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Smith

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[54] **NULL TRACK FOR AUTOMATIC STACKER**

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[58] **Field of Search** .... 179/82; 246/8, 63 R, 63 C, 246/187 B, 182 B; 318/626, 653; 214/16.4 A

[56] **References Cited**

UNITED STATES PATENTS

3,349,303	10/1967	Burnight et al.	246/187 B
3,527,897	9/1970	Sugi et al.	179/82

FOREIGN PATENTS OR APPLICATIONS

1,530,358	10/1969	Germany	246/63 C

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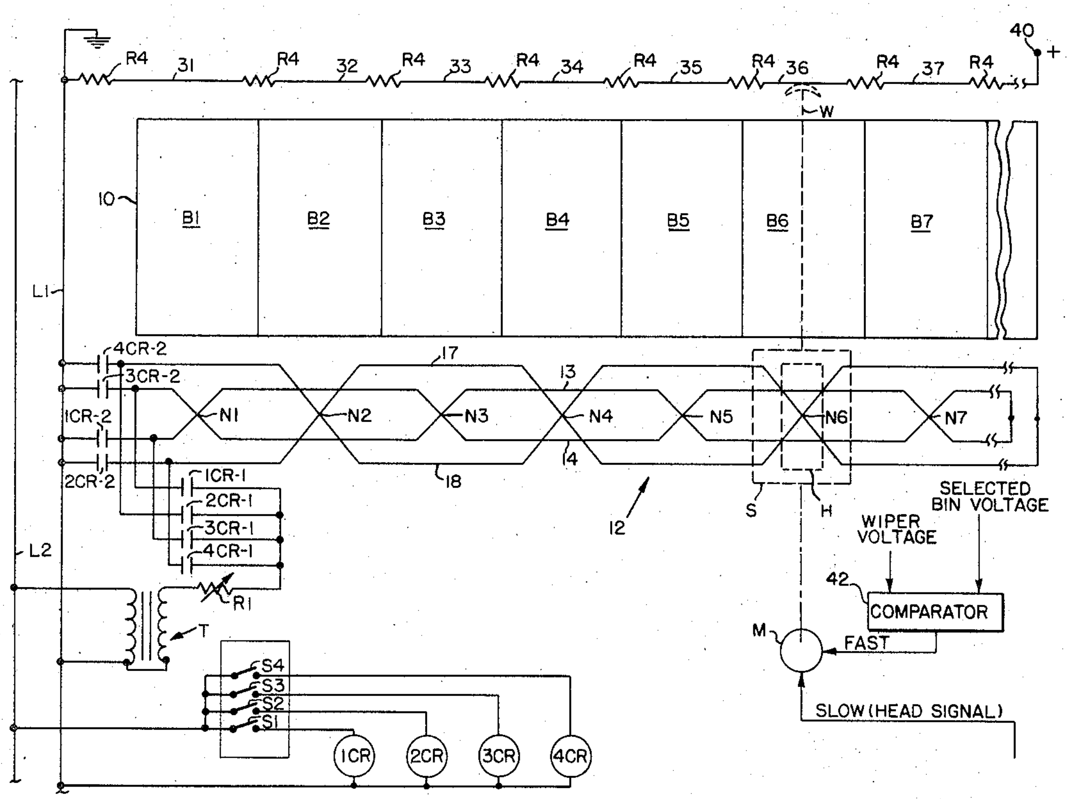
[57] **ABSTRACT**

Two pairs of null wires extend down an aisle in front of a storage rack that is serviced by an automatic stacker. The two wires of each pair are crossed and recrossed at intervals to form spaced crossover points or nulls, which register with horizontally spaced bins in the rack. The nulls of the two pairs alternate with one another, one pair of wires registering with odd-numbered bins, and the nulls of the other pair registering with the evenly-numbered bins. When the stacker control circuit is programmed to move the stacker to a preselected bin, an AC voltage is applied selectively to the four null wires to create stable nulls at every fourth bin. The stacker is then halted by known means at a preselected stable null.

