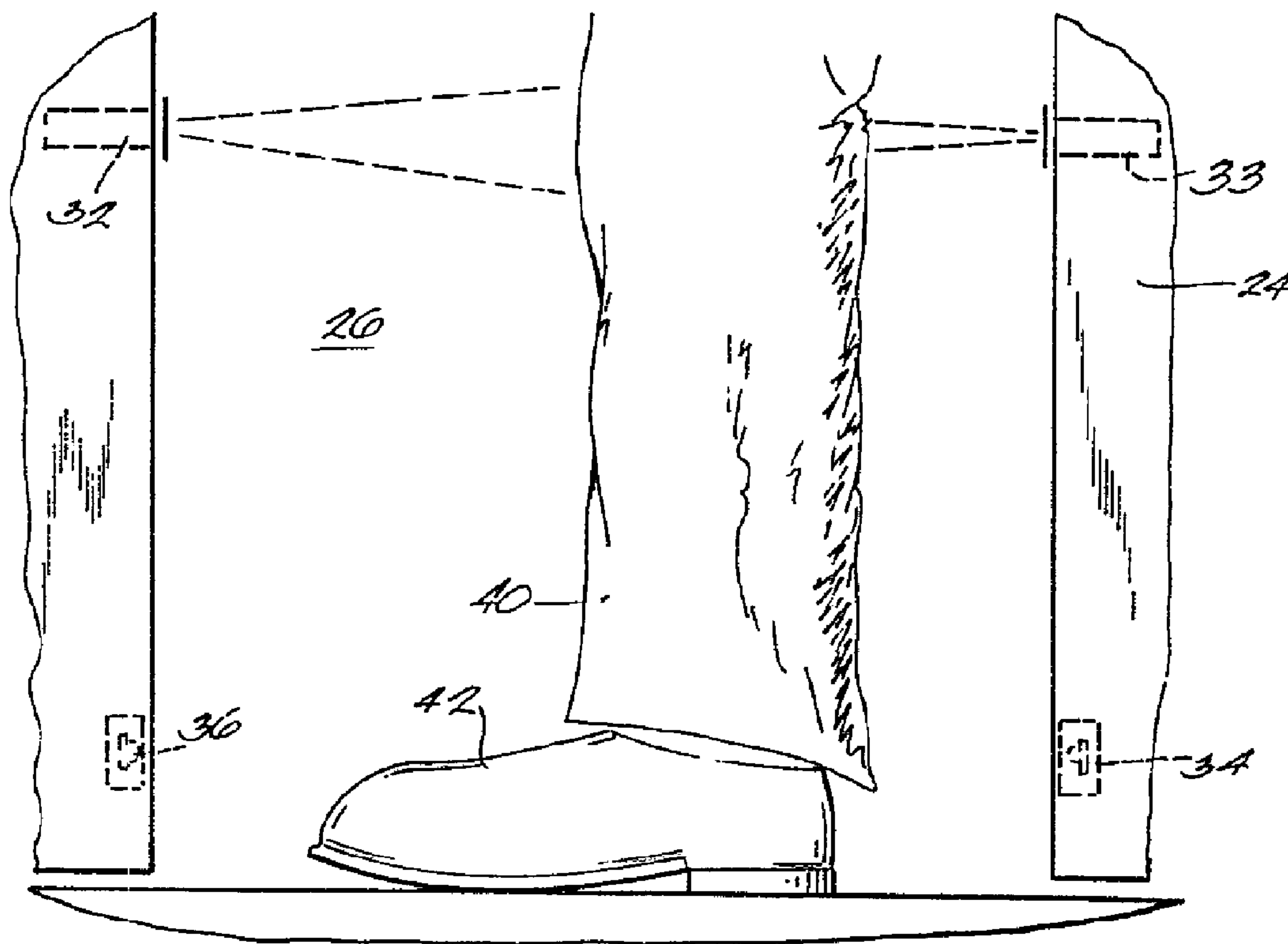




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(54) Titre : DETECTEUR DE MOUVEMENT BI-DIRECTIONNEL POUR SYSTEME DE STOCKAGE MOBILE
 (54) Title: BI-DIRECTIONAL MOTION SENSOR FOR MOBILE STORAGE SYSTEMS



(57) Abrégé/Abstract:

Directional detectors (28 and 30) are used with at least one mobile storage unit (10) having a prime mover (16) adapted to move the unit along a path and at least one blocking object (24) such as a second movable storage unit, a stationary storage unit or a wall, there being an aisle (26) formed therebetween. The directional detectors detect the entry of an obstacle into the aisle and prevent movement of the first unit until the obstacle has left the aisle. The detector includes two light source-detector pairs, the sources (28a, 30a) and the detectors (28b, 30b) of each pair are mounted to the first unit and the blocking object on opposite sides of the aisle, and facing each other. A control unit (22) is connected to the light detectors of the pairs and receives signals therefrom, indicating whether or not the detectors are receiving light from the sources.



