

[54] **RETROREFLECTIVE FINE POSITION SENSING MEANS**

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[51] Int. Cl. **G01b 11/26**

[58] Field of Search..... 250/202, 223 R; 356/152, 356/172; 214/16.4 A

[56] **References Cited**

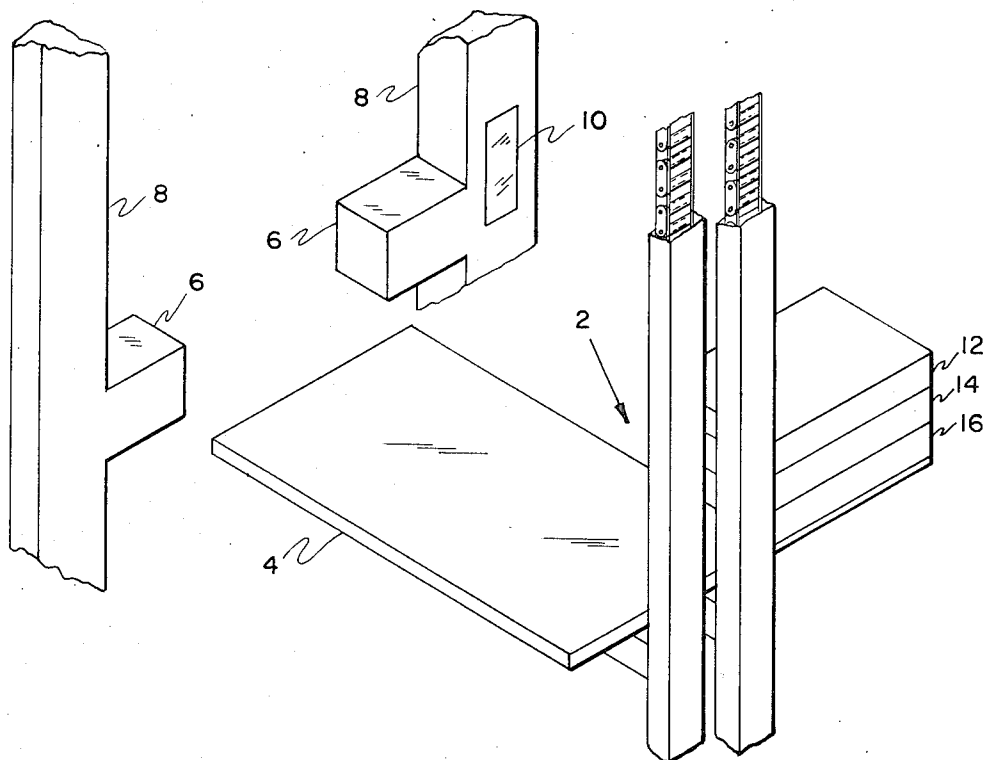
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[57] **ABSTRACT**

A position sensing method and apparatus for fine control of vehicles about a remote point comprising a strip of retroreflective material mounted adjacent the desired position and a plurality of sources of collimated light beams mounted on the vehicle together with means for sensing reflection of the light beams along the path of incidence.

