Two signals are used, namely, power-on and not in step 4 of the program.

This initial power-on is the starting point of the program and occurs when the power is first applied to the control or when reapplied after an interruption. The basic signal is provided by a timing relay with a normally closed contact to a 24 volt source. This timed signal is converted in a signal board to a high signal of proper value which is then inverted to a low signal for use in various parts of the system.

One such use of the initial power-on signal is at the left portion of FIG. 5*j* to force flip-flop FF2 to its "1" state, that is, its large package indication. The initial power-on signal is applied from terminal 33 to the set to "1" input of flip-flop FF2. To enable this flip-flop to operate, a high signal must be at its set to "0" input. In its "1" state, flip-flop FF2 indicates a large package as described in connection with FIG. 5*c*.

This high signal is obtained from logic AND–6 which has two low signals inputs. One of these low signals comes from terminal 11 designated P–3 and the other comes from terminal 21 designated Q–1 when the program leaves step 4. P–3 and Q–1 together indicate step 4 of the program, as shown in the above step program table, which is used to reset the package sizing flip-flops back to "0" state as hereinafter described.

From this it will be apparent that flip-flop FF2 can be forced to large package indication at any step of the program except step 4. This is because the table is in extended position during step 4 and size scanning will always occur when it is retracted so that no forcing of the flip-flop is necessary. Moreover, it is during step 4, just before the table is hoisted or lowered and retracted that the sizing flip-flops are normally reset. Consequently, forcing the flip-flops at the same time as they are normally reset is avoided.

RESET PACKAGE SIZING FLIP-FLOPS

The sizing flip-flops FF1 and FF2 are reset to "0" state at step 4 as follows.

Three signals are used, namely, step 4 of the program, not step 6 of the program and not initial power-on condition.

Referring to the left portion of FIG. 5*i*, high signals will appear at terminals 11 and 21 marked P–3 and Q–1 at step 4 of the program. These high signals are applied to the two inputs of logic AND–6, causing it to apply a low signal to the set to "0" inputs of both flip-flops FF1 and FF2. This low signal resets these flip-flops in view of the following permissive signals appearing at their set to "1" inputs.

One of these permissive signals is a low signal at terminal 23 marked P–1. This means that the program is not at step 6, retract operation, during which the flip-flop settings are normally utilized. This low signal keeps the output of logic AND–4 at a high signal value that is inverted in logic INV–3 to a low signal and applied to inputs of logics AND–1 and AND–2. As a result, these two AND logics apply high signals to the set to "1" inputs of the two flip-flops to allow resetting of the same.

Another permissive signal is a high signal at terminal 33 marked INITIAL POWER-ON. This means that the initial power on signal, a low signal, is absent as it should be at step 4 of the program. This high signal is applied to the set to "1" input of flip-flop FF2 to permit resetting of it to "0" state. It will be apparent that if the initial power-on signal is present on terminal **33**, the flip-flop will be reset after such signal terminates. This may be done because at step **4** the table is extended and package size will take place immediately on retraction of the table.

CEILING ERROR

The integrated circuit board shown in FIG. **5*d*** also includes means for sending the courier back to the pickup station when a ceiling error signal is received thereby.

It will be recalled from the previous description that the medium package relay and the large package relay depicted at the lower right-hand portion of FIG. **5*d*** set up a limit switch circuit when one of these relays is energized by the package sizing flip-flops. Such limit switch is arranged to be operated whenever a medium size package approaches the top of a column of small bins or whenever a large package approaches the top of a column of either small bins or medium bins. This occurs during step **15** of the store program when the courier is moving to the store address and before bin error or shelf error detection takes place. As will be apparent, under these error conditions the hoist must be stopped before the package hits the ceiling of the warehouse.

Such limit switch operation provides an error signal that is applied to input terminal **9** designated SET M–0–4 in FIG. **5*d***. This is a low signal that goes to two places. It first goes to the set to "0" input of flip-flop FF3 to flop it to its "0" state and ignite the bin selection error light. This light is lit by a high signal at terminal 7 that is an inversion by logic INV–5 of the low signal coming from flip-flop FF3. The M–0–4 error signal also goes to the mode flip-flop to shift the operation to the pickup mode M–0 while leaving it in step **15**. As will be apparent from the flow diagram in FIG. **4**, this causes the hoist to be lowered and the courier to be returned to the pickup station.

The integrated circuit shown in FIG. **5*d*** is mounted on a plug-in board and renders the variable bin error control an optional feature that may be put in or left out of the courier control system. It is put in by plugging in this board. It is left out by removing this board. Such removal automatically provides a no error indication. To this end, the terminal to which error signal output terminal **36** normally connects will be left floating voltage-wise. Since a floating condition and a high signal both indicate no error whereas a low signal indicates bin selection error, the system will operate as if no error is detected when the boar is left out.