7 Claims, 1 Drawing Figure



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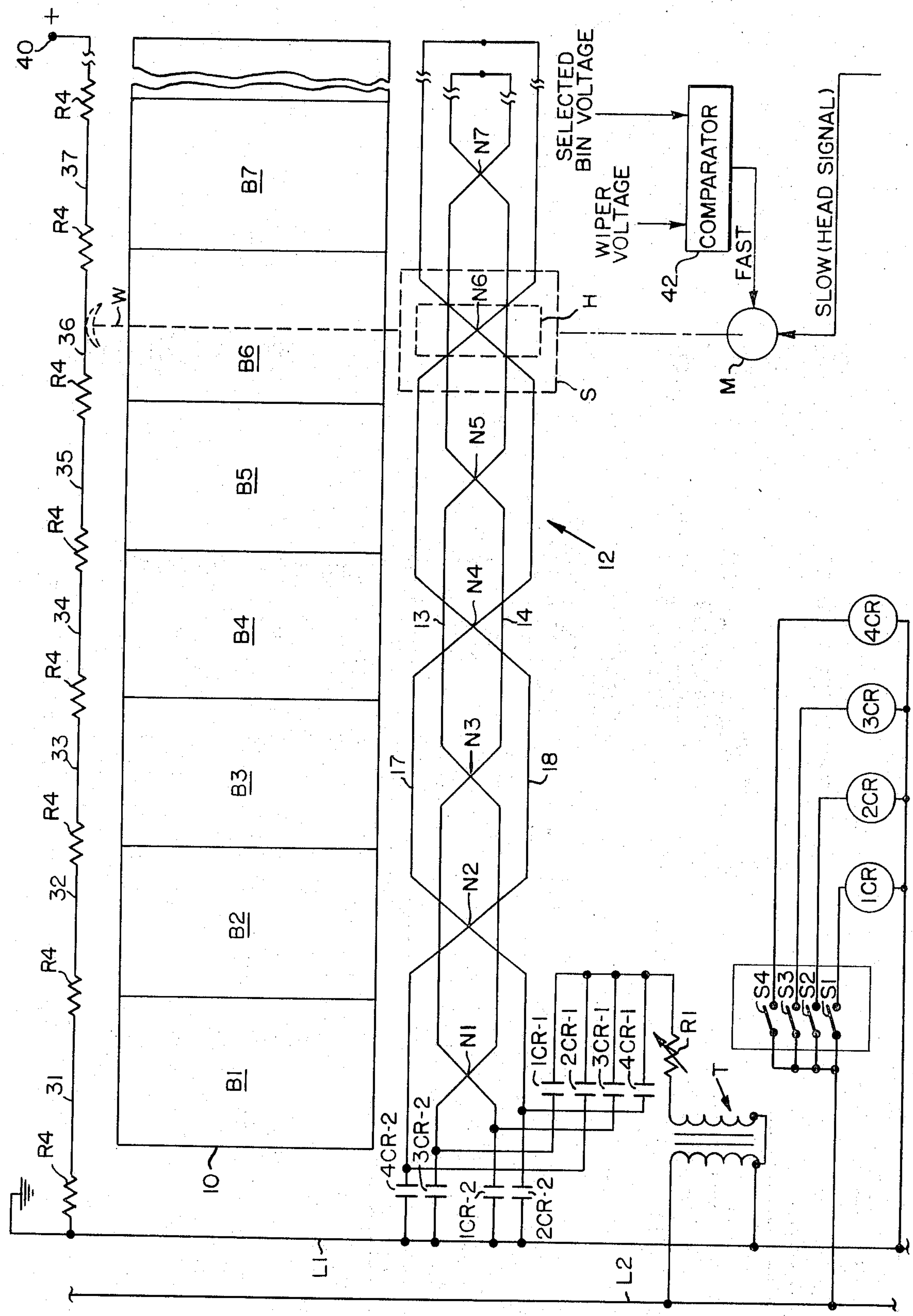

NULL TRACK FOR AUTOMATIC STACKER

This invention relates to automated storage systems, and more particularly to means for controlling the movements of an automatic stacker or load carrier employed in such systems. Even more particularly, this invention relates to an improved null track for accurately stopping the stacker at a preselected position in the system.