9 Claims, 2 Drawing Figures



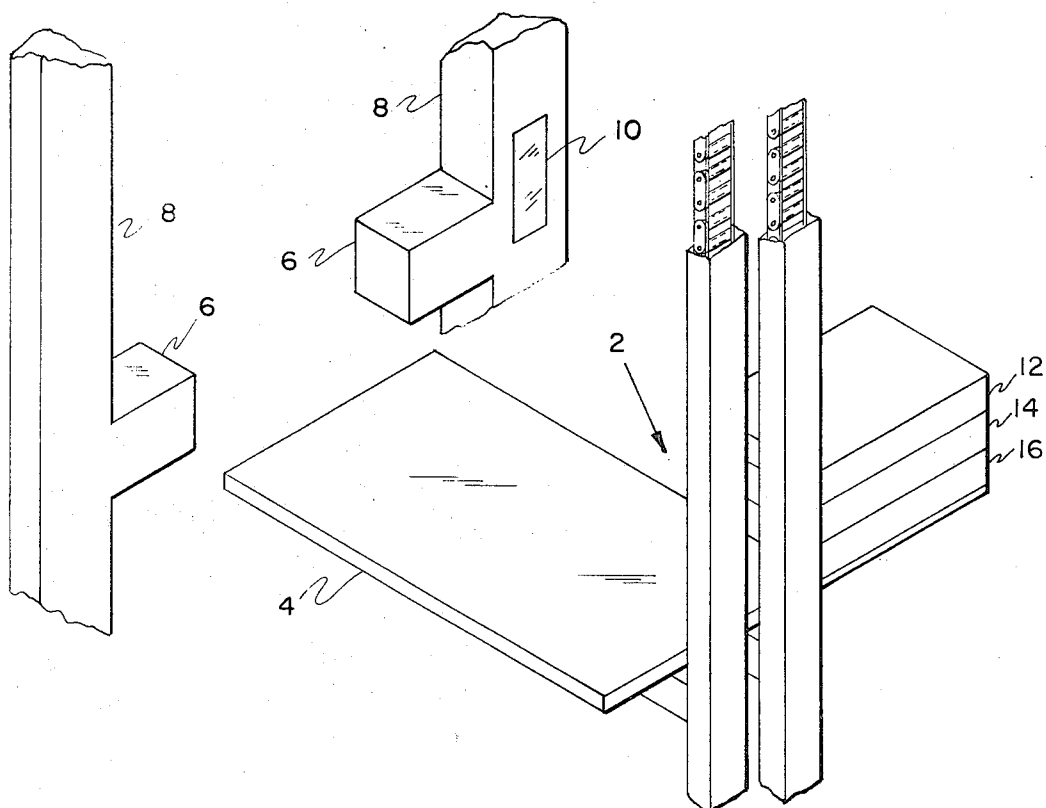


FIG. 1

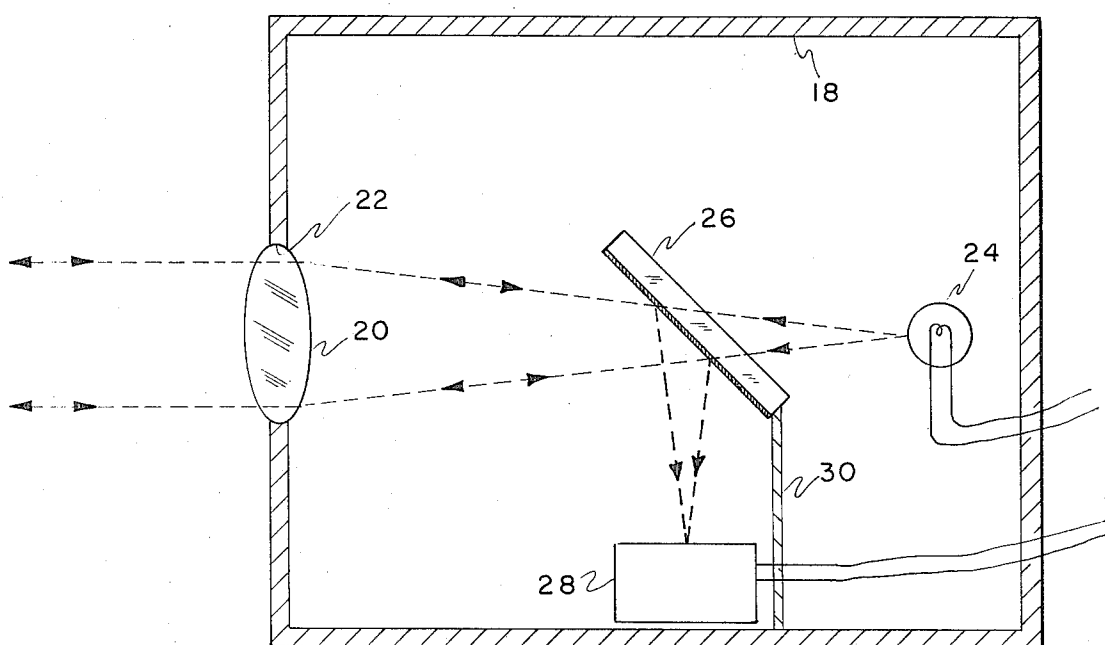


FIG. 2

RETROREFLECTIVE FINE POSITION SENSING MEANS

BACKGROUND

1. Field of Invention

This invention relates to position sensing means and particularly to means for controlling fine positioning of a controlled vehicle about a particular position.

