

[54] **PHOTOELECTRIC CONTROL FOR
LOAD HANDLING DEVICE**

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214/16.42 R, 250/222

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[58] Field of Search **187/9, 1; 214/16.4, 16.42 R;**
250/219 Q, 222, 223; 212/128 PH

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[57] **ABSTRACT**

A load handling device carrying light sensitive means and a light source moves relatively to a load with a focused beam from the light source scanning the load. The light sensitive means receives light of said beam reflected from the load, and any variations of the reflected light because of variations in the load, will cause the light sensitive means to particularly condition a control circuit for the load handling device. By utilizing a light sensitive means such as two photoelectric cells, variations in ambient light do not significantly affect the operation of the light sensitive means and control circuit.

8 Claims, 9 Drawing Figures

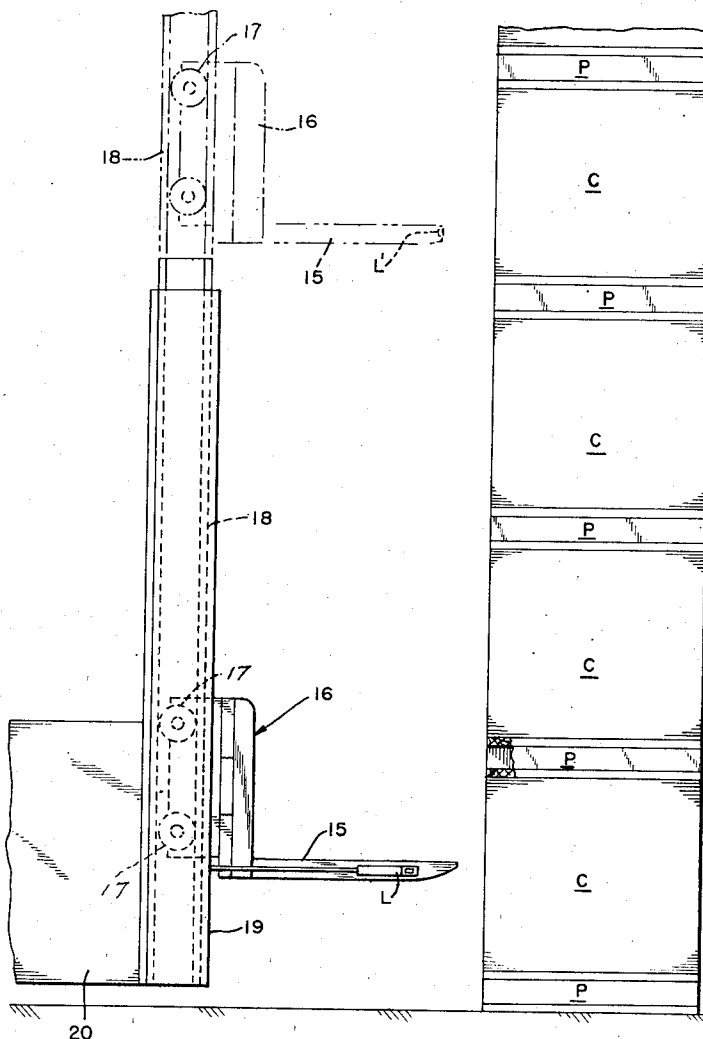
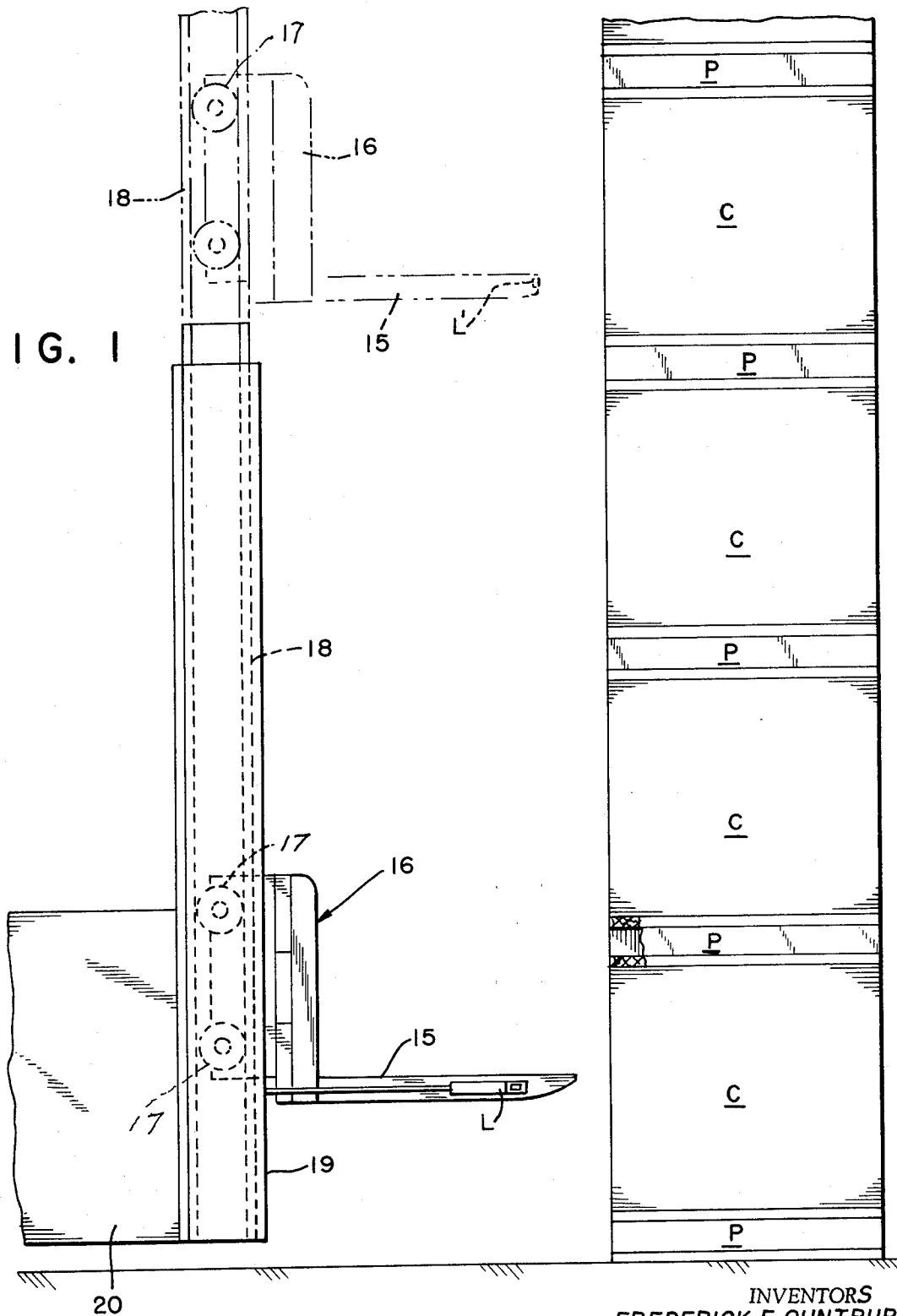


