

[54] **WAREHOUSING SYSTEM USING SLOWDOWN AND STOP BIN INDICATORS**

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[56] **References Cited**

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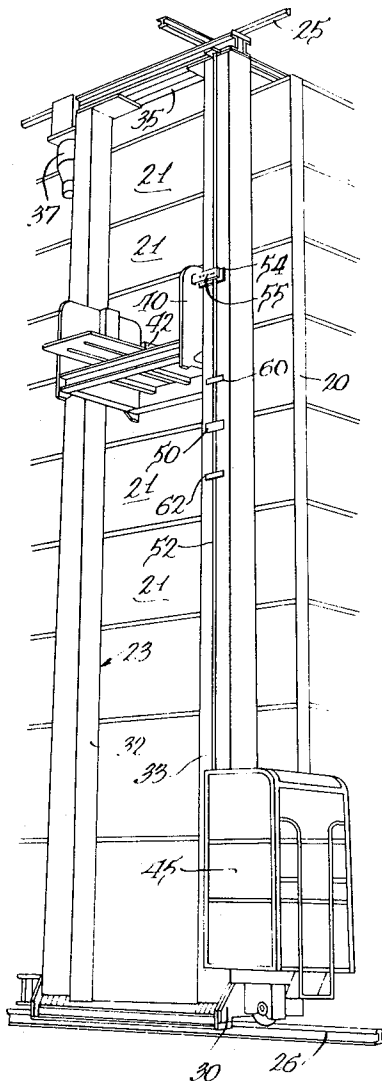