2. Prior Art

It is frequently necessary or desirable to control vehicles, such as stacker cranes and the like, from remote location. Moreover, such remote control may be accomplished automatically, as by a computer. In performing such automatic remote control, it is not difficult to accomplish gross positioning; for example, to move the vehicle from a loading dock to a storage area. However, many problems are encountered in fine positioning; that is, controlling small movements about a particular position, such as would be required to precisely align a vehicle with a loading or dumping chute or in causing lifting forks to deposit an article on a shelf or remove an article therefrom. Numerous techniques have been proposed heretofore for accomplishing fine positioning. However, none of the prior art techniques have been entirely satisfactory. Many of the prior art fine position control systems have been relatively inaccurate, while others have been extremely bulky, complex and expensive. Still other fine position control systems have required considerable maintenance.

BRIEF SUMMARY AND OBJECTS OF THE INVENTION

These disadvantages of the prior art are overcome with the present invention and a fine position sensing system is provided which is extremely accurate and reliable, yet is simple, uncomplicated and inexpensive and requires virtually no maintenance.

The advantages of the present invention are preferably attained by providing a plurality of photoelectric sensing heads mounted adjacent each other on a vehicle to be controlled and emitting collimated beams of light toward an elongated strip of retroreflective material which is mounted adjacent the position about which the vehicle is to be controlled.

Accordingly, it is an object of the present invention to provide improved means and methods for accomplishing fine position control of vehicles.

Another object of the present invention is to provide a fine position control means for vehicles which is accurate and reliable.

An additional object of the present invention is to provide a fine position control means for vehicles which is simple, uncomplicated and inexpensive.

A further object of the present invention is to provide an improved sensing means for fine position control of vehicles.

A specific object of the present invention is to provide a fine position control system comprising plurality of photoelectric sensing heads mounted adjacent each other on a vehicle to be controlled and emitting collimated beams of light toward an elongated strip of retroreflective material mounted adjacent the position about which the vehicle is to be controlled.

These and other objects and features of the present invention will be apparent from the following detailed

description taken with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic representation of a fine position control system embodying the present invention; and

FIG. 2 is a vertical section through one of the sensor heads of the device of FIG. 1.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

In that form of the present invention chosen for purposes of illustration in the drawing, FIG. 1 shows a stacker crane, indicated generally at 2, having a vertically movable platform 4 for loading articles onto or off of shelves 6 which are supported by pillars 8 in a warehouse or the like. An elongated strip 10 of retroreflective material is secured to one of the pillars 8 adjacent the shelves 6 and extends a predetermined distance above and below the shelves 6. Suitable retroreflective material is available as "Scotchlite" reflective sheeting, made by the Reflective Products Division, 3M Company, St. Paul, Minn. In addition, a plurality of photosensor units 12, 14 and 16 are carried by the platform 4 and are arranged in linear relation and positioned to sense light reflected from the retroreflective strip 10. The length of the strip 10 is preferably just long enough to permit simultaneous reflection to all of the sensors 12, 14 and 16.

The photosensor units 12, 14 and 16 are identical and, as seen in FIG. 2, each of them comprises a housing 18 having a collimating lens 20 mounted in an opening 22 formed in one side of the housing 18. Within the housing 18, a light source 24 is mounted at the focal point of the lens 20 and a half-silvered mirror 26 is mounted in an inclined position with respect to the optical axis of lens 20 between the light source 24 and lens 20. A photoelectric cell 28 is mounted to sense light reflected from the mirror 26 and is shielded against direct light from light source 24, as by opaque wall 30.

In use, light from source 24 passes through half-silvered mirror 26, is collimated by lens 20, travels to strip 10 and is reflected back along its own path to mirror 26 and, thence, to photocell 28. It is characteristic of retroreflective materials that a beam of light incident thereon is reflected only directly back along the path of incidence. Since the light from the photosensor units 12, 14 and 16 is collimated by lens 18, the photocell 28 will emit a signal only when the light paths from the source 24 to the strip 10 and from the strip 10 to the mirror 26 are precisely coincident. This permits extremely accurate positioning of the platform 4. The use of three photosensor units 12, 14 and 16 facilitates control of the platform 4 for fine movement about the shelves 6. Thus, signals from photosensor units 12 and 14, in the absence of a signal from photosensor unit 16, indicates a "low" fine position. Signals from photosensor units 14 and 16, in the absence of a signal from photosensor unit 12, indicates a "high" fine position. Simultaneous signals from all three photosensor units 12, 14 and 16 indicates a precise "center" position. The absence of a signal from photosensor unit 14 indicates a position of gross non-alignment of the vehicle with the shelves 6 since the photosensor 14 fails to provide a signal when it is not aligned with the strip 10. To de-

posit an article on the shelves 6, the platform 4 is raised to the high fine position and the platform 4 is advanced to extend above the shelves 6. Next, the platform is lowered to the low fine position, causing the article to be deposited on the shelves 6. Thereafter, the platform 4 may be retracted and the stacker crane moved to perform a subsequent operation. To retrieve an article from the shelves 6, the platform 4 is raised to the low fine position and is extended below the shelves 6. Next, the platform 4 is raised to the high fine position, lifting the article from the shelves 6. Subsequently, the platform 4 may be retracted and the stacker crane moved to deliver the article to a desired location. When it is desired to precisely position the platform 4, as to permit filling of a container carried by the platform 4 from a chute substantially the same size as the container, the platform 4 is moved to the center position.