FIG. 1



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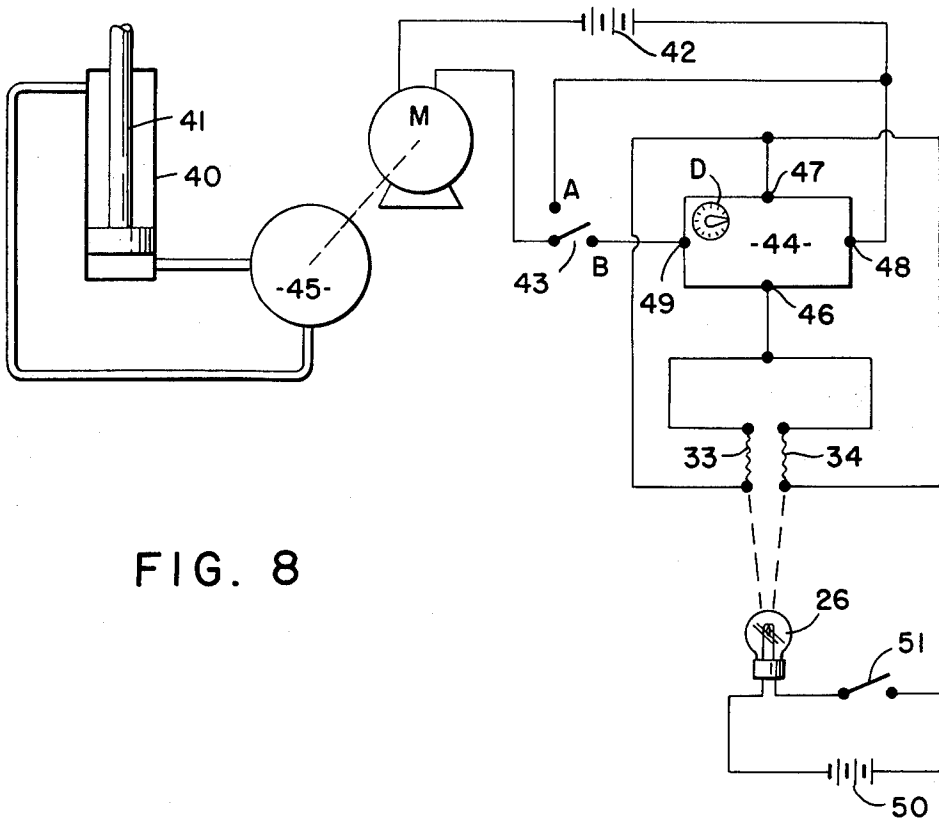
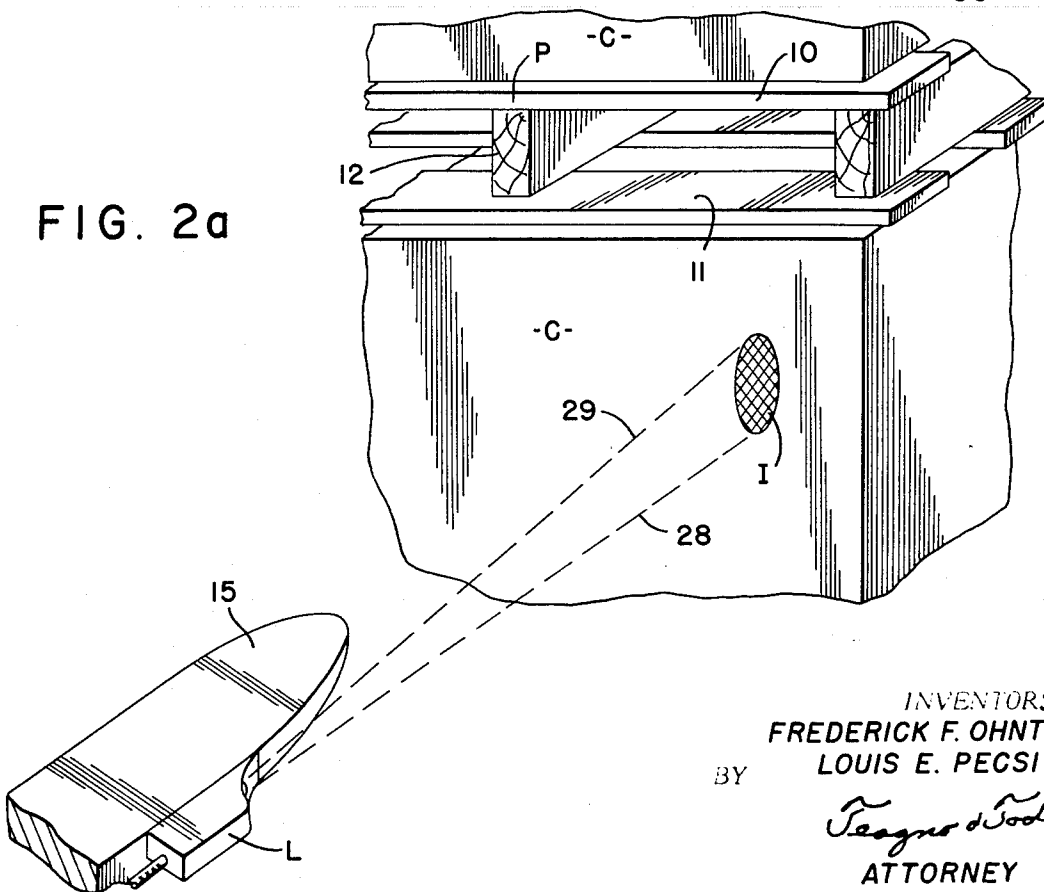