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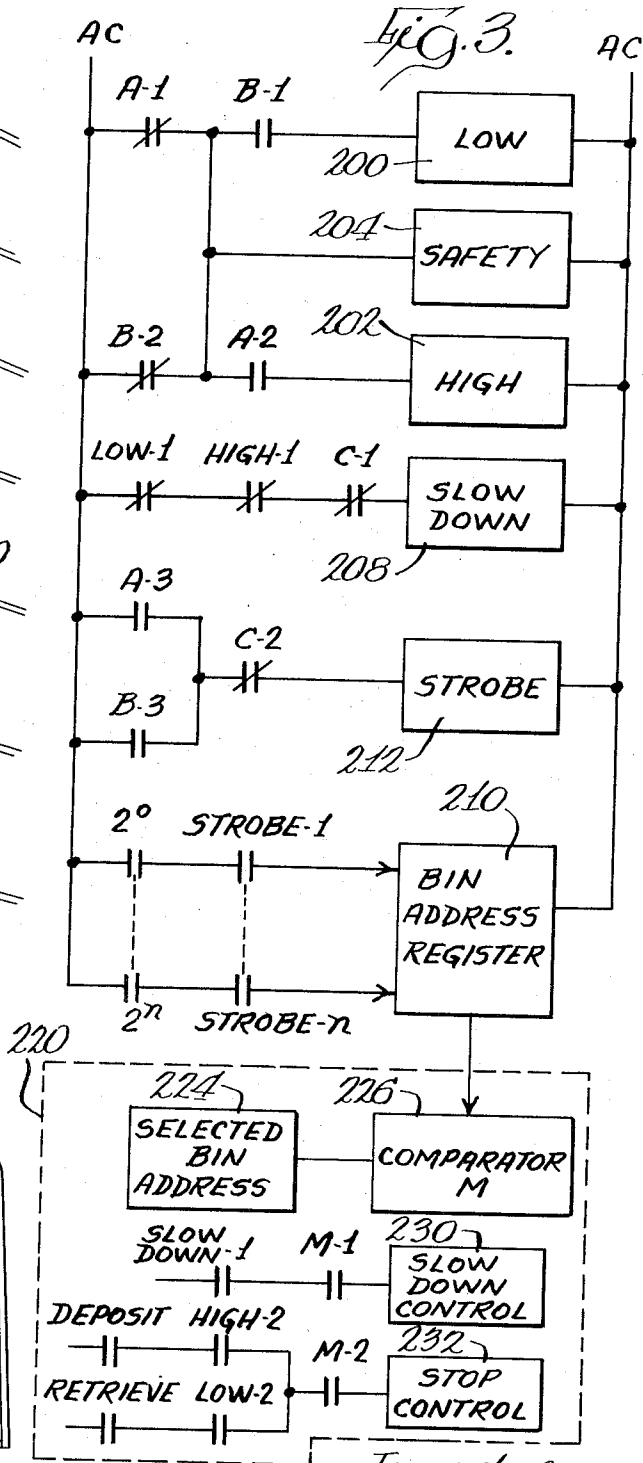
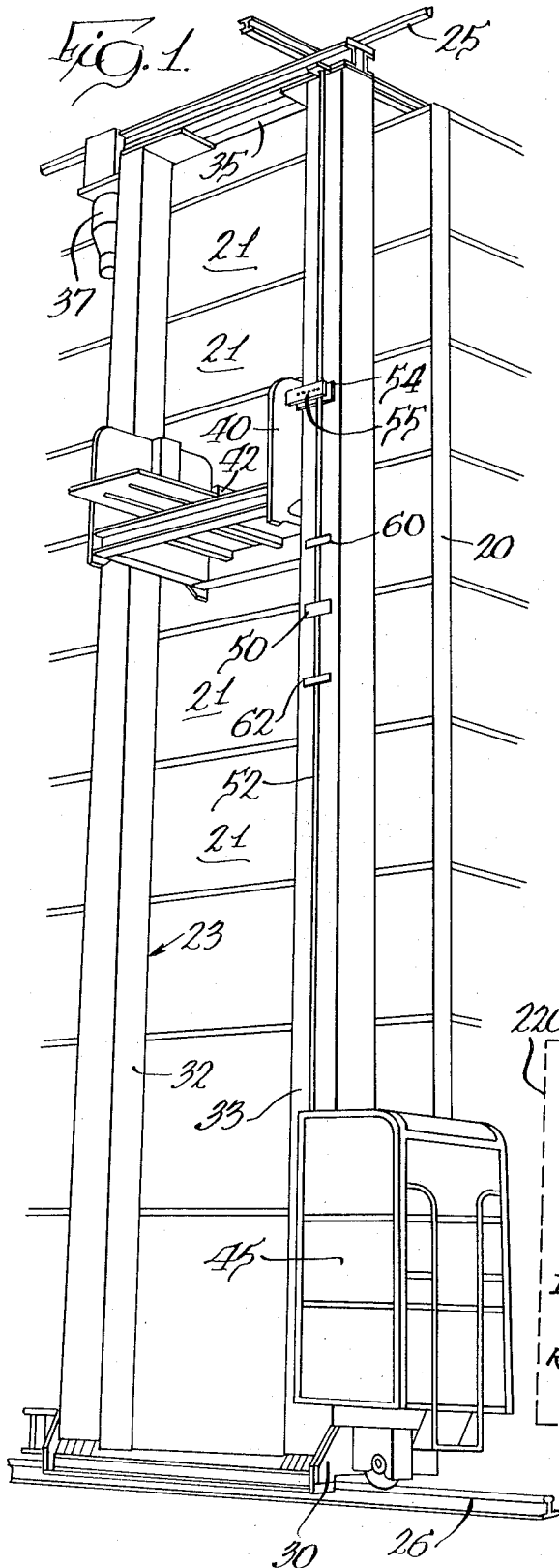
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[57] **ABSTRACT**