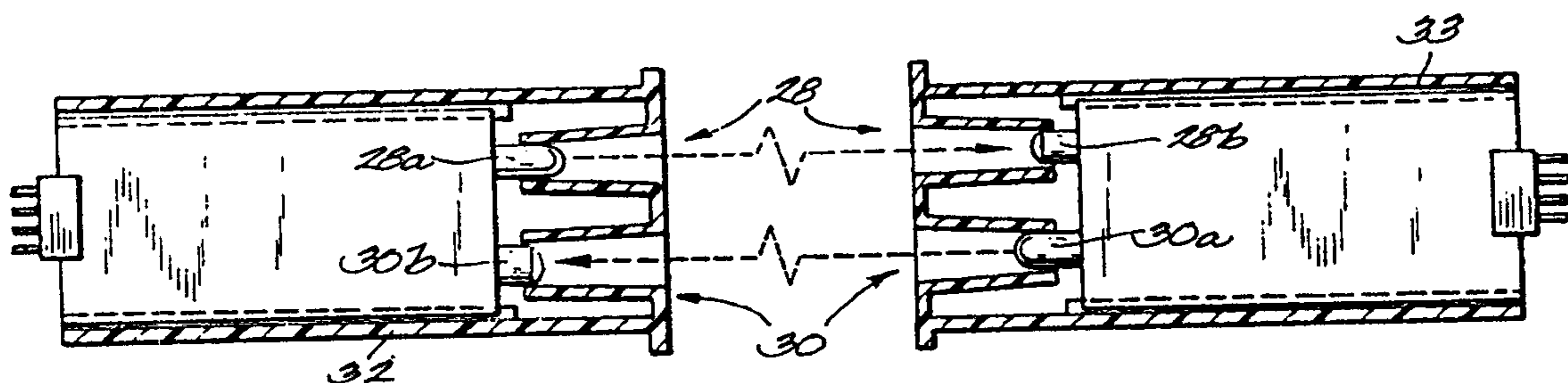
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(54) Title: BI-DIRECTIONAL MOTION SENSOR FOR MOBILE STORAGE SYSTEMS



(57) Abstract

Directional detectors (28 and 30) are used with at least one mobile storage unit (10) having a prime mover (16) adapted to move the unit along a path and at least one blocking object (24) such as a second movable storage unit, a stationary storage unit or a wall, there being an aisle (26) formed therebetween. The directional detectors detect the entry of an obstacle into the aisle and prevent movement of the first unit until the obstacle has left the aisle. The detector includes two light source-detector pairs, the sources (28a, 30a) and the detectors (28b, 30b) of each pair are mounted to the first unit and the blocking object on opposite sides of the aisle, and facing each other. A control unit (22) is connected to the light detectors of the pairs and receives signals therefrom, indicating whether or not the detectors are receiving light from the sources.

BI-DIRECTIONAL MOTION SENSOR
FOR MOBILE STORAGE SYSTEMS

Background of the Invention

5 This invention relates to mobile storage systems, and in particular to mobile storage systems having sensors to prevent the closure of an aisle between two storage units when an obstacle is present in the aisle, without the need for physical contact with the obstacle.

10 Mobile storage systems are widely used and well known to comprise a series of storage units which have shelves or bins, for example. Except for one or both of the end units, which may be stationary, each of the storage units will normally be movable, such as
15 on rails, to create an access aisle between two of the units. As this aisle opens, the other units are positioned in close side-by-side relationship to minimize the overall floor space required for the units, moving together to do so. Especially in larger mobile storage units and systems, the carriages can be quite
20 large, and the loads they carry quite heavy, such as steel or construction materials. It is commonly necessary, therefore, to provide motorized means for moving the units. These motorized moving means in turn
25 require the use of means for preventing adjacent units

from moving together when an obstacle, such as a person, is positioned between them, so as to avoid injury or damage.

5 In the past it has been customary to provide
a sweep or safety switch bar for notifying the control
system to inhibit motion of a storage unit if the bar
10 encounters, while moving to close the aisle, an obstacle or impediment to movement, as shown for instance
in U.S. Patent Nos. 4,743,078 and 4,733,923. When
such a structure is used alone to protect a person,
however, the requirement of physical contact with the
bar can be disconcerting and startling, which can make
15 use of this structure alone undesirable. Use of a
photoelectric sweep, as disclosed in U.S. Patent No.
5,121,975, is only slightly less disconcerting, as the
moving storage unit must still move quite close to a
person before its motion is interrupted.

20 Another alternative is to use a "safety
floor", such as set forth in U.S. Patent Nos.
4,744,307 and 4,693,184, which disclose constructions
of floor panels including safety switches. The weight
of a person or other obstacle on one of the floor panels
25 activates one of the safety switches, which notifies
the control system to inhibit movement of the
storage units. While these units work very well from
a safety standpoint, they can be rather expensive,
resulting in their non-use in certain situations. And
U.S. Patent No. 4,745,516 even discloses the use of a
30 safety sweep and a safety floor in combination. Even
this combination, however, may not properly sense that
an obstacle remains in the aisle even though no
switches are closed, such as on occasion may occur
when a very light obstacle is in the aisle, or when a
35 person needs to reach an item on a high shelf and may
step onto a lower shelf to reach the item.

