PHOTOELECTRIC PINFALL DETECTION SYSTEM

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Filed: June 5, 1972

Appl. No.: 259,614

U.S. Cl. 250/222 R, 250/235, 273/54 E, 273/54 C

Int. Cl. H01J 39/12

Field of Search 273/54 E, 54 C, 54 R, 250/221, 222, 223, 234, 235

References Cited

UNITED STATES PATENTS

2,609,200 9/1952 Rundell 273/43 R
3,140,872 7/1964 Bolger 273/54 E
3,145,025 8/1964 Morrison 250/222
3,309,086 3/1967 Viets 273/54 E
3,637,211 1/1972 Hutto 273/54 E
3,651,328 3/1972 Hutto 273/54 E

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ABSTRACT

The invention includes a photoelectric bowling pin detection device and its interface with a computer scoring device and automatic pinsetter. The photodetection device or scanner includes a light source and a photosensitive element mounted for simultaneous sweep across the pin deck of the lane and a drive motor. Sensing action of the scanner and transmission of pinfall data to the computer is controlled by optical sensors mechanically gated by a rotating cylindrical mask attached to the scanner drive motor. The scanner is activated by passage of a delivered ball past a ball detector which causes the count to commence immediately upon ball passage and prior to initiation of the pinsetter cycle. Two scanners may be used and their counts compared for accuracy. In the event that all pins are down, the pinsetter is signaled to set new pins without the customary delay or detection cycle.

23 Claims, 9 Drawing Figures
PHOTOELECTRIC PINFALL DETECTION SYSTEM

BACKGROUND OF THE INVENTION

The invention is in the field of pinfall detection systems for use with automatic bowling pinsetters, and is more specifically directed to the detection, storing and relaying of pinfall information to an electronic scoring system which calculates the bowler's score and may control the progress of the game by properly relating bowler identification, ball delivery and pinsetter action.

Among the previously issued U.S. Patents which may be considered relevant prior art are:

3,140,872 — Bolger: FLASH LAMP AND PHOTOCELL OPERATED BOWLING PIN SENSING DEVICE.
3,501,644 — Berler: RADIATION SENSITIVE BOWLING PIN SENSOR.
3,309,086 — Viets: PINFALL DETECTION APPARATUS.
2,613,933 — Johns: PHOTOELECTRIC CELL CONTROL FOR BOWLING ALLEYS.
2,980,424 — Sanders: AUTOMATIC PIN SPOTTER CONTROL MECHANISM.
3,239,222 — Sanders: CONTROL MECHANISM FOR DISABLING RESPOTTER UPON EITHER THE DOWNING OF A SELECTED PIN OR THE ROLLING OF A GUTTER BALL.
3,307,848 — Brackett: BOWLING PIN DETECTING APPARATUS.

The foregoing prior art illustrates that the concept of detecting pinfall with devices remote from the pinsetter is not new. However, prior to the invention, only those pin detection systems which were integrated into the automatic pinsetters were reliable enough to attain widespread public use and acceptance.

The invention was conceived primarily as a means of providing pinfall information to a bowling score machine without the necessity of electrical or physical interconnection with the pinsetter; however, optimum coordination between the two can best be provided by a ball passage detector and control circuitry which forestalls any interference from the pinsetter and causes the pinsetter to react more quickly in the event of a strike.

The background against which the invention was developed was a bowling scoring system, the principal features of which are described in U.S. Pat. No. 3,550,939 to a score computer, U.S. Pat. No. 3,582,071 to a certain peripheral equipment, and 3,278,186 to pinsetter mounted pin detection devices; all of which equipment comprises the bowling scoring system presently manufactured by the Brunswick Corporation.

The Brunswick system operates generally in the following manner. The bowler identifies himself to the computer by placing a control handle on a bowler identification panel to a position opposite his name and then proceeds to bowl in the ordinary manner. After each ball, the pinsetter cycles to clear and reset pins and to detect and signal to the computer the number of standing pins and their location. The computer calculates the bowler's score which is then printed and projected for the bowler's review, including "marks" such as strikes, spares and splits. In this system the computer exercises some control over the pinsetter, for example, by causing the rake to remain down upon the completion of a frame until the next bowler identifies himself, and also at the end of a game.