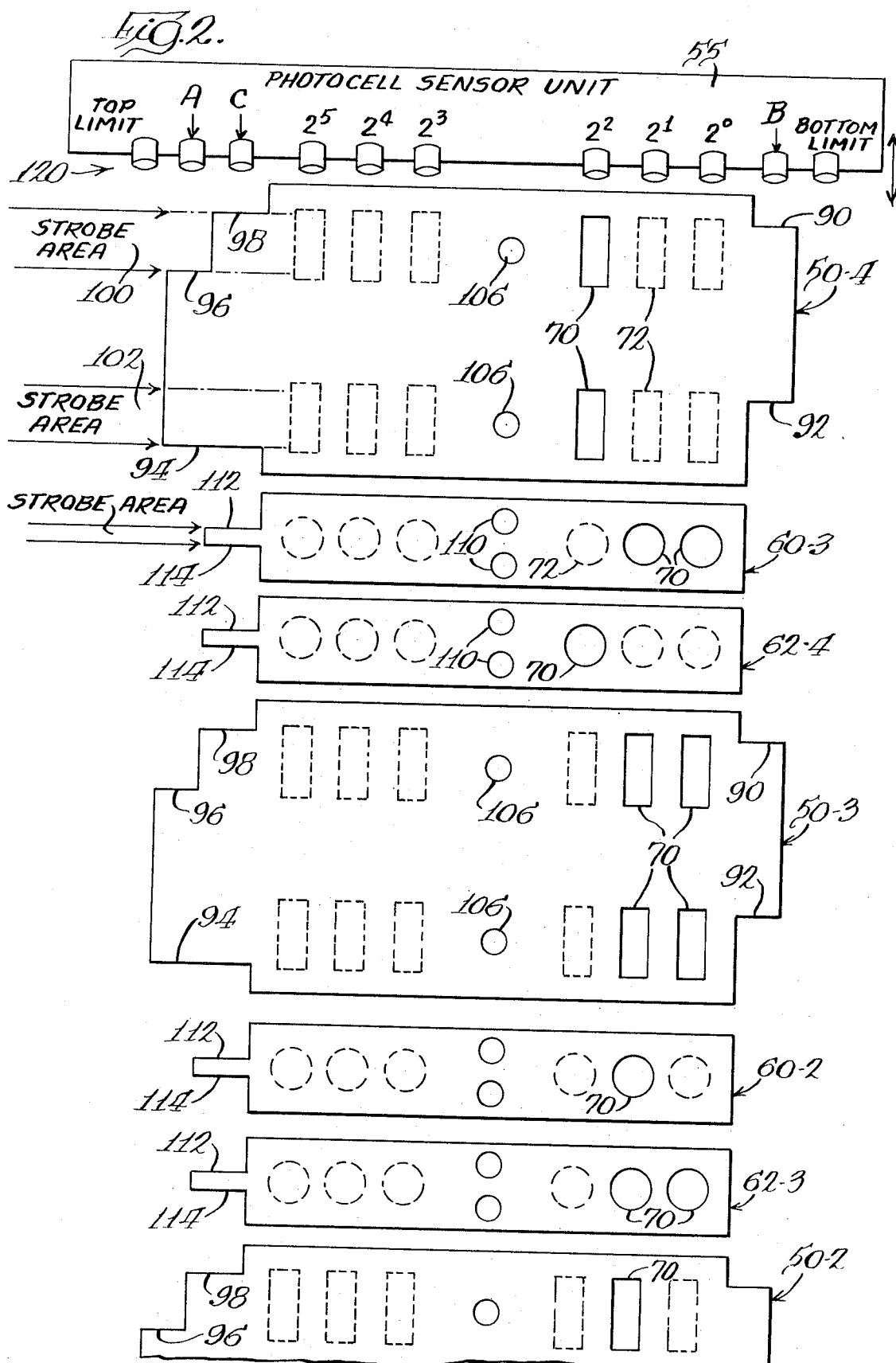
To identify vertical slowdown and stop positions for a stacker crane, each vertical bin is uniquely located by a binary coded slowdown plate and a separate binary coded stop plate. A vertical drive control is responsive to photoelectric sensors, mounted on a crane hoist, as the sensors are driven adjacent the binary coded plates. To reduce the minimum vertical spacing between bins, the coded plates are interleaved so that the slowdown plate for an adjacent bin is located between each stop plate and slowdown plate for a different bin. Various combinations of detectable elements are carried on each coded plate to provide strobe, high or deposit, and low or retrieve information.