This invention relates to improvements to the structure set forth above, and to solutions to some of the problems raised or not solved thereby.

Summary of the Invention

5 The present invention relates to a mobile storage system including at least a first movable storage unit with a prime mover adapted to move the shelving unit along a path of movement, and at least one blocking object, such as a second movable storage
10 unit, a stationary storage unit or a wall positioned on the path. Generally the path between the movable shelving unit and the blocking object can be termed an aisle, open at one or both ends. The invention provides a detector for detecting the entry of an obstacle into the aisle and for preventing movement of the
15 first unit while the obstacle is in the aisle. When the obstacle leaves the aisle, the movement of the first unit is again enabled.

 According to the invention, the detector includes at least two light source-detector pairs, each
20 pair including a light source and a light detector. Of each pair, the source is mounted to either the first unit or the blocking object, and the detector is mounted to the blocking object or first unit, respectively, opposite the source. That is, at least two
25 light sources direct beams across the entry-exit point of the aisle, and opposite each source is positioned a corresponding detector. A control unit is connected to the light detectors and receives a signal from the
30 light detectors, that signal indicating whether or not the light detectors are receiving light from the light sources. The two sources are offset substantially horizontally. The control unit disables the prime mover from moving the first unit along the path when
35 it is determined that an obstacle, such as a person

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for instance, has entered the aisle and has not exited.

One embodiment includes a number of sets of source-detector pairs, mounted in at least two columns, to the movable unit and the blocking object. This embodiment provides improved directional detection of the obstacle or person into and out of the aisle.

Another embodiment includes in addition a plurality of in-aisle light sources and detectors located in the aisle and spaced along the length of the aisle, and the control unit includes obstacle locating means for determining which of those in-aisle light detectors if any is not receiving light from a light source, once the source-detector pairs have sensed that an obstacle has entered the aisle. The fact that one of the in-aisle light detectors is not receiving light indicates that the obstacle is still in the aisle, so that the control unit refuses to permit the aisle to close when the obstacle is still there. The in-aisle detector and source are most advantageously mounted substantially at the bottom of the first unit and the blocking object. According to the invention, the obstacle locating means uses the information about which of the in-aisle detectors is not receiving light to determine where along the aisle the detectors are not receiving light from the light sources. This information is useful to continue the disablement of the prime mover, even though the entry-exit source-detector pair has determined that an obstacle has left the aisle, in cases where more than one person or obstacle had entered the aisle substantially simultaneously.

The invention may be summarized according to a first aspect as in a mobile storage system including at least a first movable storage unit with a prime mover

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adapted to move the shelving unit along a path of movement, and at least one blocking object, such as a second movable storage unit, stationary storage unit or wall positioned on the path, a detector for detecting the entry of an obstacle
5 into the path of movement and the exiting of an obstacle from the path of movement, that detector comprising: two light source-detector pairs, each including a light source and a light detector, the source and detector of each pair being mounted opposing and sight-aligned, one of each pair
10 mounted to one of the first unit and the blocking object, and the other of each pair mounted to the other of the first unit and the blocking object; those light source-detector pairs being spaced apart at least horizontally and positioned so that each light detector receives light from
15 the opposing light source when an obstacle is not positioned therebetween, thereby providing reliable information on the direction of movement of the obstacle between the sources and detectors; and a control unit connected to the light detectors and receiving a signal from each light detector,
20 that signal indicating whether or not the light detector is receiving light from one of the light sources, the control unit disabling the prime mover from moving the movable shelving unit along the path when the control unit determines that an obstacle has entered the path and has not
25 yet left the path.

According to another aspect the invention provides a mobile storage system comprising: at least a first movable storage unit; a prime mover adapted to move the storage unit along a path of movement; at least one blocking object, such
30 as a second movable storage unit, stationary storage unit or wall, positioned on the path; two light source-detector pairs, each including a light source and a light detector, one of each pair mounted to one of the first unit and the

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blocking object, and the other of each pair mounted to other
of the first unit and the blocking object, the two source-
detector pairs laterally spaced apart from each other; those
light source-detector pairs positioned on the first unit and
5 blocking object so that each light detector receives light
from the opposing light source when an obstacle is not
positioned therebetween, so as to provide reliable
information on the direction of movement of the obstacle
between the sources and detectors; and a control unit
10 connected to the light detectors and receiving a signal from
each light detector, that signal indicating whether or not
the light detector is receiving light from the respective
light source, the control unit disabling the prime mover
from moving the movable shelving unit along the path when
15 the control unit determines that an obstacle has entered the
path and has not yet left the path.