The invention was conceived as a novel means for providing pinfall information to the computer and also as a means for eliminating the time delay and detection cycle of the pinsetter in the event that all pins were knocked down either by the first or second ball. The inventors realized that if a quick pin count could be conducted immediately after ball passage and prior to the pinsetter cycle, the need for the traditional three-second delay in the pinsetter cycle to allow for late falling pins could be eliminated in the event that no pins remained standing; and the pinsetter signaled to set a full set of pins without going through its customary detection cycle. The invention has solved the problems of when and how to conduct such a count and the problems of how to interface the pin detector of the invention with a scoring computer and the pinsetter to achieve these desired results.

SUMMARY

Basically the invention includes a photodetection device having a light source and an optical detector axially aligned in a vertical plane, and means for sweeping the detection window of this assembly across the area occupied predominantly by the heads of standing pins. A frequency compensated direct coupled amplifier amplifies and separates the light pulses reflected from the pins for counting. A ball detector activates the scanner and its related computer control system immediately upon the passage of a ball through a selected position line across the lane. Timing of the scan is controlled by a pair of photocells and light emitting diodes gated by apertures in a rotating cylinder attached to the scanner drive motor. A binary code is utilized to coordinate data intake with the position of the scanning head relative to the pin standing areas of its two adjacent lanes. As each pin standing area may be interrogated by two scanners, means may be provided for comparing the two pin counts, with the highest being accepted by the computer. In the event that no pins are detected by the scanner, means are provided to signal the pinsetter to set a full set of pins without its programmed time delay or detection cycle.

Among the novel features and advantages of the scanner of the invention are:
1. its ability, with a single photocell, to discriminate between standing pins;
2. its ability to detect pins standing in either of two adjacent lanes;
3. it permits use of a bowling scoring system with minimum modification of the associated pinsetters; and
4. it greatly reduces the effect of pinsetter malfunction upon the performance of a bowling scoring system;
5. it is more economical to manufacture and install than pinsetter-mounted pin detection devices;
6. it eliminates the need for out-of-range detection on the pinsetters;
7. it eliminates pinsetter time delays in the event of a strike or a spare;
8. it is compatible with presently used bowling scoring devices; and
9. it eliminates feedback within the system through the use of optical coupling.
Accordingly, the primary objective of the invention is to provide pinfall information to a scoring computer through a device positioned apart from the pinsetter.

It is a further objective of the invention to detect a strike or spare condition prior to cycling of the pinsetter in order to eliminate that portion of the pinsetter cycle devoted to time delay and the sensing of standing pins.

It is another objective of the invention to provide a pinfall detection system suitable for use with a variety of automatic pinsetters, and which may in addition be coupled simultaneously to more than one scoring computer.

Other objectives, advantages and various further features of novelty and invention will be pointed out or will occur to those skilled in the art from a reading of the following specification in conjunction with the accompanying drawings.

**BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 is a schematic vertical cross section through a detector of the invention illustrating the manner in which a sensing light beam is focused upon and reflected from a standing pin.

FIG. 2 is a schematic illustration of two adjacent bowling lanes equipped with an optical detection system of the invention employing two scanners for each lane.

FIG. 3 is a vertical cross section through an optical scanner of the invention.

FIG. 4 is a cross sectional view of an optical scanner of the invention taken along the line 4-4 of FIG. 3.

FIG. 5 is a timing diagram of the data control signals or "windows" of the scanner of FIG. 3.

FIG. 6 is a schematic wiring diagram for an optical scanner of the invention.

FIG. 7 is a schematic wiring diagram of the interface between a scanner of the invention, a related pinsetter and an automatic scoring computer.

FIG. 8 is a wiring diagram of a synchronization network for use with the system of FIG. 7.

FIG. 9 is a schematic illustration of a detection system of the invention utilizing two scanners for each lane.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

FIG. 1 is a schematic representation of a detector 1 of the invention illustrating its mode of pin detection. The detector 1 is comprised of a base housing 2 upon which is mounted a drive motor 3 and a rotating oscillating shaft 4. A light source 5 with a focusing lens 6 and an optical detector 7, including a light collecting lens 8 and a phototransistor 9, are attached to the shaft 4.

The light source 5 and the optical detector 7 oscillate in unison and are focused at a mean distance of the pin heads 10 so that as the illuminating beam 12 sweeps across each pin head 10, a portion of the filament image generally focused thereon will be reflected back along the axis 15 of the optical detector 7 to a phototransistor 9. A series of such light pulses reflected by standing pins are detected by the phototransistor 9, amplified and counted as described below. The filament 13 of the source light 5 should align as nearly as possible with the vertical axis of the oscillating shaft 4 in order that the character of the illuminating beam 12 may be consistent throughout its detection sweep.