13 Claims, 3 Drawing Figures





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WAREHOUSING SYSTEM USING SLOWDOWN AND STOP BIN INDICATORS

BACKGROUND OF THE INVENTION

This invention relates to a warehousing system which uses separate slowdown and stop bin indicators.

Many warehousing systems uniquely identify horizontal bin position by mounting binary coded address plates to a storage framework, and identify vertical bin position by mounting binary coded address plates to a column of a stacker crane. Each address plate is aligned to correspond with the position of the bin associated therewith. To identify vertical slowdown and stop positions for each stacked bin, it has been conventional to provide a unitary, vertically elongated cam plate having a plurality of cam surfaces extending between lower and upper slowdown positions. The lower slowdown position is used to decrease the speed of the crane hoist when approaching a selected bin from a lower vertical level. Conversely, the upper slowdown position is used to decrease the speed of the crane hoist when approaching a selected bin from a higher vertical level.

In addition to upper and lower slowdown cams, the elongated cam plates have included further cams for identifying the high and low stop positions for the hoist. When initiating a deposit or a retrieve cycle, the forks on the crane hoist must initially be stopped at the high or low stop positions, respectively.

In order to stack a greater number of bins in a given vertical height, the unitary binary code plates have been spaced closer together. The minimum spacing required between adjacent bins, however, has heretofore been limited by the height of the unitary vertical code plates. In a high speed system in which the slowdown position must substantially precede the stop position, the minimum vertical spacing between bins has therefore been severely limited.

SUMMARY OF THE INVENTION

In accordance with the present invention, an improved bin indicating system substantially reduces the minimum spacing necessary between adjacent bins. The system is equally applicable to uniquely identify slowdown and stop positions for bins spaced in a horizontal and/or vertical direction in a storage framework. This is accomplished by providing separate slowdown and stop bin indicators which are interleaved throughout the length of the bin framework. Preferably, each indicator is binary coded, and contains additional elements for identifying other information useful in decoding and controlling the crane drive mechanism.

A principle object of this invention is the provision of a warehousing system using interleaved slowdown and stop bin indicators in order to allow complete versatility in spacing and arranging bins.

BRIEF DESCRIPTION OF THE DRAWINGS

Further advantages and features of the invention will be apparent from the following description, and from the drawings, in which:

FIG. 1 is a perspective elevational view of a warehouse with a stacker crane, in which vertical bin positions are identified by use of the applicant's invention;

FIG. 2 is a plane elevational view of a plurality of bin identifying plates, attached to one vertical column of the stacker crane shown in FIG. 1, and detected by a

photocell sensor unit which is mounted to the carriage hoist shown in FIG. 1; and

FIG. 3 is a schematic diagram of a drive control circuit which, in response to the photocell sensor unit in FIG. 2, controls the vertical speed of traverse of the crane hoist.

DESCRIPTION OF THE PREFERRED EMBODIMENT

While an illustrative embodiment of the invention is shown in the drawings and will be described in detail herein, the invention is susceptible of embodiment in many different forms and it should be understood that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiment illustrated.

FIG. 1 illustrates a warehousing system embodying the invention. A storage rack 20 contains a plurality of individual bins 21 or other load supporting means for holding articles therein. The bins 21 extend horizontally along a row and are vertically stacked to any desired height. A load conveyor or article handling device, such as a stacker crane 23, travels in an aisle or other travel zone adjacent the row of storage bins 21. The stacker crane 23 is guided in a horizontal direction between an overhead horizontal guide or support rail 25 and a floor mounted horizontal drive rail 26. A horizontal crane carriage 30 is driven along the floor rail 26 by a conventional drive mechanism (not illustrated) which moves the stacker crane 23 in either a forward or reverse direction adjacent the bins 21.

A vertical mast structure extends upward from the horizontal carriage 30 and includes a pair of spaced columns 32 and 33 which are rigidly tied together through an upper carriage frame 35. The frame 35 mounts a conventional hoist mechanism which is driven by a hoist motor and brake apparatus 37. The hoist mechanism may, for example, take the form of a pair of chain belts, wound on a hoist shaft which is rotated by the motor 37, which connect to a vertical hoist carriage 40 which is thereby vertically propelled between the spaced columns 32 and 33.

Mounted on the vertical hoist carriage 40 is a conventional fork mechanism 42 which can be horizontally propelled into an adjacent bin 21 in order to deposit or retrieve a pallet on which the load may be deposited. Typically, another storage framework (not illustrated) is spaced from the illustrated framework, with the crane 23 being driven along a narrow aisle therebetween. In such installations, the fork mechanism 42 could be selectively horizontally propelled to either the right or left in order to service both storage frameworks.

The stacker crane 23 may be operated automatically under control of externally generated signals, or manually by an operator standing in an operator's cab 45 and actuating control switches on an operator panel (not illustrated). Many other conventional structural and control elements omitted for clarity, may be provided as desired.

In order to identify the vertical position of each bin 21, a unique address plate 50 is mounted to a vertically extending rail 52 which is secured relative to and spaced from one vertical column of the stacker crane, herein column 33. The rail 52 is spaced from column 33 in order to define an opening therebetween for pas-

sage of a light source 54 attached to carriage 40. A photocell sensor unit 55, similarly mounted to the vertical carriage 40, is spaced on the opposite side of the rail 52 and aligned to intercept photobeams generated by the light source 54. As the hoist is vertically driven by the motor and brake mechanism 37, the light source 54 and photocells 55 move pass each code plate mounted on the address rail 52 in order to detect the vertical position of the carriage 40.