FIG. 8

FIG. 2a



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FIG. 2b

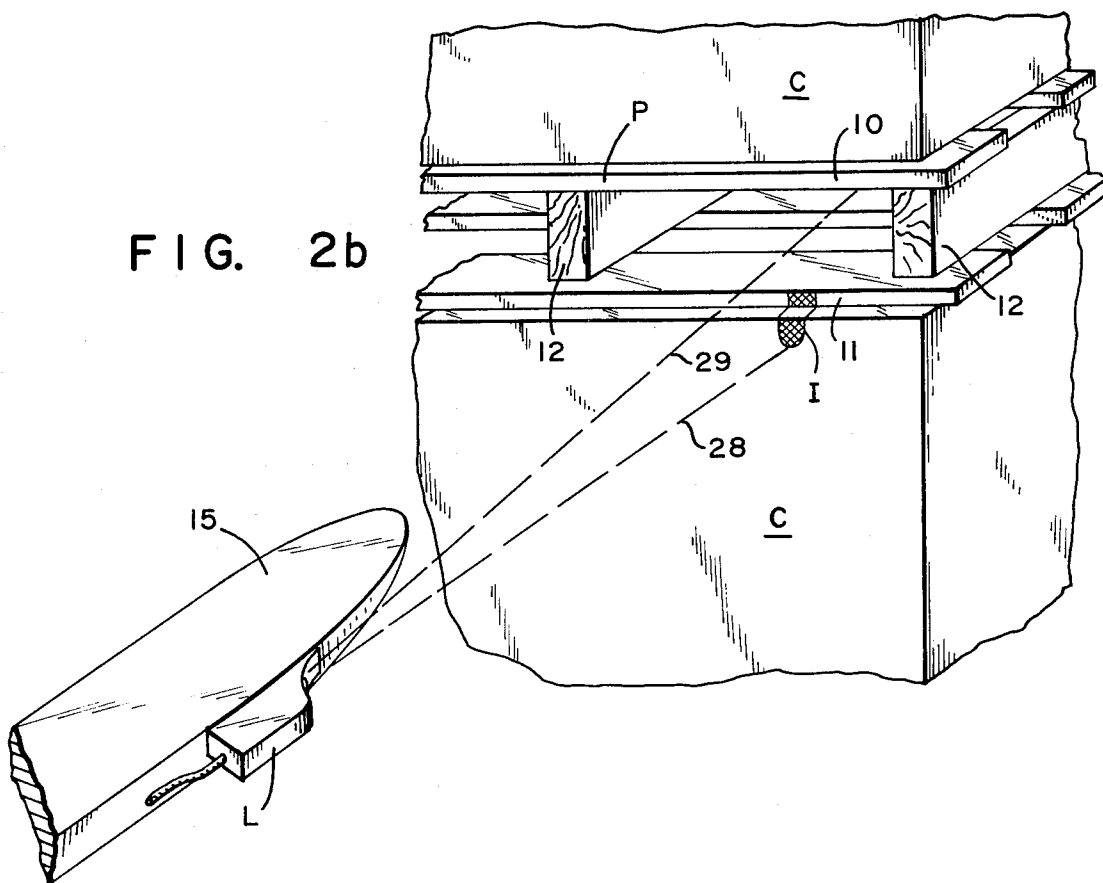
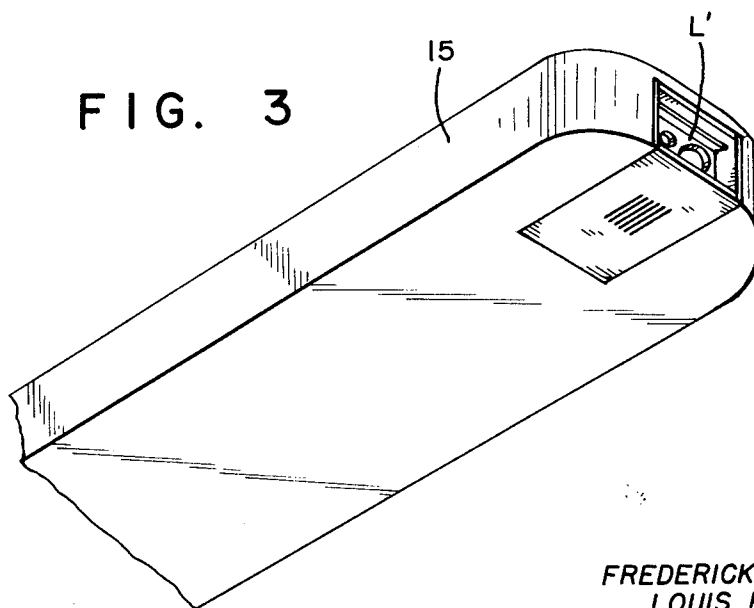