The Burnight & Burch U. S. Pat. No. 3,349,303 discloses a servo mechanism which utilizes a pair of intersecting conductors for accurately halting a motor-driven carriage at a predetermined point along a stationary track. In practice, servo mechanisms of this type have been employed to control both the horizontal and vertical movements of a load carrier or stacker of the type disclosed, for example, in the Hartman U. S. Pat. No. 3,352,978.

In the system of U.S. Pat. No. 3,352,978, a pair of conductors control the horizontal travel of the load carrier along an aisle and another pair of conductors control the travel of an elevator on the load carrier. Each pair of conductors is connected to a source of alternating current, and the two conductors of each pair are crossed and recrossed at spaced points along their lengths. Successive cross-over points of the conductors, which control horizontal travel, register with successive columns of bins in confronting storage racks that flank the aisle; and successive cross-over points of the conductors, which control travel of the elevator, register vertically with successive bins of these confronting racks. These cross-over points are known as "stable nulls"; and the intervening points, where the conductors are recrossed, are termed "unstable nulls." As the stacker moves horizontally in the aisle, or the elevator moves vertically on the stacker, a transducer thereon travels along the conductors, so that the AC current in the conductors causes the transducer to develop a signal which is utilized to stop the stacker, or elevator, as the case may be, when the transducer approaches a preselected stable null. If the stacker or elevator overruns the selected stable null the motion is reversed and the stacker or elevator returns to the stable null to be halted finally exactly in front of the preselected bin in the storage racks.

One disadvantage of using a single pair of intersecting conductors to control the stopping of the stacker or of the elevator is that successive stable nulls are often so close together that difficulty is experienced at times in bringing the stacker or elevator to a halt at the preselected stable null.

It is an object of this invention to provide an improved system of controls for halting a stacker or elevator at preselected bins in a storage rack. To this end it is a purpose of this invention to provide an improved null track, or cross-over wire control device, which is more accurate and reliable than prior such systems.

A further object of this invention is to provide an improved null track system which permits greater spacing between stable nulls thereby minimizing the likelihood of halting the stacker or elevator at an improper location.

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

The drawing is a wiring diagram illustrating a four wire null track system made in accordance with one embodiment of this invention, and illustrating fragmentarily and schematically a stacker controlled thereby.

Referring now to the drawing by numerals of reference, **10** denotes a conventional storage rack containing, for example, a plurality of horizontally arranged storage bays of bins denoted as **B1, B2, B3** etc. In practice rack **10** may be placed at one side of an aisle along which an automatic load carrier or stacker S (broken lines in drawing) is adapted to travel to convey loads to selected bins in the rack. A loading station (not illustrated) may be located at the head of the aisle at the left hand side of bin B1 to hold loads that the carrier is to transfer into, or transfer out of, the bins in rack **10.**

Mounted in any desired manner on the floor of the aisle along which the stacker S travels in a four-wire null track denoted generally at **12.** This track comprises two pairs of insulated wires or conductors **13** and **14, 17** and **18,** which extend longitudinally down the aisle in front of rack **10** in offset, substantially parallel relationship to each other.

At one end of the aisle, for instance the right end as illustrated in the drawing, the conductors **13** and **14** are connected to one another; and at the opposite end, or head of the aisle, conductors **13** and **14** are connected, respectively, through normally-open relay switches **3CR-2** and **1CR-2** with ground L_1 of main lines L_1, L_2. At selected points intermediate their ends conductors **13** and **14** are crossed and recrossed relative to one another to form a plurality of spaced null points, successive ones of which, commencing with the point adjacent the head of the aisle, are denoted at **N1, N3, N5, N7,** etc. At the right end of the aisle conductors **17** and **18** are also connected to one another, and at their opposite ends (adjacent the head of the aisle) they are connected through the normally-open relay switches **2CR-2** and **4CR-2,** respectively, with ground line **L1.** Intermediate their ends conductors **17** and **18** are crossed and recrossed at spaced points to form a plurality of spaced null points, successive ones of which, again commencing with the null point closest to the head of the aisle, are denote at **N2, N4, N6,** etc. Successive null points **N2, N4, N6,** etc. are spaced between, respectively, successive null points **N1, N3, N5, N7,** etc. of conductors **13** and **14.**

As noted hereinafter, nulls **N1, N3,** etc. are adapted selectively to halt the stacker S in registry with one of the alternate or odd-numbered bins (**B1, B3, B5, B7,** etc.) in rack **10.** On the other hand, the nulls **N2, N4, N6,** etc. are designed to halt stacker S selectively in registry with the intervening or evenly-numbered bins (**B2, B4, B6,** etc.).