Obviously, numerous variations and modifications may be made without departing from the present invention. Accordingly, it should be clearly understood that the form of the present invention described above and shown in the accompanying drawing is illustrative only and is not intended to limit the scope of the present invention.

What is claimed is:

1. A device for controlling fine movement of a load platform of a vehicle about a predetermined shelf location to allow transfer of material between said load platform and said shelf location, said device comprising:

an elongated strip of retroreflective material mounted adjacent said shelf position to extend a predetermined distance on both sides of said shelf about which said load platform of said vehicle is to be alignably moved,

a plurality of sensor heads stackably mounted on said platform of said vehicle to move with said platform and being operative to direct a collimated beam of light from each of said plurality of sensor heads, each of said sensor heads emitting an electrical signal in response to reflection of its light from said strip along the path of incidence of said light as said platform moves along said shelf location, all of said sensor heads emitting said electrical signal to indicate a first position having an aligned relation of said vehicle with respect to said shelf location about which said platform of said vehicle is moved, and all but the end mounted sensor heads at one end of said stackably mounted sensor heads emitting said electrical signal to indicate a second position wherein said platform of said aligned vehicle is moved into said shelf location to transfer material between said shelf and said platform.

2. The device of claim 1 wherein at least one of said sensor heads comprises:

a housing having an opening formed in one side thereof,

a collimating lens mounted in said opening to direct said light normally to the plane of said strip,

a light source mounted at the focal point of said lens,

a partially-reflective mirror interposed between said light source and said lens and inclined at an angle with respect to the optical axis of said lens and serving to transit light from said source to said lens and to reflect light passing from said lens to said mirror, and

a photocell positioned to detect light reflected from said mirror and emitting an electrical signal in response to such light.

3. The device of claim 1 wherein said plurality of sensor heads comprises three stacked sensor heads with all three sensor heads emitting said electrical signal to indicate a complete alignment of said vehicle with said shelf location about which said platform of said vehicle is to be moved, and with all but one of said end mounted sensor heads emitting said electrical signal to indicate a material transfer position of said platform with respect to said shelf.

4. The device of claim 1 wherein the length of said strip is just sufficient to permit simultaneous reflections to all of said plurality of sensor heads as an indication of alignment of said vehicle with said position.

5. The method of determining the position of a movable vehicle, having a movable platform, about a desired location to allow transfer of material between said platform and said desired location, said method comprising the steps of:

mounting a strip of retroreflective material adjacent said desired location,

mounting a plurality of sources of collimated light beams on said movable platform of said vehicle to emit light toward said strip of retroreflective material when said vehicle is moved substantially opposite said retroreflective material,

sensing when the number of said light beams reflected from said strip of retroreflective material is equal to the total number of said plurality of light sources to indicate the position of said vehicle as being in an aligned position with said desired location,

moving said platform of said vehicle in a first direction away from said vehicle aligned position until all but one end source of said plurality of light sources is reflected from said strip of retroreflective material, and

extending said platform into said desired location to allow material to be transferred between said platform and said desired location.

6. The method of claim 5 wherein:

the number of said sources of light beams is three, and

simultaneous reflection of only two of said light beams provides an indication of the position of said platform of said vehicle as being extendible into said desired location for transfer of material.

7. The method of claim 5 wherein:

the number of said sources of light beams is three, and

simultaneous reflection of all three of said light beams provides an indication of the position of said vehicle as being at said desired location.

8. The method of claim 5 further including the steps of:

moving said platform of said vehicle in a second direction opposite to said first direction until all but a second end light source opposite said one end light source is reflected from said strip of retroreflective material, and

retracting said platform from said desired location to allow said vehicle to be moved to another location.

9. The device of claim 1 including means for extending said platform of said vehicle into said predetermined shelf location after sensing said electrical signals indicative of said first position and said second position.

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