FIG. 3



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FIG. 4

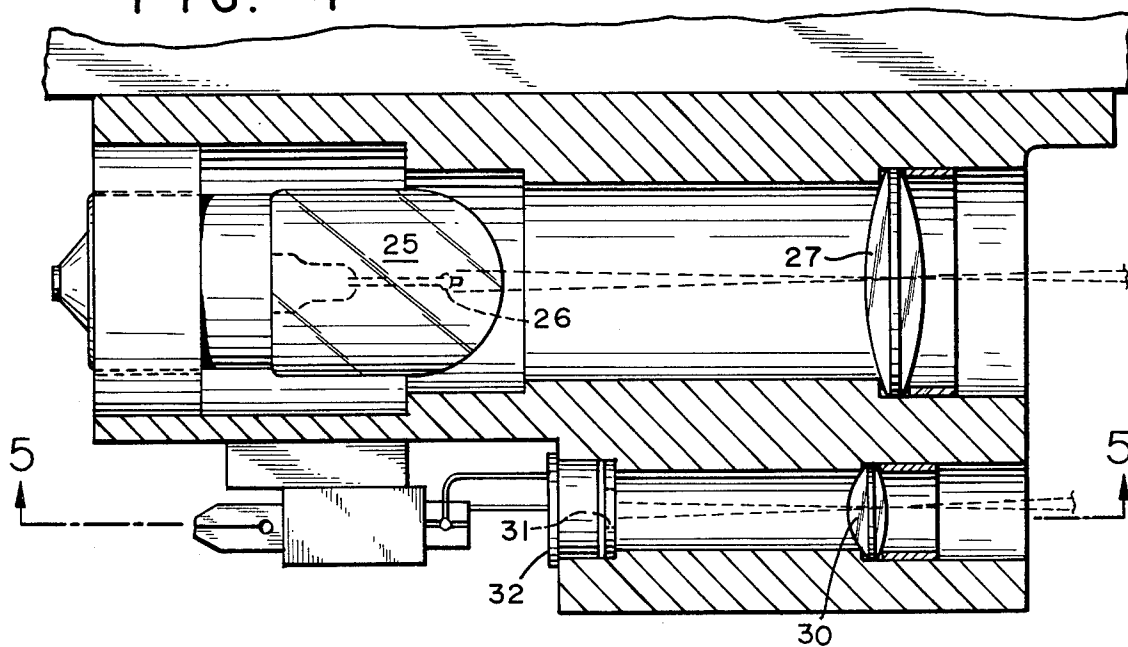


FIG. 5

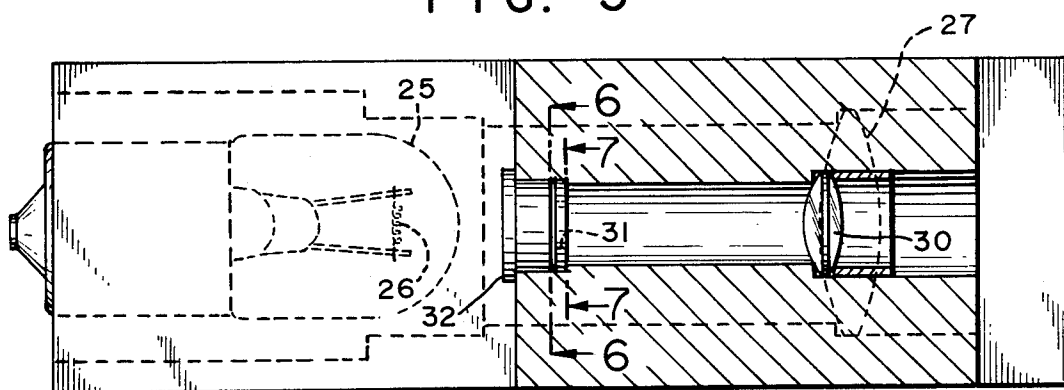


FIG. 6

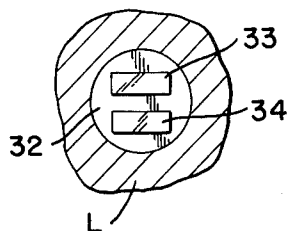
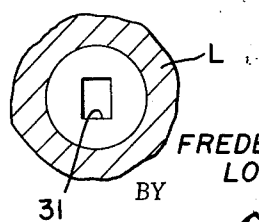


FIG. 7



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PHOTOELECTRIC CONTROL FOR LOAD HANDLING DEVICE

BACKGROUND OF INVENTION

This invention relates to means for controlling material handling apparatus, so as to position that apparatus effectively relatively to a load. More particularly, the invention relates to means, including light sensitive means, that may, as an example, stop the movement of a load handling mechanism so that the load handling mechanism will be in effective relation to a load.