In a high speed system, it is necessary to provide slowdown indicators which indicate when the motor 37 should be controlled to produce a slow speed of traverse in anticipation of reaching a desired vertical level. For this purpose, a high slowdown indicator 60 is spaced vertically above the address plate 50 to indicate the slowdown point when the carriage 40 is being driven downwardly. A similar low slowdown indicator 62 is spaced vertically beneath the code plate 50 to indicate the slowdown point when the carriage 40 is located below the desired bin and is being driven upwardly. For clarity, the code plate 50 and its associated slowdown plates 60 and 62 for only a single bin have been illustrated in FIG. 1, it being appreciated that similar indicators are provided for all vertical bins 21. The exact form of the indicators 50, 60 and 62 is illustrated in detail in FIG. 2 for several bins.

Turning to FIG. 2, a portion of the address plates associated with three vertical bins, arbitrarily identified by decimal numbers 2, 3 and 4, have been illustrated. All stop indicators 50, upper slowdown indicators 60, and lower slowdown indicators 62 have been identified by the same reference numeral, followed by a number which indicates the bin identified by that indicator. For example, the stop address plate for bin 3 is identified as 50-3. Each vertical bin level is assigned a unique address, preferably a binary number formed from a combination of indicia. The binary number is illustratively comprised of six binary digits or bits.

The presence or absence of a bit can be indicated by any type of on or off, 0 or 1 indicating element, and herein comprises the presence or absence of a light passageway or opening in the plates. Arbitrarily, the presence of an opening represents a 1 bit and is illustrated by a solid line 70. Similarly, the absence of a passageway represents a 0 bit and is illustrated by a dashed line 72 adjacent the area through which the photobeam would otherwise pass. Thus, plates 50-2 and 60-2 associated with bin 2 carry the binary code 000010, the plates 50-3, 60-3 and 62-3 associated with bin 3 carry the binary code 000011, while the plates 50-4 and 62-4 associated with bin 4 carry the binary code .00100.

In accordance with the present invention, the slowdown address plates 60 and 62 are separate from the stop address plates 50. Any one or more of the slowdown indicators 60 and/or 62 may be interleaved between the indicators for other bins. In the illustration, slowdown indicator 60-2 has been interleaved or placed between the stop indicator 50-3 and the lower slowdown indicators 62-3. Similarly, lower slowdown indicator 62-4 has been interleaved between the stop indicator 50-3 and the upper slowdown indicator 60-3. While the slowdown indicators of adjacent bins have been interleaved, it will be appreciated that the indicators could be further spaced apart, as might be advantageous in a very high speed system.

Considering the bin indicators in detail, each stop address plate 50 carries a pair of identical binary codes, located at the high and low stop position for the vertical carriage. When the vertical carriage is to deposit a load, the forks must be stopped at a high position to allow the forks to be extended with a skid located thereon. After the forks are extended, the vertical carriage moves downward to the low stop position to allow the forks to be withdrawn. Conversely, when a retrieve operation is being performed, the vertical carriage is first stopped at the position of the lower binary codes, and after extending the fork, is driven vertically upward to the position of the upper binary code before retracting in order to retrieve a skid.

Each stop plate 50 further includes a plurality of tabs or surfaces to provide gating and other information. A high position strobe tab is located between an upper surface 90 aligned with the upper binary code and a lower surface 92 aligned with the lower binary code. A low position strobe tab extends between surfaces 94 and 96. The tab surface 96 extends inward for a limited distance, and then vertically rises to an upper surface 98 which is vertically level with surface 90. The area between surfaces 90 (or 98) and 96 forms a strobe or trigger area 100 for the upper binary code, and the area between surfaces 92 and 94 forms a low binary code strobe or trigger area 102. The stop address plate 50 may be attached to the vertical rail 52 of FIG. 1 by screws extending through a pair of openings 106 located in the center of the plates.

The pair of slowdown plates 60 and 62 for the same bin are of identical construction. A pair of openings 110 allows each slowdown plate to be attached to the vertical rail 52 at any desired vertical level. Only a single binary code is carried on each plate, since it is sufficient to provide only one advance slowdown position regardless of whether the vertical carriage will be stopped at a high or low position. Of course, separate binary codes for the high and low stop positions could be provided, if so desired. A strobe or triggering area is defined by an upper tab surface 112 and a lower tab surface 114, which surfaces are vertically aligned with the tab surfaces 98 on stop plates 50.