In order to reduce the amount of light from the light source 5 which will be visible to a bowler, red filter 11 may be placed in front of the focusing lens 6.

In order to avoid interference caused by reflections from other sources of illumination generally used in bowling establishments, an infrared filter 17 is placed in front of the light collecting lens 8. This filter helps eliminate detection of spurious reflections from extraneous sources of light which could produce a miscount. The discriminating characteristics of the detection and amplification circuitry described below further aid in avoiding any such spurious detection.

The detection field of the light-receiving and detecting unit 7 is determined by the characteristics of the light collecting lens 8 and is preferably limited to the approximate area of the image of the lamp filament 13 projected upon the pin heads by the light focusing lens 11. The resistance of the phototransistor 9 will vary with the variation in the intensity of the light reflected to it as the scan progresses across the pins. This variation creates a series of electrical pulses within the detection circuit (see FIG. 6), the peaks of which represent the points of maximum reflection from standing pins.

Discrimination between pins is aided by restricting the size of the filament image in the pin area to a flat plane area or detection window having a height of approximately three inches and a width of approximately one inch, and by focusing the filament image at a point where it will be most nearly focused upon the several pin heads during the scan. What the detector effectively "sees" is a bright vertical line of light created by that portion of the filament image reflected directly to the detector from the curved surface of a pin head.

FIG. 2 illustrates an embodiment of the invention wherein a detector 1 is positioned between two adjacent bowling lanes and counts pins standing upon each lane. For optimum performance a scanner may be placed on each side of each lane, or between each pair of lanes, so that the pin count is taken by two scanners. The two counts are then compared, with the higher being accepted as the most accurate.

As a result of extensive testing, a scanning sweep of approximately 60°, 30° to each side of the lane divider axis, has been found to be most satisfactory, with the scanner placed between 117 and 154 inches in front of the last row of pins; depending upon whether it is positioned over a ball return or a lane division cupping.

As optical ball passage detector 16, similar to a foot foul detector known to the art, is oriented across each lane in a position adjacent the scanner. As will be explained, detection of a passing ball by the ball detector 16 initiates the action of the scanner.

FIG. 3 is a more detailed schematic view of a scanner of the invention. A gating cylinder 20 is mounted upon a circular disc 21 attached to the bottom of the drive shaft 22 of the motor 3. An articulating linkage 23 having one arm 24 pivotally connected to the disc 21 at a point 25, and a second arm 26 rigidly connected to the bottom of shaft 4, oscillates the shaft 4 through a sector of approximately 60°. The shaft 4 is supported in the vertical position by a journal 27 attached by appropriate means to the housing 2.

FIG. 4 is a plan view of the gating cylinder 20 and its relation to electro-optical switching elements "A" and
“B” through which it functions to control the actions of the scanner. The electro-optical coupler units A and B are each comprised of a light emitting diode (LED) 31 on one side of the gating cylinder 20 and a phototransistor 30 disposed opposite thereto on the other side of the gating cylinder 20. The phototransistors 30 are connected in a series in the scanner control circuits so that current can flow within a circuit only when light from a LED 31 is permitted to illuminate its companion phototransistor 30. The side walls 33 of the gating cylinder 20 will block such light emissions except where the side walls have been cut away, as at 32, to permit light to pass. In FIG. 4 the hatched area 32 represents cutaway portions of the gating cylinder 20, while the solid portions 33 represent light blocking portions of the gating cylinder 20. For purposes of interpreting the following table, when the side wall 33 comes between a LED 31 and its companion phototransistor 30, the unit is considered to be in digital condition “0” or non-conductive; and when one of the window areas 32 opens therebetween, the unit is considered to be in digital condition “1” or conductive. The preferred angular spacing of the two optical coupler units A and B, and the sectors occupied by the solid 33 and the cutout 32 portions of the gating cylinder 20 are specified in FIG. 4. In this configuration the digital states assumed by detection units A and B as the gating cylinder 20 revolves therebetween are as follows:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>NO SCAN (Between Lanes)</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>OUTWARD SCAN RIGHT LANE</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>NO SCAN (Outside Edge of Right Lane)</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>RETURN SCAN RIGHT LANE</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>NO SCAN (Between Lanes)</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>OUTWARD SCAN LEFT LANE</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>NO SCAN (Outside Edge of Left Lane)</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>RETURN SCAN LEFT LANE</td>
</tr>
</tbody>
</table>

The optical axis of each detector is aligned between the adjacent bowling lanes when units A and B are in the “0” or “1” position, and the direction of rotation of the gating cylinder 20 must be appropriate to the right or left indication.