DESCRIPTION OF THE PRIOR ART

There is much prior art that discloses means for stopping the movement of a load handling device at a particular point, so that a load may be deposited by the load handling device, accepted thereby, or otherwise handled. This is particularly true in the control of vertically moving load handling devices. The reasons for this are made clear when it is understood that warehouses, because of land costs, are now erected with extremely high ceilings so that containers or the like may be stacked one on top of another, or on skids or pallets, to a very considerable height. The operator of the load handling device, unless he moves with the container, if it forms the load, finds it extremely difficult to align the load handling device with the position where the container is to be accepted or deposited by the materials handling device. This is particularly true where the operator is standing or sitting on a vehicle at a relatively low level, and the container or other load is to be stacked or removed from a stacked position at a relatively high level.

By moving the operator and the load together, it is naturally possible to obviate some of the difficulties, but a vehicle for moving the operator and the load together is relatively costly and also very large and cumbersome.

It has been suggested that some means, such as calibrated tapes or calibrated load moving mechanisms be utilized, these mechanisms being calibrated in accordance with standard load spacings. However, such mechanisms are not desirable, since it is very difficult to obtain the correct calibration, as those skilled in the art will appreciate. Also, the utility of said calibrated means is limited because of variations in loads.

There are also material handling mechanisms in which light sensitive means are utilized to control movement of certain load handling devices. However, light sensitive means of the class described and today known, must also be calibrated in order to operate effectively, as they generally rely on the making and breaking of a light beam and are difficult to control and regulate. In any event, so far as we know, no effective photoelectric control mechanism has ever been contributed by the art to yield the results which flow from our invention.

OUTLINE OF INVENTION

Our invention contributes to the art a concept of a photoelectric control for material handling mechanism, that is most simple and effective and is usable with varying sizes of containers or other load units. Our photoelectric control, unlike that of any prior art control, utilizes a light image reflected from the load as the load is scanned by a moving beam of light from a light source. The word load, as used by us, may mean a stack of cartons, a series of containers resting on superimposed racks, or any other arrangement of material to be handled. Since there is always a considerable differential between the light reflecting characteristic of a load element such as a carton relatively to the light reflecting characteristic of a space between the loads or a pallet for supporting a carton, it therefore becomes relatively simple to control the load handling mechanism by providing control means which operate on the differential in the light reflected from the carton and the space between cartons or between the carton and a pallet or other carton supporting means.

It is also possible to utilize particular reflecting materials located on the load or load spacer in operating under the broad concept of our invention.

As a feature of our invention, we preferably mount a light source on a part of the load handling mechanism that moves relatively to the load units to be handled. Thus, if load forks constitute a part of the load handling mechanism, the light source will be on the forks. The light sensitive means will also preferably be on the forks. Therefore, as the forks move, a defined light image emanating from the light source will scan the load. We are here using the word load broadly as earlier defined. The image on the load caused by the light will be reflected directly to the light sensitive means, and obviously, any variations in reflected light will be detected in direct relation to the position of the forks relatively to the load.

As a particular feature of our invention, we utilize a pair of light sensitive means spaced in that direction in which the load handling device moves and we apply both ambient light and reflected light from the image to both light sensitive elements. In other words, both light sensitive elements are exposed to the light within the warehouse in which the load handling device operates, generally termed ambient light and to reflected light from the projected image. By placing the light sensitive elements in juxtaposition, but spaced in a direction in which the load handling device moves and utilizing an image elongated in that direction, it is obvious that even a very slight movement of the load handling device in a particular direction can be controlled by the light sensitive elements when a substantial change in reflected light occurs during said movement of the load handling device.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view showing a typical load handling mechanism positioned relatively to a typical load comprising a series of cartons stacked on a series of pallets.

FIG. 2a is an isometric view showing a preferred embodiment of the present invention and the manner in which a light beam is projected for reflection from a load such as that shown in FIG. 1.

FIG. 2b is an isometric view showing the position at which the light beam of FIG. 2a would stop the load handling mechanism.

FIG. 3 is an isometric view showing the invention of the present application applied to the forks of an industrial truck in a form different from that illustrated in FIGS. 2a and 2b.

FIG. 4 is a sectional view taken horizontally through the casing shown in FIG. 2a in which the light source and light sensitive elements of the present invention are mounted.

FIG. 5 is a sectional view taken along line 5-5 of FIG. 4.

FIG. 6 illustrates the vertical spacing of the light sensitive elements used in the construction shown in FIGS. 4 and 5.

FIG. 7 is a sectional view taken along line 7-7 showing an apertured disc utilized as part of our invention.

FIG. 8 is a diagrammatic showing of a control circuit utilizing our invention.

DESCRIPTION OF THE INVENTION

Referring now more particularly to the drawings, we show in FIG. 1 a typical load handling mechanism and a typical load comprising a series of cartons C stacked vertically, with each carton resting on what the art calls a pallet P.

In FIG. 2a we show in more detail two cartons C separated by a pallet P. Here the pallet has upper boards 10 and lower boards 11 separated by what the art terms stringers 12.

Standard industrial truck forks are adapted to enter between the two boards 10 and 11, with one fork at one side of a central stringer 12 and another fork at the other side of the central stringer 12. Obviously, vertical upward movement of the forks, when so positioned, will lift the carton and pallet with the spaced forks providing the necessary support for balancing the carton.