Photocell sensor unit 55 contains a plurality of individual photocells 120 horizontally spaced to detect the various information carried on plates 50, 60, and 62. As viewed from left to right in FIG. 2, the first photocell 120 is a top limit indicator which detects a special safety plate (not illustrated) which is located at the highest vertical position for the carriage 40. This photocell is connected to override any up vertical command. The next photocell 120, labeled A, is positioned to detect the stop plate tab located between surfaces 96 and 94. The following photocell 120, labeled C, is positioned to detect the stop plate tab located between surfaces 98 and 94, and also to detect the slowdown plate tab located between the surfaces 112 and 114.

The following six photocells 120 detect the binary number formed by the indicium 70 and 72 which are carried by all plates. The six photocells therefore indicate a 0 or 1 bit at the 2⁵ through the 2⁰ bit locations of the binary code. The tenth photocell 120, labeled B, detects the stop plate tab located between surfaces 90 and 92. Finally, the last photocell 120, labeled bottom limit, detects a special safety plate (not illustrated) which is located at the lowermost vertical level. This

photocell is connected to override any down vertical command.

A control system which is responsive to the photocell sensor unit 55 is illustrated in FIG. 3. For clarity, the conventional amplifiers and relay coils energized by the photocells 120 have not been illustrated. Each relay contact has been illustrated, and is identified by a letter corresponding to the letter of the photocell which controls the contact, followed by a number identifying the individual contact. When the photobeam is uninterrupted, the associated relay is energized and the illustrated contacts change state. When the photobeam is broken, the corresponding relay is deenergized and the contacts return to or remain at their normal or unenergized position illustrated in FIG. 3.

For example, when the sensor unit 55 of FIG. 2 is located so that no plate breaks the photobeam impinging photocell A, the normally closed contact A-1 changes to an open state. As the A photobeam is broken by the stop plate tab located between surfaces 96 and 94, the relay contact A-1 returns to its normally closed position, as illustrated.

In operation, each time the photocell sensor unit 55 detects the lower strobe area 102 of a stop plate 50, a LOW relay 200 is energized by a series path formed through normally closed contact A-1 and an energized contact B-1. This indicates that the photobeam for photocell A has been interrupted while the photobeam for photocell B is not interrupted, which condition uniquely identifies the low strobe area 102. Conversely, the opposite logic states for the contacts of photocells A and B energize a HIGH relay 202. Thus, these circuits satisfy the Boolean equations:

$$LOW = \bar{A} \cdot B$$

(1)

$$HIGH = A \cdot \bar{B}$$

(2)

Whenever the sensor unit 55 is vertically located between tab surfaces 90 and 94, a SAFETY relay 204 is energized. Heretofore, a similar SAFETY relay has been energized by providing a continuous high-low trigger cam which has extended the whole distance between the uppermost and lowermost stop positions for the vertical carriage. The unique combination of tab surfaces which produce the equation.

$$SAFETY = \bar{A} + \bar{B}$$

(3)

eliminates the conventional high-to-low trigger indicator heretofore provided. The output of the SAFETY relay 204 is coupled to a conventional control circuit (not illustrated) which uses this information to make safety correlation checks.

When neither LOW relay 200 nor HIGH relay 202 is energized, and the photobeam for photocell C is broken, a SLOWDOWN relay 208 is energized. This combination, namely

$$SLOWDOWN = \overline{LOW \cdot HIGH \cdot C}$$

(4)

indicates that the sensor unit 55 is adjacent a slowdown plate 60 or 62.

The output of the six binary photocells 2⁰ to 2ⁿ is gated into a bin address register 210 only when valid information is present. Each binary photocell output is in series with a STROBE contact from a STROBE relay 212. The STROBE relay 212 is connected through a series normally closed contact C-2 in parallel with a pair of normally open contacts A-3 and B-3. Thus, when the Boolean equation

$$STROBE = \bar{C} (A+B)$$

(5)

is satisfied, the bin address register 210 records the six bits then being sensed. As is apparent from FIG. 2, the STROBE relay 212 is energized only when sensor unit 55 is within strobe area 100, strobe area 102, or the strobe area between tab surfaces 112 and 114.