According to yet another aspect the invention
provides a mobile storage system comprising: at least a
first movable storage unit; a prime mover adapted to move
20 the storage unit along a path of movement; at least one
blocking object, such as a second movable storage unit,
stationary storage unit or wall, positioned on the path,
there being an aisle between the storage unit and the
blocking object when they are spaced apart from each other;
25 two light source-detector pairs spaced apart at least
horizontally, each pair including a source and a detector,
the source and detector of each pair mounted opposing, one
of each pair mounted to one of the storage unit and the
blocking object, and the other of each pair mounted to the
30 other of the storage unit and the blocking object, each
light detector thus receiving light from the opposing light
source when an obstacle is not positioned therebetween,
thereby providing reliable information on the direction of

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movement of the obstacle between the sources and detectors;
a control unit receiving a signal from each light detector
indicating whether or not each detector is receiving light
from one of the light sources, the control unit disabling
5 the prime mover from moving the movable shelving unit along
the path when the control unit determines that an obstacle
has entered the aisle and has not yet exited the aisle; a
plurality of in-aisle light sources mounted to one of the
first unit and the blocking object, and a plurality of in-
10 aisle light detectors mounted to the other of the first unit
and the blocking object, the in-aisle light sources and
light detectors positioned so that the in-aisle light
detectors are likely to be blocked by an obstacle existing
in the aisle; the control unit including discerning means
15 for determining which of the in-aisle light detectors if any
is not receiving light from the in-aisle light sources.

Other objects and advantages of the invention will
become apparent hereinafter.

Description of the Drawing

5 Fig. 1 is a perspective view of a mobile storage system including a directional detector constructed according to a preferred embodiment of the invention.

Fig. 2 is a top cross sectional view of Fig. 1, taken substantially along line 2-2 thereof, showing two entry-exit source-detector pairs according to the invention in more detail.

10 Fig. 3 is a side elevation view of a portion of the mobile storage system shown in Fig. 1, showing a person entering the aisle, with the person's leg acting as an obstacle to the light from the entry-exit sources.

15 Fig. 4 is a top view of the mobile storage system shown in Fig. 1, again showing a person's legs entering the aisle and acting as an obstacle to the light from the entry-exit sources.

20 Fig. 5 is a perspective view of a mobile storage system including a directional detector constructed according to a different embodiment of the invention, wherein there are multiple light source-detector pairs mounted vertically in two columns on both sides of the aisle entry point.

25 Fig. 6 is a view of Fig. 5, taken substantially along line 6-6 thereof, in effect a front elevational view of the multiple entry-exit pairs mounted in two columns.

Description of the Preferred Embodiment

30 Referring now to Fig. 1, there is shown a mobile storage unit 10, including several shelves 12. The storage unit 10 is moved along a set of rails 14 by a prime mover 16, such as an electric motor 18 connected to a drive wheel 20 which runs along at least
35 one of the rails. A control unit 22 is provided for

determining the rate and direction of movement of the motor 18 and drive wheel 20, and also for determining whether it is safe for the storage unit 10 to move at all.

5 The limit of movement of the mobile storage unit 10 is a blocking object 24, such as a second mobile storage unit as shown in Fig. 1. The blocking object 24 could just as easily be a stationary storage unit, or a blank wall, at the end of the row of mobile storage units. When the mobile storage unit 10 is spaced apart from the blocking object 24, as shown in Fig. 1, there is considered to be an aisle 26 between the two. As indicated earlier, it is conventional for any safety sweep and/or safety floor (not shown) to be connected to the control unit 22, so as to provide information to make the determination of whether it is safe to move, that is, whether there is any substantial obstacle in the aisle 26, or in the path of movement of the mobile storage unit 10, because of which the mobile storage unit should be prevented from moving. The present invention calls for that determination to be made in a different manner.

10 According to the present invention, two light source-detector pairs 28 and 30 are mounted to the mobile storage unit 10 and the blocking object 24. As shown in more detail in Fig. 2, each source-detector pair includes a light source 28a and 30a, such as an infrared light emitting diode, mounted to one side of the aisle, whether that be to the movable unit 10 or the blocking object 24. Each source-detector pair 28, 30 also includes a light detector 28b, 30b such as an amplified photodiode assembly, mounted across the aisle from and sight-aligned with the corresponding sources 28a, 30a. The light detectors 28b, 30b are most preferably sensitive to the particular type of

light emitted by the sources 28a, 30a, although there are also instances where it is advantageous to use ambient light as the source. As shown in Fig. 2, a light source 28a and a light detector 30b may be mounted together in a housing 32 on one side of the entry-exit point of the aisle, with the corresponding detector 28b and source 30a mounted on the opposite side of the entry-exit point of the aisle, in a housing 33 of substantially the same construction as housing 32. Just as well, there could be two sources on one side of the aisle and two detectors, one aligned with each source, on the opposite side of the aisle, all mounted in respective housings.

The important point is that the two source-detector pairs are spaced apart slightly, substantially horizontally with respect to each other. This orientation is indicated by the fact that Fig. 2 is designated a top cross sectional view. As also shown in Fig. 2, the sources 28a, 30a and detectors 28b, 30b are preferably mounted in a recessed manner, to protect them from damage, to improve ease of manufacturing and assembly, and to reduce interference from spurious light sources.

The horizontal orientation of the source-detector pairs produces the desirable result that they then provide reliable information on the direction of movement of any object between them as shown in Fig. 3, that is, whether that movement is into the aisle or out of the aisle.