In FIG. 1 the forks of the load handling mechanism are designated by reference numeral 15, and in the particular form illustrated, these forks are part of a carriage 16 that has vertically spaced upper and lower rollers 17 mounted for

movement in the channel of a standard form of secondary or moving upright 18. This secondary upright 18 is adapted to move relatively to a primary or relatively fixed upright 19. The fixed upright 19 is shown as being attached to a generalized mobile support 20. The purpose of the arrangement is to allow relatively high movement of the carriage relatively to the primary uprights 19 through movement on the movable uprights 18, which in turn move relatively to the uprights 19. The particular construction will not be described more fully, since it is a standard in the art, and generally forms part of an industrial lift truck.

The forks may be part of a stacker or even a crane. It is only necessary to know that our invention provides means for controlling the positioning of a load handling device such as the carriage 16 and any load handling means thereon, such as forks, a ram, platform, or the like with respect to a load.

The forks 15 shown in the lower position in FIG. 1 in solid lines are equipped with light means within a casing designated generally by the letter L, this being the particular construction that is also illustrated in FIGS. 2a and 2b where casing L is shown applied to a fork 15.

In the upper fork position of FIG. 1 drawn in phantom, we show the carriage 16 elevated, and there as well as in FIG. 3 a different form of light sensitive assembly L' is illustrated. Thus, it will be seen in FIG. 3 that the casing L' is housed within the fork 15 and at the very end thereof.

In FIG. 1 the secondary upright 18 is shown in phantom in an elevated position, and with the carriage 16 also elevated thereon to a relatively high position. Again, it is indicated that this showing is merely for the purpose of setting forth the general relationship of our invention to the art.

Referring now to FIGS. 4, 5, 6 and 7 we illustrate in detail the construction of a preferred form of the light mechanism of our invention. There it will be noted that within the casing L there is a lamp 25 having a strong light projecting filament 26. The light emitted by the filament 26 is projected by a beam focusing lens 27, which sends forth what is termed an incident beam which is focused as an image I on the loads being scanned. As is well illustrated in FIG. 2a, this beam will lie generally between the two lines 28 and 29 extending from the casing L, to the load. The beam of light and the resulting projected image I are well defined with a minimum of light loss due to scatter.

The light reflected back from the cartons C, should be received by light sensitive means as closely aligned to the light source as is possible. In fact, theoretically, coaxial alignment would be most desirable. Naturally, this is not possible, but we have arranged to place the photocells that we utilize as closely as possible to the axis of the light source 25.

In the preferred form of our invention, the light image I from filament 26 is reflected from the surface of carton C and enters the casing L through a lens 30 positioned with its center relatively near the centerline of the focusing lens 27. This lens 30 focuses and transmits the reflected image of light through an apertured disc 31 shown best in FIG. 7 onto a pair of photoconductive elements 33 and 34 which we utilize. This aperture in disc 31 is generally rectangular and relatively small. The purpose of the aperture in disc 31 is to crop or eliminate as much ambient light as possible in order to maintain more uniform control of the light received by the photoconductive elements 33 and 34. The light sensitive photocell or photoconductor is held within a casing 32, and comprises an upper photoconductive element 33 and a lower photoconductive element 34. In the construction we have utilized and as shown in FIG. 6 these conductors are vertically spaced and separated and have an overall width greater than the width of the aperture in disc 31. The vertical spacing is necessary in order to allow physical separation of the signal created in the elements 33 and 34 by the reflected image focused thereon and to prevent electrical shorting of the elements 33 and 34.

The width of the elements 33 and 34 is dictated by the fact that the light source and the photosensitive elements are not

coaxial. In other words, the reflected image received by the elements 33 and 34 will move horizontally across the elements 33, 34 as the angularity of the incident and reflected image varies due to changes in the distance between the light casing L or L' and the load.

It will now be appreciated that when light is transmitted from the filament 26 through the lens 27 and is focused against the cartons C as a well defined image I, a portion of the light from the image I will be reflected back to the two photoconductors 33 and 34.

Due to the defined and coherent nature of the image I on the carton C, the reflected light is also defined and coherent in pattern, although a portion of the reflected light is, of course, lost in scatter. A sufficient quantity of light is returned so as to be focused by the lens 30 on the photoconductive elements 33, 34. The result of the focus of lens 30 on the photoconductive elements 33, 34 is to illuminate the photoconductive elements 33, 34 with a high quantity of light.

Since the original image I focused on the cartons C was created by the filament 26 of the lamp 25, the original image will approximate, within reasonable limits, the shape of the filament 26. Hence, for most effective utilization of the light available from the lamp 25 used in our invention, we have orientated the lamp 25 so that the longitudinal axis of the filament 26 is disposed in a direction parallel to the direction of motion of the carriage 16 and hence the longitudinal axis of the image is orientated in the same direction. The advantages of this procedure will become more apparent from a further reading of the description which follows.

Orientating the longitudinal axis of the image in the direction of motion of the carriage 16, allows the reflected image which is focused by the lens 30 at the surface of the photoconductors 33, 34 to have its maximum dimension in the direction of motion of the carriage 16 and permits approximately equal portions of the focused, reflected image to fall onto the respective photoconducting surfaces of photoconductive elements 33 and 34.

The reflected image of light is focused through the lens 30 and will be inverted at the photoconductive elements 33, 34. In other words, the portion of reflected light above the axis of the lens 30 will strike lower photoconductive element 34 and the portion of reflected light below the axis of the lens 30 will strike upper photoconductive element 33.

The photoconductive elements 33, 34 will receive equal amounts of ambient light at all times. Ambient light is focused by the lens 30 onto the photoconductive elements 33 and 34 and is additive to the light from the image focused thereon. Thus, when a load is being scanned as shown in FIG. 2a, these elements 33, 34 will each receive equal amounts of reflected focused light from the image projected onto the cartons C and additionally each will receive equal amounts of ambient light.