While the apparatus hereinbefore described is effectively adapted to fulfill the objects stated, it is to be understood that the invention is not intended to be confined to the particular preferred embodiment of integrated circuit courier control system disclosed, inasmuch as it is susceptible of various modifications without departing from the scope of the invention.

I claim:

1. In a courier control system for an automatic warehouse having a rack providing a multiplicity of storage bins arranged in a plurality of zones with each zone having the same size bins and the bins in adjacent zones being of different size, and adjacent zones having the bin shelves at the same or different levels, and an article handling courier provided with an article supporting extendable table, and a pickup station from which the courier picks up an article by extending and lifting and retracting its table, digital codes mounted along the horizontal and vertical paths of movement and digital address code controlled means including means for connecting power thereto and being operable in accordance with pickup and store and retrieve operating programs for moving the courier to the pickup station or in front of a selected bin in one of the zones and for extending the table to reach into the bin and lower and retract the table to store an article therein or to reach into the bin and lift and retract the table to retrieve an article therefrom, the digital address code controlled means including means providing input digital codes indicative of the coordinate horizontal and vertical positions of desired bins, horizontal and vertical reader means for reading actual position digital codes along the coordinate paths of movement of the courier, and means for comparing the input codes with the actual position codes to control movement of the courier to its selected final horizontal and vertical destination, the improvement comprising:
   - bin selection error program means for preventing initiation of the table extension operation in the event of address error in bringing the courier to the selected bin comprising:
   - additional digital address comparing means having registered therein a digital boundary code indicative of the boundary between adjacent zones;
   - said additional digital address comparing means comprising means for comparing at least one of the actual position digital code that is read when the courier reaches its destination with said digital boundary code to provide a first zone signal if the actual position digital code is smaller than the boundary code indicating that the courier has arrived in a first zone and to provide a second zone signal if the actual position digital code is larger than the boundary code indicating that the courier has arrived in the next zone;
   - means for sizing the article and for registering a classification signal indicative of its size category;
   - means for comparing the zone signal with said size classification signal to provide an error signal if the article is too large for the bin in the arrived-at zone;
   - and means operable by said error signal for returning the courier to its pickup station.

2. The invention defined in claim 1, wherein said digital boundary code comprises:
   - a binary code corresponding to the code of the first row of bins at the leading edge of the zone immediately following the boundary between adjacent zones;
   - and said actual position digital codes comprise binary codes whereby a subtraction produces a carry for said first zone signal corresponding to a first binary symbol value of voltage when said actual position binary code is smaller than said boundary binary code, and said subtraction produces a carry for said second zone signal corresponding to the other binary symbol value of voltage when said actual position binary code is equal to or larger than said boundary binary code.

3. The invention defined in claim 1, wherein said bin selection error program means comprises:
   - means for providing a shelf validity signal when the courier arrives at the selected bin indicative of whether there is a bin shelf for the size of bin required by the size of the article destined therefor;
   - and means responsive to such shelf validity signal indicating the absence of a bin shelf at the arrived-at address for preventing extension of the table.

4. The invention defined in claim 3, wherein said means for providing a shelf validity signal comprises:
   - a shelf validity code added to the vertical movement control code;
   - and means for reading said shelf validity code at the same time as the vertical code is read when the article arrives at its destination.

5. The invention defined in claim 2, wherein said sizing means comprises:
   - means for scanning the article as the extendable table is being retracted to detect the largest dimension thereof;
   - a size indicating flip-flop circuit for registering sizing information;
   - and means responsive to said scanning means for setting said flip-flop circuit.

6. The invention defined in claim 5, together with means for resetting said flip-flop circuit on a predetermined step in the operation program.

7. The invention defined in claim 5, together with:

means responsive to reconnection of power to the system following interruption thereof when there is an article on the table for forcing said size indicating flip-flop circuit to large article indication to prevent attempted insertion of an article into a bin too small to receive it regardless of its original pre-programmed destined bin or zone.

8. The invention defined in claim 6, together with:

permissive means for allowing setting of said size indicating flip-flop circuit during the program step that retraction of the table occurs and allowing resetting thereof during the program step that extension of the table occurs.

9. The invention defined in claim 1, wherein said means for comparing said actual position digital code with said zone boundary digital code comprises:

integrated circuit adder means and means for applying said actual position digital code thereto in inverted form so that it will perform a subtraction to indicate on which side of said boundary the article has arrived.

10. The invention defined in claim 9, wherein said digital boundary comprises code comparing means:

an integrated circuit board bucket into which said integrated circuit adder means is inserted to connect it to the system;

and jumper wire means connecting voltage to certain of the bucket terminals to wire in said digital boundary code.

11. The invention defined in claim 1, wherein said means for comparing the zone signal with said size classification signals comprises:

integrated circuit AND/OR inversion logic circuit means for providing said error signal to shift the program from store mode to pickup mode thereby to return the article back to the pickup station.

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