One embodiment of the invention further includes several in-aisle light sources 34 mounted to either the mobile storage unit 10 or the blocking object 24, directing light across the aisle 26 toward the other of the mobile storage unit and blocking object. In Figs. 1 and 4 those in-aisle light sources

34 are mounted to the blocking object 24. Several in-
aisle light detectors 36 are then mounted opposite the
corresponding in-aisle light sources 34. In Figs. 1
and 4 those detectors 36 are mounted to the mobile
5 storage unit 10. The detectors 36 are connected to
the control unit 22 so that, if any one of the detec-
tors is screened from receiving light from any of the
light sources, the control unit 22 also prevents the
prime mover from moving the storage unit 10. The con-
10 trol unit 22 also includes circuitry or discerning
means to determine which of the in-aisle detectors 36
is not receiving light from the in-aisle light sources
34.

The still detection provided by the in-aisle
15 light detectors 36 is in addition to the directional
sensing provided by the entry-exit source-detector
pairs 28, since it is possible that two persons or
obstacles could enter substantially at once, so that
the entry-exit source-detector pairs only indicate one
20 entry, and then one of the obstacles exits the aisle
26, leaving behind the other obstacle.

As shown in Figs. 1 and 2, the in-aisle
light sources 34 and in-aisle light detectors 36 are
preferably mounted near the bottom of the mobile stor-
25 age unit 10 and blocking object 24. This position was
selected so that the beam 38 of light from the light
sources 34 is broken or screened by the lowest part of
a person's body, the lower leg 34 or foot 42 (Fig. 2),
and the lowest part of an obstacle of any other type.
30 This positioning was selected of course because of the
ubiquitous influence of gravity. That is, if an ob-
stacle has fallen off a shelf, it will normally come
to rest on the floor, and may not be detected if the
light sources and detectors are not located near the
35 floor. A person's weight will normally be borne by

the floor when that person is in the aisle. The floor is simply the lowest plane for supporting any potential obstacle. On the other hand, the entry-exit source-detector pairs 28 are most preferably positioned somewhat higher, between knee height and end-of-arm height, so as to give the most reliable directional indication. Horizontally, the in-aisle light sources 34 and light detectors 36 are preferably placed every twelve to eighteen inches along the length of the blocking object 24 and movable storage unit 10, respectively.

Another embodiment of the invention is shown in Figs. 5 and 6. In this embodiment an array 44 of light source-detector pairs are mounted to the mobile storage unit 10 and the blocking object 24, positioned at the entry point to the aisle 26. As with the entry-exit source-detector pairs 28, 30 shown in Figs. 1 through 4, the source and detector of each pair are mounted to opposite sides of the aisle, and sight-aligned with each other. In this embodiment, the source-detector pairs are arranged in two substantially parallel substantially vertical columns. As with the embodiment shown in Figs. 1 through 4, in this embodiment the detectors of each source detector pair are connected to the control unit 22, permitting the control unit to determine when an obstacle enters the aisle, and when an obstacle exits the aisle. This arrangement has the effect of providing a "curtain" of light sources and detectors, improving further the reliability of the directional detection of movement into and out of the aisle, and resulting in the ability to count persons or obstacles entering or leaving the aisle. In this embodiment the control unit 22 includes corresponding programming to keep track of how many persons (or other obstacles) have entered the

aisle, and how many of those persons or obstacles have left the aisle. That way, the control unit 22 will refuse to close the aisle if there are still persons or obstacles in the aisle.

5 Accordingly, the invention provides improved functionality over prior art sweeps and safety floors, even the photoelectric sweep disclosed in U.S. Patent No. 5,121,975, referred to above.

10 While the apparatus hereinbefore described is effectively adapted to fulfill the aforesaid objects, it is to be understood that the invention is not intended to be limited to the specific preferred embodiment of bi-directional motion sensor for mobile storage systems set forth above. Rather, it is to be
15 taken as including all reasonable equivalents within the scope of the following claims.

We claim:

1. In a mobile storage system including at least a first movable storage unit with a prime mover adapted to move the shelving unit along a path of movement, and at least one blocking object, such as a second movable storage unit, stationary storage unit or wall positioned on the path, a detector for detecting the entry of an obstacle into the path of movement and the exiting of an obstacle from the path of movement, that detector comprising:

two light source-detector pairs, each including a light source and a light detector, the source and detector of each pair being mounted opposing and sight-aligned, one of each pair mounted to one of the first unit and the blocking object, and the other of each pair mounted to the other of the first unit and the blocking object;

those light source-detector pairs being spaced apart at least horizontally and positioned so that each light detector receives light from the opposing light source when an obstacle is not positioned therebetween, thereby providing reliable information on the direction of movement of the obstacle between the sources and detectors; and

a control unit connected to the light detectors and receiving a signal from each light detector, that signal indicating whether or not the light detector is receiving light from one of the light sources, the control unit disabling the prime mover from moving the movable shelving unit along the path when the control unit determines that an obstacle has entered the path and has not

35

yet left the path.

5

2. The combination of claim 1 wherein the path of movement between the first unit and the blocking object when they are separated forms an aisle, those light source-detector pairs being mounted such that the light from the light sources passes across an entry point of the aisle.