FIG. 5 is a timing diagram of the output signals 34 and 35 of the optical coupler units A and B as the gating cylinder 20 rotates through 360°. As shown in FIG. 6, signals 34 and 35 drive an exclusive OR circuit 36 which produces the data control signals or “windows” 42 and 43 in accordance with the above logic table.

FIG. 6 is a diagram of the scanner sensing, amplifier and control circuits, with a scanner interfaced with two separate scoring computers; as would be the case where the right lane scan is controlled by one computer and the left lane scan by another.

Referring to the lower portion of FIG. 6, output signals 34 and 35 from the electro-optical switching elements A and B are fed to an exclusive OR circuit 36 which determines where the scanner is looking in accordance with the above logic table. The outputs 38 and 39 of the OR circuit 36 are optically coupled through couplers 40 and 41 to the left and right scoring computers 44 and 45 where they become data control inputs or “windows” 42 and 43. The data control signals 42 and 43, derived from the output signals 34 and 35 of the optical couplers A and B, assure that incoming data on pin count is attributed to the proper lane.

Power for the left and right data control signals 42 and 43 is supplied by the left and right computers 44 and 45 respectively through the phototransistor elements 48 and 49 of the optical couplers 40 and 41.

All coupling between the scanner and its associated computers is optical to avoid problems of feedback between the scanner and the computer, or between the two computers and the scanner where two computers are involved.

Referring to the upper portion of FIG. 6, the scanner may be activated by an enabling signal 50 or 51 from the left or right computer, or a ball detector 16. The enabling signals 50 and 51 are optically coupled to a 28 volt AC power supply circuit 52 through optical couplers 54 and 55 respectively. Phototransistors 56 and 57 of the optical couplers 54 and 55 are connected in parallel within the power supply circuit 52 so that when either conducts as a result of light being emitted by its companion diode, 28 volts AC will be supplied through a triac 58 to a transformer 59 whose secondary coils 68 and 69 supply the drive motor 3 and the light source 5 of the scanners respectively.

The drive motor 3 is a constant speed motor rotating at approximately 150 RPM. This speed of rotation is significant in that it imparts a characteristic frequency to the signals representing standing pins, which characteristic is utilized by a frequency compensated operational amplifier 62 to distinguish signals representing standing pins from noise.

Referring to the center portion of FIG. 6, light pulses reflected from the pins render the phototransistor 9 conductive, causing current pulses to flow from a +15 VDC power source 60 through an 18K ohm current limiting resistor 61 to an input 83 of an operational amplifier 62. The strength of such signals varies generally from 30 to 60 MV. The voltage level of input 83 to the amplifier 62 is drawn down by connecting it through a 91K ohm resistor 84 to a variable 5K ohm pot 85. The pot 85 is connected in series between ground and a 470K ohm resistor 87 connected to a (−)15 VDC power source 86. The pot 85 is utilized to adjust the static output voltage 63 of the amplifier to (−)5 VDC in order to eliminate the possibility of noise triggering the Schmidt trigger 64.

The operation of the amplifier is controlled by a feedback loop 75 including 100K ohm resistor 76 connected to ground through a variable 10K ohm pot 77, and to the input 70 of the amplifier 62 through a 1 megoohm resistor 78. As the input 83 to the amplifier 62 is negatively biased, current flow representing signals received by the phototransistor 9 is controlled by a 499K ohm resistor 80 and RC network 79 connected in parallel between ground and the input 70 to the amplifier. The RC network 79 includes a 33K ohm resistor 82 and a 0.0056 microfarad capacitor 81 in series. The resistance of the RC circuit 79 is sensitive to the oscillating character of pulse type signals representing standing pins. The invention capitalizes upon this known characteristic to peak and separate the signals received from the phototransistor 9, and thus maximize the ability of the scanner mechanism to distinguish between pins standing very close together.