When the scanning beam of light or image I of FIG. 2a reaches an opening in the load as shown at FIG. 2b, one portion of the image I, the lower portion, is still reflected from the carton C and is focused by the lens 30 onto the upper photoconductive element 33; the other portion of the image I passes off into the space between the boards 10 and 11 of the pallet and is not reflected, thus depriving photoconductive element 34 of reflected light. Thus, the lower photoconductive element 34 will not receive the same amount of reflected light as the upper photoconductive element 33.

As persons skilled in the art know, the conducting capacity of a photoconductor is dependent upon the amount of light it receives. When both photoconductors 33, 34 receive equal amounts of light, their respective conductances are equal. When an opening in the load being scanned is reached as shown in FIG. 2b, an imbalance or differential in conductivity of the elements 33, 34 is created. Consequently, when the photoconductive elements are wired as shown in the circuit of FIG. 8, it is possible to obtain and utilize a differential in potential drop across the respective photoconductors 33, 34 to actuate a control 44 to stop the motor M which will stop the pump 45, the piston 40 and the carriage 16 which is attached to the piston 40 through the rod 41.

At all times, the photoconductors 33 and 34 will receive some ambient light as well as light reflected back from the cartons C. From the circuit of FIG. 8 it can be seen that the effect of ambient light, regardless of the intensity (within a reasonable upper limit) will be negated and have little effect on the operation or sensitivity of our device as our device operates on the differential between the light falling on photoconductor 33 and that falling on photoconductor 34. As earlier outlined, the load will actually be scanned by the moving light beam generated by filament 26, as the fork 15 of FIG. 2a moves upwardly, and the light from the image I will be reflected to photoconductors 33 and 34. When a portion of the beam projected against a carton C moves into the space between the upper and lower boards 10 and 11, as shown in FIG. 2b, one of the photoconductors 33, 34 will receive less reflected light than the other as was described in detail above. When this happens, a differential voltage is created across the photoconductors 33 and 34 which can be utilized to actuate a control mechanism for stopping any further movement of the carriage 16, as was indicated above and will be further outlined hereinafter.

It will now be appreciated that our invention resides basically in the concept of utilizing light reflected from a load having light reflecting portions of varying effectiveness, for controlling the movement of a load handling mechanism. At the same time, through the use of a particular arrangement of photoconductor elements, we eliminate any errors that may develop because of ambient light. It should be appreciated that the light from filament 26 could be directed at an angle so as to scan juxtaposed portions of a carton covered by reflective tapes. Obviously, light reflected by the tapes would exercise the same control over the photoconductors 33, 34 as in the example we just described, where the light beam scans a carton and pallet.

By reference to FIG. 8, we shall now describe the operation of the invention, with certain additional control mechanisms applied thereto, in order to make possible more effective utilization of our invention.

In FIG. 8, reference numeral 40 indicates a hydraulic cylinder having a piston 41 that is utilized for lifting a load. In the present apparatus, this load will be the carriage 16 carrying forks 15. The piston 41 will move under the control of a pump 45 driven by a motor M. Thus, upon actuation of the motor M, the pump 45 will transmit fluid to ram cylinder 40 to lift the carriage 16. Naturally, other controls such as valves will be utilized, but it is not necessary to outline those here as they are standard in the art and do not aid in an understanding of the present invention.

Motor M is in a circuit with a power source such as battery 42, and a manually operated switch 43. The switch 43 has actuated positions A and B, so that the operator may manually start or stop the operation of the motor M and motor driven pump 45 whenever that is desired by moving the switch 43 to the position designated A.

When switch 43 is moved to position B, the circuit includes a control box 44. Means are provided within this control box for interrupting current flow through the circuit in response to a voltage differential between the photoconductors 33 and 34, thus stopping further the operation of the motor M. Therefore, the operator may start the lifting of the forks 15 by closing the switch 43 to position B, but the circuit that he has closed, will be opened by operation of control box 44 whenever the forks move into a particular elevated position as determined by the light sensitive means, photoconductors 33, 34 as controlled by the reflected light from the image I of light source 26. The two photoconductor elements 33 and 34 will operate to control the circuit of the motor M in a standard manner at box 44, and that is why no particular circuit within the box 44 will be described.

In the circuit we utilize, light from the filament 26, when received by the two photoconductor elements 33 and 34 in equal intensity, will set up a condition in which no current will flow through the control circuit in box 44, since the voltages at 33 and 34 will be equal. When either of the two photoconduc-

tors 33 and 34 receives more light than the other, there will be a difference in the voltage drops across these elements, and control current will flow through the control circuit in box 44 for opening the circuit through the motor M.

Unless controls additional to those illustrated are present, it is obvious that the forks 15 would, utilizing the circuit thus far described, stop each time they moved opposite a pallet P. This may not be desirable. As an example, should it be desired to lift only the topmost carton C of a series of cartons, with the forks 15 moving from the lower position of FIG. 1, the motor M should operate until the forks 15 pass several pallets P. This can be arranged by determining that filament 26 not be energized until after it moves with forks 15 into a particular height zone.

For this purpose, it will be noted in FIG. 8 that filament 26 receives its electric current from a battery 50. Electricity will flow from the battery to filament 26, and then through a normally open switch 51.

As an additional feature of our invention, we have included in control box 44 means in the form of a standard stepping relay or the like which is actuated by dial D to override the means for interrupting the power flow between terminals 48 and 49 until a preselected number of differentials in voltage drop between control terminals 46 and 47 occur.