3. The combination of claim 2 wherein the two source-detector pairs are substantially horizontally aligned.

5

4. The combination of claim 3 further comprising a plurality of in-aisle light sources mounted to one of the first unit and the blocking object, and a corresponding number of in-aisle light detectors mounted to the other of the first unit and the blocking object, the in-aisle light sources and light detectors positioned so that the in-aisle light detectors are likely to be blocked by an obstacle existing in the aisle.

5. The combination of claim 4 wherein the in-aisle light sources and light detectors are mounted substantially at the bottom of the first unit and the blocking object.

6. The combination of claim 5 wherein said control unit includes discerning means for determining which of the in-aisle light detectors if any is not receiving light from the light sources.

5

7. The combination of claim 6 wherein the discerning means uses the information about which of the in-aisle light detectors is not receiving light to determine where along the aisle the light detectors are not receiving light.

8. The combination of claim 1 wherein the light sources transmit infrared light.

9. A mobile storage system comprising:

at least a first movable storage unit;
a prime mover adapted to move the storage unit
along a path of movement;
5 at least one blocking object, such as a second
movable storage unit, stationary storage
unit or wall, positioned on the path;
two light source-detector pairs, each including
a light source and a light detector, one of
10 each pair mounted to one of the first unit
and the blocking object, and the other of
each pair mounted to other of the first unit
and the blocking object, the two source-de-
tector pairs laterally spaced apart from
15 each other;
those light source-detector pairs positioned on
the first unit and blocking object so that
each light detector receives light from the
opposing light source when an obstacle is
20 not positioned therebetween, so as to pro-
vide reliable information on the direction
of movement of the obstacle between the
sources and detectors; and
a control unit connected to the light detectors
25 and receiving a signal from each light
detector, that signal indicating whether or
not the light detector is receiving light
from the respective light source, the con-
trol unit disabling the prime mover from
30 moving the movable shelving unit along the
path when the control unit determines that
an obstacle has entered the path and has not
yet left the path.

10. A mobile storage unit as recited in claim 9
wherein the path of movement between the first unit
and the blocking object when they are separated forms

an aisle, those light source-detector pairs being mounted such that the light from the light sources passes across an entry point of the aisle.

11. A mobile storage unit as recited in claim 10 wherein the two source-detector pairs are substantially horizontally aligned with each other.

5 12. A mobile storage unit as recited in claim 11 further comprising a plurality of in-aisle light sources mounted to one of the first unit and the blocking object, and a plurality of in-aisle light detectors mounted to the other of the first unit and the blocking object, the in-aisle sources and detectors positioned so that the in-aisle detectors are likely to be blocked by an obstacle existing in the aisle.

13. A mobile storage system as recited in claim 12 wherein the in-aisle detectors and sources are mounted substantially at the bottom of the first unit and blocking object.

14. The combination of claim 9 wherein the light sources transmit infrared light.

15. A mobile storage system comprising:

at least a first movable storage unit;

a prime mover adapted to move the storage unit along a path of movement;

5 at least one blocking object, such as a second movable storage unit, stationary storage unit or wall, positioned on the path, there being an aisle between the storage unit and the blocking object when they are spaced apart from each other;

10 two light source-detector pairs spaced apart at least horizontally, each pair including a source and a detector, the source and detector of each pair mounted opposing, one of

15 each pair mounted to one of the storage unit
and the blocking object, and the other of
each pair mounted to the other of the stor-
age unit and the blocking object, each light
20 detector thus receiving light from the op-
posing light source when an obstacle is not
positioned therebetween, thereby providing
reliable information on the direction of
movement of the obstacle between the sources
and detectors;

25 a control unit receiving a signal from each light
detector indicating whether or not each de-
tector is receiving light from one of the
light sources, the control unit disabling
the prime mover from moving the movable
30 shelving unit along the path when the con-
trol unit determines that an obstacle has
entered the aisle and has not yet exited the
aisle;

35 a plurality of in-aisle light sources mounted to
one of the first unit and the blocking ob-
ject, and a plurality of in-aisle light de-
tectors mounted to the other of the first
unit and the blocking object, the in-aisle
light sources and light detectors positioned
40 so that the in-aisle light detectors are
likely to be blocked by an obstacle existing
in the aisle;

45 the control unit including discerning means for
determining which of the in-aisle light
detectors if any is not receiving light from
the in-aisle light sources.