To apply AC power selectively to the four wires **13, 14, 17** and **18** of the null track **12** a transformer T has its primary winding connected at one end to, for example, a 120 volt AC power supply line **L2,** and at its opposite end to the ground line **L1.** The secondary winding of this transformer is connected at one end to line **L1,** and at its opposite end through a variable resistor **R1** to one side of each of four relay switches **1CR-1, 2CR-1, 3CR-1** and **4CR-1,** the opposite sides of which are connected to conductors **13, 18, 14** and **17,** respectively.

The relay switches are controlled by four relay coils **1CR, 2CR, 3CR** and **4CR,** one end of each of which is connected to ground line **L1,** the opposite ends thereof being connected through four separate selector switches S1, S2, S3 and S4, respectively, to main line L2. Switches S1 through S4 are shown to be of the normally-open variety, so that the associated relays 1CR through 4CR normally are deenergized. Consequently the above-noted relay switches are also normally open.

In use the illustrated null track **12** is used in conjunction with a conventional stacker control circuit comprising a plurality of series-connected conductors **31, 32, 33, 34, 35, 36, 37,** etc., which are mounted above stacker S for registry horizontally with successive bins B1 through B7, respectively. At one end this series of conductors is connected through a resistor R4 to the ground line L1, and at its opposite end to the positive terminal **40** of a DC power supply. Adjacent ends of these conductors are separated by resistors R4, so that the voltages on the conductors will increase by a like increment for each successive conductor. For the example a DC voltage potential of 1, 2, 3, 4, 5, 6 and 7 volts may exist on the conductors **31, 32, 33, 34, 35, 36** and **37,** respectively.

To control its position stacker S carries an electrically conductive wiper W (broken lines in the drawing), which has sliding engagement with conductors **31, 32,** etc. For example, when the stacker S is in registry with bin B6, wiper W will be midway of conductor **36,** so that the wiper W will be at a potential of 6 volts. Similarly, when the stacker is in registry with any of the bins B1 through B5 or B7, the wiper W will be in contact with the midpoint of conductor **31, 32, 33, 34, 35** or **37,** respectively; and will be at the voltage potential of the conductor with which it is engaged.

In use, to move the stacker to a selected bin, an operator or programming device selects a voltage corresponding to that of the desired bin — e.g., 1 volt for bin B1, 2 volts for bin B2, etc. As the stacker travels along the aisle, this selected bin voltage is compared with the voltage on the wiper W at a voltage comparator **42.** As long as the preselected bin voltage differs from the voltage on the wiper W, the stacker S is driven by motor M at fast speed up or down the aisle until wiper W moves into engagement with the conductor (**31, 32,** etc.) which has a voltage equal to that of the preselected bin voltage. For example, if the stacker S is located in front of bin B6 wiper W is applying a six voltage potential to one input of comparator **42,** and if it is desired to move the stacker into registry with bin B3, a potential of 3 volts is applied through the programming device to the other input of the comparator. Then, since its two input voltages differ, the comparator produces a signal which causes the stacker motor to move the stacker rapidly toward the head of the aisle until wiper W engages the conductor **33.** Here the two inputs to comparator **42** are equal, and control of the stacker is switched from the voltage comparator **42** to the head H carried by the stacker. The signal developed by the head H then slows the stacker gradually to a halt in front of the selected bin B3.