In summary, when the sensor unit 55 is adjacent either of the slowdown plates 60 or 62, the SLOWDOWN relay 208 is energized, and at the same time the binary address register 210 records the address of that slowdown plate. When the sensor unit 55 is adjacent the high stop position of a stop plate 50, the HIGH relay 201 is energized, and at the same time the binary number thereof is entered in register 210. Similarly, when the sensor unit 55 is adjacent the low stop position of a stop plate 50, the LOW relay 200 is energized and at the same time the binary number thereof is entered in register 210.

Any conventional speed control may be used in combination with the above described circuit to control the movement of vertical carriage 40. By way of example, a portion of a conventional vertical speed control 220 has been illustrated. The address of a selected bin from a central data source or from a manual operator panel, is stored in a SELECTED BIN ADDRESS unit 224. A conventional direction-of-travel circuit (not illustrated) causes the vertical carriage 40 to be driven at a high speed of traverse and in the proper direction toward the address stored in unit 224. Each time a vertical address is stored in register 210, it is coupled to a comparator 226 which compares the address with the stored selected bin address. When a match occurs, a match relay M is energized, thereby closing its normally open contacts M-1 and M-2.

When the first match occurs, the photocell sensor unit 55 will be adjacent one of the slowdown plates 60 or 62, and the slowdown relay 208 will have been energized. This closes a slowdown-1 contact and the M-1 contact, thereby completing an energizing circuit for a conventional slowdown speed control 230 for motor and drive mechanism 37. This causes the vertical carriage 40 to decrease in speed to a slow speed of traverse and continue toward the stop position. As the vertical carriage is traveling at this slow speed, the sensing unit 55 will pass at least one other slowdown plate. Since the different binary address of that plate will not produce a match, relay M will not become energized and thus the circuit is not effected.

As the sensor unit 55 is driven adjacent the stop plate, relay M in comparator 226 will again become energized, closing contact M-2. The contacts HIGH-2 and/or LOW-2 will similarly close as the HIGH relay 202 and/or LOW relay 200 are energized. A conventional canned deposit or retrieve program will have al-

ready closed either a normally open deposit contact or a normally open retrieve contact. Assuming a deposit cycle is to occur, the DEPOSIT contact will be closed, and upon energization of HIGH relay 202, a path will be completed to energize STOP CONTROL 232. This will cause the vertical carriage to come to an abrupt halt.

While slowdown and stop indicators have been illustrated for vertical bins, it will be appreciated that the system is equally applicable for use with horizontal bins. Furthermore, the results produced by uniquely identifying both slowdown and stop positions can be accomplished by uniquely identifying only certain of the stop and slowdown plates, with appropriate circuitry being provided to identify the bin number of an unmarked plate by referring to previously sensed addresses. Other modifications will be apparent to those skilled in the art.

I claim:

1. In a warehousing system having a plurality of load storing means, rail means extending along and fixed with respect to said load storing means, carriage means movable along said rail means and including load carrier means for depositing and retrieving loads from adjacent load storing means, and drive means for moving said carriage means including drive slowdown means actuable to decrease the speed of said carriage means in anticipation of reaching a selected load storing means and drive stop means actuable to stop said carriage means at the selected load storing means, the improvement comprising:

a plurality of separate address means mountable at different spaced locations on said rail means for uniquely identifying slowdown and stop positions for each of said load storing means, each separate address means including coded slowdown indicating elements for identifying the slowdown position at which said drive slowdown means should be actuated and coded stop indicating elements separate and spaced from said slowdown indicating means for identifying the stop position at which the drive stop means should be actuated when the load carrier means is to service the load storing means associated therewith, each separate address means further including control elements for modifying the operation of the drive means for the same address as identified by the indicating elements;

interleave means for mounting said separate address means at desired spaced locations along said rail means with at least one of said coded slowdown indicating means being mounted to said rail means at a location between the coded slowdown indicating means and the coded stop indicating means for a different load storing means;

plural sensor means mounted to said carriage means and movable adjacent said rail means for detecting said indicating elements and said control elements; control means responsive to detection of the coded slowdown and coded stop indicating elements in conjunction with the control elements associated with the selected load storing means for actuating the drive slowdown means and the drive stop means, respectively.