16. A mobile storage system as recited in claim
15 wherein the discerning means uses the information
about which of the in-aisle light detectors is not re-

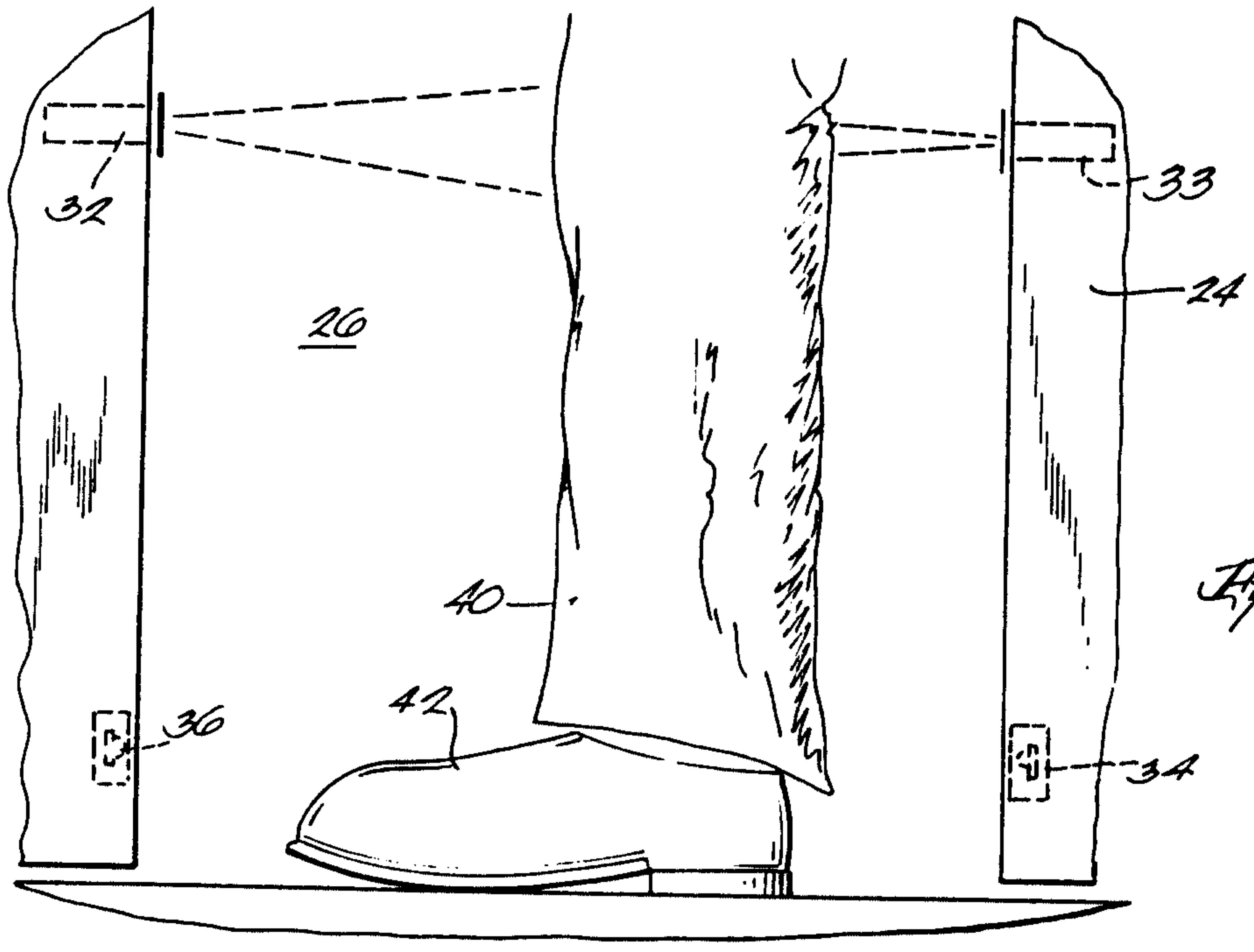
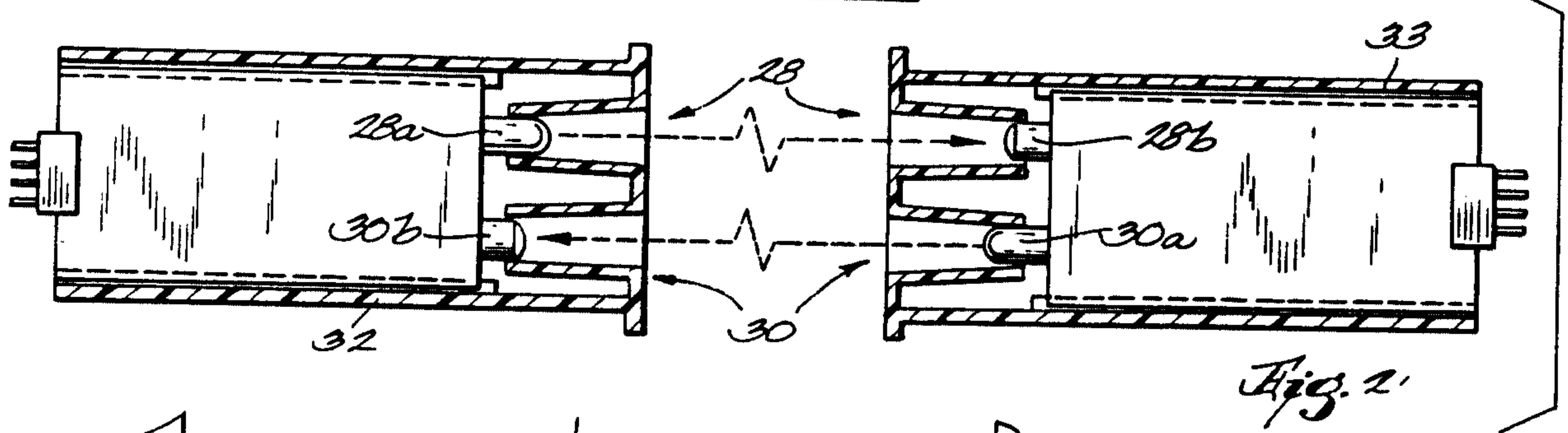
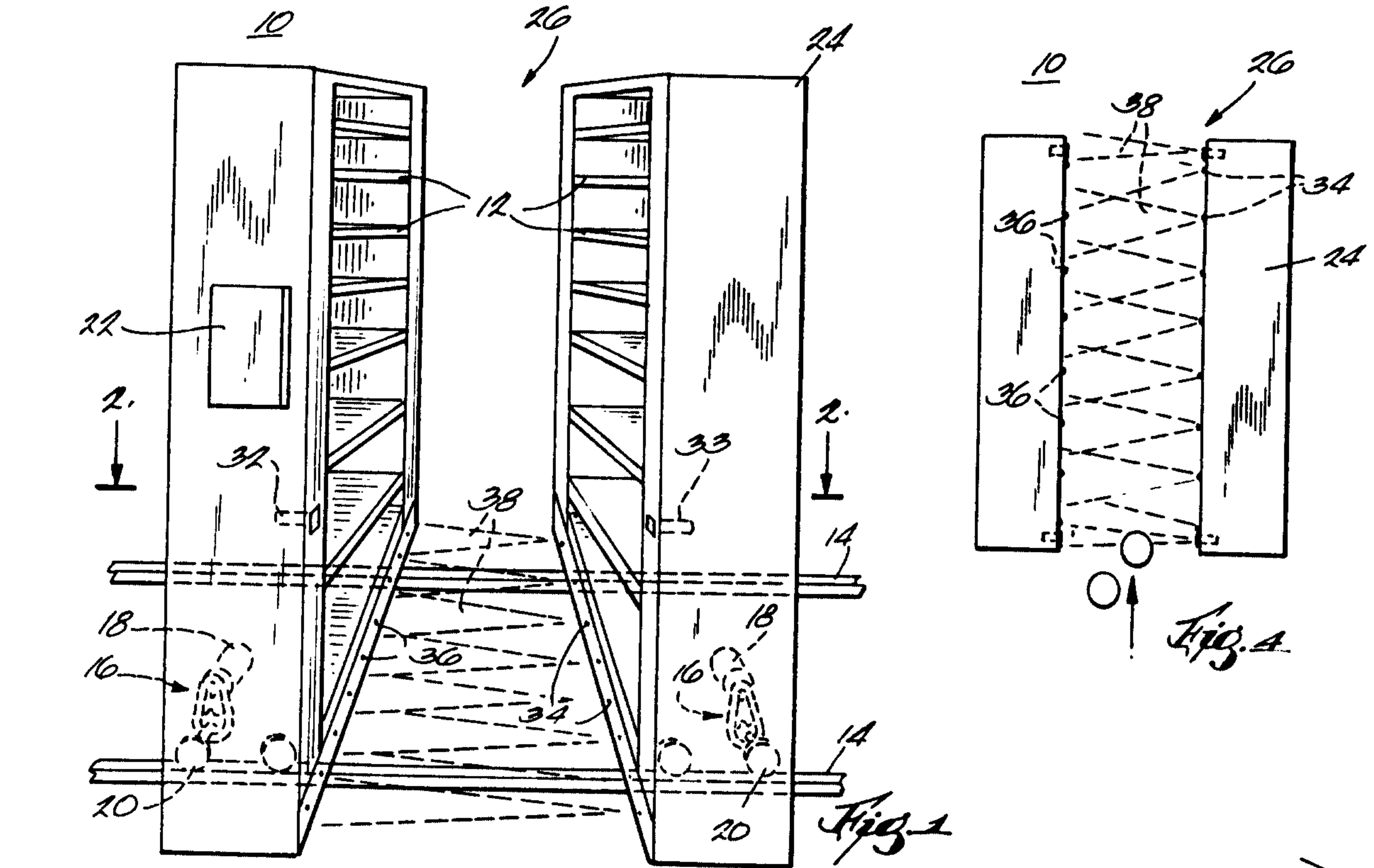
ceiving light to determine where along the aisle the in-aisle light detectors if any are not receiving light from the in-aisle light sources.

17. A mobile storage system as recited in claim 15 wherein the in-aisle light detectors and light sources are mounted substantially at the bottom of the first unit and the blocking object.

18. A mobile storage system as recited in claim 15 wherein the light sources transmit an infrared signal.

5 19. A mobile storage system as recited in claim 15 further comprising an array of light source-detector pairs mounted to the storage unit and the blocking object, positioned at the entry point to the aisle, the source and detector of each pair being mounted across the aisle from each other and sight-aligned, and arranged in two substantially vertical columns, each row having two sources or detectors substantially horizontally aligned.

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