When the control circuit is operated to apply a preselected bin voltage to one input of comparator **42,** the control circuit also closes automatically one of the four selector switches S1, S2, S3 or S4. Specifically, when the selected bin is either the first, fifth, ninth, etc. from the head of the aisle (i.e., B1, B5, etc.), the control circuit will cause switch S1 to be closed, thereby energizing relay 1CR. This closes switches 1CR-1 and 1CR-2 so that AC voltage is applied from line L_2 by transformer T through resistor R1, switch 1CR-1, conductor **13,** conductor **14** and switch 1CR-2 to ground. This causes stable nulls to exist at alternate cross points N1, N5, etc. in the track represented by the two wires **13** and **14,** and unstable nulls to exist at the intervening cross points N3, N7, etc. As a result when control of the stacker is switched to head H, and the head is moved into operative relation to one of these stable nulls N1, N5, etc., the stacker will be stopped in registry with the associated bin B1 or B5, etc. in the manner disclosed in the above-mentioned U.S. Pat. No. 3,349,303.

Whenever the stacker is to be moved into registry with either the second, sixth, tenth, etc. bin from the head of the aisle (B2, B6, etc.), operation of the programmer will cause switch S2 automatically to be closed, thereby to energize relay 2CR and close switches 2CR-1 and 2CR-2. AC power is then supplied through conductor **18,** conductor **17** and switch 2CR-2 to ground, producing stable nulls at crossover points N2, N6, etc. of wires **17** and **18,** and unstable nulls at their crossover points N4, N8, etc. The stacker will then slow down and stop at the selected bin.

To move the stacker into registry with any one of bins B3, B7, B11, etc. the proper voltage will be applied to the comparator which, when operated in conjunction with the programming means would automatically close switch S3. This would energize relay 3CR, closing switches 3CR-1 and 3CR-2 so that AC power would be applied through conductor **14,** conductor **13** and switch 3CR-2 to ground. This has the effect of reversing the phase relationship of the current flow in conductors **13** and **14** as compared to the current which flowed therein when relay 1CR was energized. Consequently, the points N1, N5, N9, etc. are now unstable nulls, while points N3, N7, etc. function as stable nulls capable of halting the stacker S in registry with either bin B3, B7, B11, etc.

When the stacker is to be moved to either of bins B4, B8, B12 (not illustrated), etc., the switch S4 is closed to energize relay 4CR, thus closing switches 4CR-1 and 4CR-2, so that AC power is supplied through conductor **17,** conductor **18** and switch 4CR-2 to ground. This is the reverse of the phase relationship of the current that flowed in the conductors **17** and **18** when the relay 2CR was energized, so that now the nulls N2, N6, etc. are unstable, while the null points N4, N8, etc. are stable, and capable of halting the stacker in front of either bin B4, B8, etc. as will be apparent from the above description.

From the foregoing, it will be apparent that, unlike the construction, wherein only two cross-over wires were employed to produce stable nulls simultaneously at each successive bin in a horizontal row thereof, the instant invention permits substantially greater spacing between such nulls — i.e., a space equal at least to the width of four successive bins in a rack. Moreover, by employing two sets or pairs of crossover wires in the null track **12,** the wires defining the nulls (for example N3 and N5) for the two bins (B3 and B5) immediately adjacent to a selected bin (bin B4) are not even energized at the time that the stacker is travelling toward the selected bin (bin B4), so that there is absolutely no likelihood of the stacker being stopped accidentally in front of the bin located to one side or the other of the selected bin.

The advantage of the four wire null track system, as compared with the prior two wire system, is that it is now possible to make the controls for the fast speed or coarse movement of the stacker less sensitive, and therefore less expensive. For example, in a two wire null system in which the stable nulls exist in front of each bin, a slight error in the voltages on conductors **31**, **32**, etc., could erroneously cause the voltage comparator prematurely to switch control to the stacker head H, thus bringing the stacker to a halt in registry with the bin immediately adjacent to the selected bin, rather than in registry with the selected bin itself. With the instant invention, however, the two null points at opposite sides of the selected bin are completely deenergized at the time that the stacker moves into proximity with the selected bin, while the next two closest null points are in unstable modes. Consequently, whereas in prior systems of the type described an error of 1 volt in the conductors **31**, **32**, **33**, etc. could result in the stacker being halted in front of the wrong bin, it would require a four volt error in conductors in the system of the present invention to cause the stacker to be halted accidentally in front of the wrong bin opening.

While the invention has been described specifically in connection with control of the stacker itself, the same basic control system can be applied also to the slowing and stopping of the elevator on the stacker. The conductors are merely arranged vertically instead of horizontally, and the sensor head is on the elevator instead of the horizontally moving carrier.