2. The improvement of claim 1 wherein each coded slowdown indicating element carries a plurality of detectable indicia which uniquely identifies the load storing means associated therewith and each of said coded

stop indicating elements carries a plurality of detectable indicia which uniquely identifies the load storing means associated therewith, one of said plural sensor means detecting said detectable indicia for transmission to said control means.

3. The improvement of claim 2 wherein each of said address means carries a binary code for uniquely identifying the slowdown and stop positions of the associated load storing means, and the detectable indicia on the slowdown indicating element and the stop indicating element for the same load storing means comprises identical binary bits defining said binary code.

4. The improvement of claim 3 wherein said control means includes selective address means for storing a binary code of a selected load storing means, match means having inputs coupled to said sensor means and said selected address means and actuated when a match has occurred, slowdown relay means actuated each time the sensor means detects one of said slowdown indicating elements, stop relay means actuated each time said sensor elements detects one of said stop indicating means, slowdown circuit means responsive to actuation of said match means and said slowdown relay means for actuating said drive slowdown means, and stop circuit means responsive to actuation of said match means and said stop relay means for actuating said drive stop means.

5. The improvement of claim 1 for a warehousing system in which the drive means is bidirectional for moving said carriage means in opposed directions adjacent the load storing means, wherein said coded slowdown indicating element comprises first and second coded slowdown members spaced on opposed sides of the associated coded stop indicating element for the same load storing means.

6. The improvement of claim 5 wherein said first coded slowdown member defines a slowdown position located in one direction preceding the associated coded stop indicating element and said second coded slowdown member defines a slowdown position located in an opposed direction preceding the associated coded stop indicating element, and said interleaving means mounts the first coded slowdown member for an adjacent load storing means between the second coded slowdown member and the coded stop indicating element for the same load storing means.

7. The improvement of claim 5 wherein each of said coded slowdown members carries an identical plurality of detectable indicia which define the same unique number.

8. The improvement of claim 7 wherein each coded stop indicating element carries a plurality of detectable indicia identical to the plurality of detectable indicia on the associated pair of coded slowdown members.

9. The improvement of claim 1 wherein at least one of said coded indicating elements for each address means carries a plurality of detectable binary bits which identify a unique binary number associated with only that coded address means, each coded stop indicating element includes at least one strobe element for indicating when information detected by said plural sensor means is valid, each coded slowdown indicating element carries at least one strobe element for indicating when information detected by said plural sensor means is valid, said plural sensor means includes at least binary bit detector means for detecting said binary bit elements and strobe means for detecting said strobe

elements, and said control means being enabled only when said strobe means indicates that valid information is present.

10. The improvement of claim 9 wherein each coded stop indicating element includes at least two strobe elements corresponding to said control element, and said control means includes safety means responsive to selected combinations of detected strobe elements on said coded stop indicating element for indicating that the carriage means is positioned within a predetermined stop zone.

11. The warehousing system of claim 1 in which the plurality of load storing means comprises horizontally spaced and vertically stacked bins, said carriage means comprises a stacker crane having hoist means vertically movable adjacent the vertically stacked bins for depositing and retrieving loads therefrom, said drive means includes vertical drive means for vertically propelling said hoist means in upper and lower directions for servicing the vertically stacked bins, vertical drive slowdown means actuable to decrease the vertical speed of propulsion of said hoist means and vertical drive stop means for precisely stopping the hoist means at a selected bin, each of said control elements includes a high position element and a low position element for identifying high and low vertical positions, respectively, for each vertically stacked bin, said plural sensor means includes address detector means for detecting the

unique address associated with each address means and control element detector means for detecting said control elements, and said control means includes deposit circuit means responsive to detection of the stop indicating element having a selected unique address and the high position element for actuating said vertical drive stop means and retrieve circuit means responsive to detection of the stop indicating element having a selected unique address and the low position element for actuating said vertical drive stop means.

12. The improvement of claim 11 wherein each coded stop indicating element carries a pair of identical binary bit means located at positions corresponding to said high and low vertical positions, and said high and low position elements comprise strobe indicators aligned with the pair of binary bit means.

13. The improvement of claim 1 wherein each of said coded indicating elements and each of said control elements includes a plurality of areas which each either pass or block a photobeam to indicate the state of a bit, and said plural sensor means comprises light source means generating photobeams directed at a spaced photocell means and mounting means for locating said photobeams in a path which passes through the areas of said coded indicating elements and said control elements in order to detect said bits.

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