The circuit of FIG. 8 being so comprised, thus provides for manual, semi-automatic or totally automatic operation of the lifting mechanism.

The operation of the various circuits just described will become more fully apparent from the description which follows.

If one thinks of the stack of cartons C as being divided into numbered height zones by the pallets P, the following description of operation can be more readily understood. In other words, the lowest pallet in the stack would be in zone "1," the second pallet would be in zone "2," the third pallet would be in zone "3" and so on.

If the operator desired totally manual operation of the load lifting mechanism, he would place switch 43 in position A and would thus bypass control 44. He would then proceed to raise the load lifting mechanism in the standard manner and complete the lifting and transfer of the load manually.

If the operator desired semi-automatic operation he would place switch 43 in position B. However, since light source 26 is powered by a second battery 50 and controlled by a second switch 51, only ambient light would be received by the photoconductive elements 33 and 34. Since the light received would be equal on both elements, no differential in voltage drop would exist at control terminals 46 and 47, therefore, power would flow from terminal 48 through control box 44 to terminal 49 and the load lifting mechanism would begin to rise. When the load lifting mechanism approached the zone at which the operator desired to make a lift, he would close switch 51 which would light the lamp 26 and project an image I of light onto the cartons C as shown in FIG. 2a.

The reflection of this image would be focused by lens 30 onto the photoconductive elements 33 and 34 and, since the reflected image is symmetrical with respect to the axis of the elements 33 and 34, each will receive an equal amount of illumination which is additive to the ambient illumination already existing on the surfaces thereof. Since, when equal quantities are added to already existing equal quantities, the results are still equal, no differential in voltage drop will exist across the terminals 46 and 47 and the load lifting mechanism will continue to rise.

When the load lifting mechanism reaches the position of FIG. 2b, one portion of the image will pass off into the space between the floorboards of pallet P, the other portion will be reflected from carton C to photoconductive element 34. As a result, a differential in voltage drop will occur across control terminals 46 and 47 and the control circuit 44 will be actuated to interrupt the flow of current between terminals 48 and 49 which will stop motor M. The operator can then proceed to insert the forks 15 between the floorboards of the pallet P and make the lift in the standard manner.

If totally automatic operation is desired, the operator will set dial D to the number of the zone at which he desires to make the lift. This will position a stepping counter or the like within control box 44 to count the number of differentials in voltage drop and only allow interruption of the power circuit when the predetermined number is reached. It should be noted at this point that two differentials in voltage drop will occur for each zone which the operator wishes to bypass. One when the top portion of the image reaches the opening in the pallets P and a second when the top portion of the image leaves the opening in the pallet P.

However, this is merely a factor in selection of the control 44. Such devices are presently known in the art and no further description is necessary for a full understanding of the invention of the instant application.

After setting the dial D to the number of the zone at which he wishes to make the lift, the operator will close switch 51 which will allow battery 50 to light lamp 26 and project its image onto a carton C of the stack to be scanned. The operator now will move switch 43 to position B which will actuate the load lifting mechanism. As the image from lamp 26 scans the stack of cartons C, the stepping counter within the control box 44 will count the zones through which the image passes and will allow the power circuit interrupting means within the control box 44 to be effective to stop operation of the motor M only when the preset number of zones have been passed.

It will be appreciated by those skilled in the art, that we can also arrange for the energizing of the filament 26 automatically by the movement of the carriage 16, utilizing various relays and switches. Also, we could otherwise arrange to render the means in box 44 inoperative except in a particular zone. Actually, it is merely important to consider that under our concept we not only bring about a stopping of the load carriage 16 at any desired zone in a stack of cartons, but do this with extreme accuracy because of the utilization of filament 26 and the photoconductor elements 33 and 34, with the filament and elements 33, 34 preferably movable together relatively to the load.

What we claim is:

1. In a combination of the class described, a load handling device, power means for moving said load handling device relatively to a load, light sensitive means for controlling said power means, a light source, focusing means whereby said

load handling device effects the directing of light from said light source, in a defined coherent beam toward said load to scan said load as said load handling device moves relatively to said load, means positioning said light sensitive means to receive light from said light source reflected from said load as it is scanned incidental to the movement of said load handling device, said light sensitive means comprising two light sensitive elements spaced apart in the direction of travel of said load handling device so that each receives a portion of the light from said light source reflected by the load whereby variations in light so reflected by said load as said beam is interrupted by elements other than said load will affect the operation of said light sensitive means and the control of said power means by said light sensitive means independent of variation in ambient light conditions.

2. In the combination of claim 1, the feature that said light source is on said load handling device.

3. In the combination of claim 2, the feature that said light sensitive means is also on said load handling device.

4. In the combination of claim 1, the feature that said light source and light sensitive means are in electrical circuit means, and means for controlling said electrical circuit means to render said light sensitive means inoperative when said load handling device is in particular parts of the path in which it is moved by said power means.

5. The combination of claim 1, in which said focusing means includes a first lens spaced from said light source to focus the beam emanating from said source against a load, and said load handling device further includes a second lens spaced from said light sensitive means to focus the beam reflected from said load thereon.

6. The combination of claim 1, in which said coherent beam is elongated in the direction of travel of said load handling device.

7. The combination of claim 5, including an apertured disc disposed between said second lens and said light sensitive means to further define said focused light beam reflected from said load.

8. The combination of claim 6, in which said light source comprises a lamp having a filament, and wherein the longitudinal axis of said filament is oriented in the direction of travel of said load handling device.

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