While the invention has been described then in connection with one embodiment thereof and use therefor, it will be understood that it is capable of further modification and use; and this application is intended to cover any modifications or uses of the invention that come within the disclosure or the scope of the appended claims.

I claim:

1. A control circuit for positioning apparatus of the type in which a first member is movable along a predetermined path, and selectively to any one of a plurality of different positions of rest relative to a second member, comprising

electrical conductors defining a plurality of spaced null points along said path at intervals corresponding to said positions of rest,

means for selectively energizing said conductors simultaneously to place certain only of said null points selectively in stable and unstable modes, respectively,

an actuatable sensor mounted on said first member for movement thereby into registry with successive ones of said null points during movement of said first member in one direction, and operative, when actuated, to stop and first member when moved into registry with a selected null point disposed in its stable mode,

said energizing means including means operative to maintain only every other one of said certain null points in a stable mode during movement of said first member.

2. A control circuit as defined in claim **1**, wherein said energizing means comprises

first switch means operable to place simultaneously only alternate null points along said path in said stable and unstable modes, respectively, and

second switch means operable to place simultaneously only the null points located between said alternate null points in said stable and unstable modes, respectively.

3. A control circuit as defined in claim **2**, wherein said null points are defined by two pairs of conductors which extend along said path,

4. A control circuit as defined in claim **3**, wherein said energizing means comprises an AC power supply,

said first switch means comprises a first plurality of switches operable selectively to connect one of the conductors of said one pair to said power supply and the other conductor of said one pair to ground, thereby selectively to place either the odd or even numbered ones of said alternate null points in a stable mode, and

said second switch means comprises a second plurality of switches operable selectively to connect one of the conductors of said other pair to said power supply and the other conductor of said other pair to ground, thereby selectively to place in a stable mode either the odd or even numbered ones of the null points located between said alternate points.

5. In a storage system having an automatic stacker that travels in an aisle adjacent a storage rack for registry with a selected bin in the rack, a device for halting the stacker, comprising

a first pair of electrically-conductive wires crossed and recrossed at intervals intermediate their ends to form a first plurality of spaced crossover points that register with alternate bins in said rack,

a second pair of wires being crossed and recrossed at intervals intermediate their ends to form a second plurality of spaced crossover points that alternate with those of said first plurality to register with intervening bins in said rack,

means for selectively applying an AC voltage to said wires one pair at a time, thereby selectively to develop stable nulls at alternate crosspoints only in one pair of said wires, and

a sensing head on the stacker moved in operative relation to said pairs of wires to stop said stacker when said head registers with a selected stable null.

6. In a storage system as defined in claim **5**, where said means comprises

a first plurality of switches for selectively connecting each of said wires to an AC power supply,

a second plurality of switches for selectively connecting each of said wires to ground, and

control means operable selectively to close a first one each of said first and second pluralities of switches to apply AC voltage of one phase to one of said pairs of wires to develop stable nulls at its alternate crossover points, and to close a second one each of said first and second pluralities of switches to apply AC voltage of opposite phase to said one pair of wires to develop stable nulls at its intervening crossover points, between the alternate crossover points thereof.

the two conductors of one pair thereof are connected to said first switch means and intersect each other at spaced intervals to form said alternate null points at the intersections thereof, and

the two conductors of the other pair are connected to said second switch means and intersect each other at spaced intervals to form at the intersections null points alternating with the null points of said one set of conductors.

7. In a storage system comprising a storage rack having a plurality of bins arranged in horizontal rows and vertical columns, and a movable transporting member for depositing loads in and removing loads from the bins,

electrically operative means for controlling the transporting member to determine at what bin it is to be stopped for deposit or removal of a load, comprising

two pairs of electrically conductive wires, the wires of each pair crossing and recrossing one another at intervals, and the wires of one pair being disposed so that its points of crossing and recrossing alternate with those of the other pair in the direction of movement of the transporting member,

means connected to said transporting member to move therewith for sensing the crossing points of the two pairs of wires, and

means for selectively applying to each of said two pairs of wires one of two pulsating voltages having opposed phases.

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