By variation of the 10K pot 77 and the negative voltage pickoff at the 5K pot 85, the amplifier 62 may be tuned dynamically with the scanner sweeping the pins at its preestablished rate to achieve the optimum in signal differentiation.
The output 63 of the operational amplifier 62 is fed to a Schmidt trigger 64. The output 65 of the Schmidt trigger 64 generates a series of pulses representing pin count and is optically coupled to the left and right pin data input lines 71 and 72 of the computers through optical couplers 66 and 67 respectively. The output 65 of the Schmidt trigger 64 simultaneously lights light emitting diodes 73 and 74 of the couplers 66 and 67 so that the pin data is supplied simultaneously to both the left and right pin data input lines 71 and 72. However, such data will be accepted by the computer only as directed by the left and right data control signals 42 and 43, so that pin count will be credited only to the proper lane.

Referring now to FIG. 7, what follows is a functional description of the logic and circuitry which control the scanner and its interface with an associated pinsetter and scoring computer.

The data control and pinfall signals 42 and 71 from the scanner are fed to a sync network 100. The leading edge of one of the scanner control "windows" 42 (see FIG. 6) conditions the sync register 106 to permit pinfall data to pass through line 101 to a down-counting binary register 102. The trailing edge of the pinfall window closes the sync network 100 to any further passage of pinfall data until the sync network is reset. The closing of the sync network 100 is accompanied by the generation of a "data entered" signal 117, indicating that a complete pin count has been taken. In this manner the control signals generated by the scanner effectively limit its detection activity to the area of the lane where the pins are standing.

As a distinction is drawn between a strike or spare condition, and the condition where pins are left standing after a first or second ball, special mention will be made as to the functioning of the system in either of these events.

The pinfall data entered on register 102 is monitored by a NAND gate 103, connected as illustrated to the outputs of counter 102. In the event that no pins are standing, an output signal 106 is generated at NAND gate 103. The output signal 106, representing a pinfall of ten, is NANDed at gate 107 with a first ball signal 108 and a timing pulse 109. If a pinfall of ten occurs on the first ball, a "strike" signal 110 is generated at NAND gate 107. The strike signal 110 may be used to light a strike light, initiate a no-delay trigger of the pinsetter, and to cause the pinsetter to immediately set a new set of ten-pins without performing the pin pickup portion of the cycle. The pinfall of ten signal 106 is also ORed at gate 112 with a "foul" signal 113 and a "stop-scan" signal 114 from the pinsetter or a timer. In the event of no pins remaining standing, or a foul, or the expiration of time allotted for pin count by the timer, an output 115 is generated at gate 112 and is NANDed at gate 116 with the "data entered" signal 117 from the sync network 100. The output of NAND gate 116 is an "accept data" signal 120 which may be used to (a) inactivate the scanner, (b) initiate a "no-delay" trigger of the pinsetter, and (c) initiate a sequencer 150 described below.

Should the accept data signal 120 be generated by a spare on a second ball, it may be very effectively used to initiate the "no-delay" trigger on the pinsetter. As the pinsetter is already conditioned for a second ball cycle, it is not necessary to preempt the pin pickup portion of the pinsetter cycle.

The accept data signal 120 output of NAND gate 116 is NANDed at gate 122 with the "data entered" signal 117, so that in the event that the pinfall is other than ten, a "reject data" signal 123 will be generated at NAND gate 122 upon the occurrence of data entered 117. The "reject data" signal 123 is used to reset the sync network 100, and cause the system to retake data until such time as an "accept data" signal 120 is generated at gate 112, generally by the occurrence of either a ten pinfall count or a "stop-scan" signal 114. The "stop-scan" signal 114 may be initiated either by a timer or the cycling of the pinsetter to a point just prior to where the rake will interfere with the optical scanning process.

The passage of a ball by the ball detector 16 generates an output signal 125 which is ORed at gate 126 with the reject data signal 123 and a reset signal 128 from the sequencer 150, to assure that the system is prepared for the pinfall data to follow. The output 130 from the OR gate 126 resets the sync network 100 and clears the down-counting register 102, conditioning the system to look to the "data entered" and "pinfall" signals which will continue to come in until the scanner is inactivated. The output signal 125 of the ball detector is also utilized to initially enable the scanner, either directly or through an associated scoring computer upon the passing of a delivered ball.

Once a ball passing the ball detector enters the pit area, the pinsetter cycle will be initiated. At some point in the cycle of the pinsetter, such as the dropping of the rake or the lowering of the pin pickup table, the physical presence of the pinsetter structure will interfere with the taking of a valid pin count by the scanner. At this point it is desirable to stop the pin count by disabling the scanner. The precise point in the pinsetter cycle at which this action should be taken will be determined by the particular type of pinsetter being utilized. For example, in the Brunswick pinsetter, it will be at what is known as the 44° position on first ball, and the 148° position on second ball. At this point the stop-scan signal 114 may be generated at the pinsetter 133 by any appropriate means, which signal functions through gates 112 and 116 as previously described, to generate the accept data signal 120 as soon as a full window of pin count has been entered in the register 102 and the data entered signal 117 is generated by the sync mechanism 100. In an alternate configuration a rake switch may be employed to disable the scanner whenever the rake is in motion, i.e., neither "up" nor "down", as the scanner can count with the rake down.

The "accept data" signal 120 is fed to a sequencer 150, which includes a decimal counter 151 and a related decoder 152. The counter is activated by clock pulse 153 from any appropriate source. The generation of an "accept data" signal 120 starts the counter 151 initiating the following series of events:

a. the timing pulse 109 is applied to NAND gate 107 as previously described, to generate the "strike" signal 110, if appropriate;
b. an output 155 loads a storage register 156 with the count contained in the counter 102;
c. a pinfall ready signal 157 is sent to an associated scoring computer indicating that pinfall information on storage register 156 is ready for entry; and
d. lastly, the reset signal 128 is generated to clear the sync network 100 and the down-counting register 102.

The reset signal 128 is also fed to the ball detector 16.
to condition it to react to the passage of a subsequent ball.

The action of the sequencer may be preempted by a "wait" signal 154 from the computer which is NANDed with the clock signal 153 at gate 160, so that in the event that the associated scoring computer is not ready to accept pin data, the aforementioned sequence of events will be momentarily delayed.

In the event that it is impossible or undesirable to have the pinsetter function to stop the scanner and associated pin count, a timer 162 such as that indicated in phantom in FIG. 7 may be used for this purpose. In this event, the ball detect signal 125 is utilized to initiate the timer, and the output 163 of the timer 162 will constitute the stop-scan signal 114 previously described. The advantage of this arrangement is that no mechanical or electrical connections whatsoever are required between the scanner and the pinsetter.

FIG. 8 is an electrical schematic of an advantageous sync network 100. The network includes two J-K flip-flops 170 and 171. The incoming negative-going control signal "windows" 42 are first inverted at 172 in order that the trailing edge of a window may be used to set flip-flop 171. The control window 42 is again inverted at 173 prior to being applied to pin 174 of flip-flop 170. The appearance of a signal at pin 174 of flip-flop 170 drives its output pin 175 to logic state "1". Pin 175 of flip-flop 170 is connected both to the input 176 of flip-flop 171 and to the NAND gate 180. The output of pin 177 is NANDed at gate 180 with the output of pin 175 of flip-flop 170 and with the incoming pinfall data signals 71, so that with the flip-flops "set" as described, pinfall data will pass through line 101 to the down-counting register 102.

When the trailing edge of a control window 42, inverted at 172 so that it is negative-going, is applied to input pin 181 of flip-flop 171, the state at its output pin 177 is reversed to a logic "0". This effectively closes NAND gate 180 and blocks any further passage of pinfall data until the flip-flops 170 and 171 are reset. Simultaneously, output pin 182 of flip-flop 171 assumes a logic state of "1" which constitutes the aforementioned "data entered" signal 117.

From the foregoing, it will be understood that once flip-flops 170 and 171 are set as described by a control window 42, they will remain locked in the set condition until a reset signal 130, generated by one of the various inputs to OR gate 126, causes them to reset.

FIG. 9 is a schematic illustration of an alternate detection system in which the pinfall of each lane is monitored by two scanners 201 and 202, one on each side of the lane. In this system, when the ball detector 16 is actuated by a ball passage, scanners 201 and 202 on the right and left sides of the lane respectively are simultaneously enabled. The count taken by scanner 201 is entered into a register 203 and the count taken by the scanner 202 is taken into a register 204 in the manner described in connection with FIGS. 7 and 8. The counts in register 201 and 202 are compared by a comparator 205 and the higher of the two counts feeds to a buffer 206 for pickup by the computer, and to an equivalent of NAND gate 103 in FIG. 7. The output 106 of NAND gate 103 is then processed in the manner described in connection with FIG. 7 to provide the appropriate strike 110, "accept data" 120 and "reject data" 123 signals, which may be used as previously described to activate the pinsetter and cause the pinfall data to be entered into the scoring computer.

While the principles of the invention have been described in connection with the above specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of the invention.

We claim:

1. A photoelectric pin counting device comprising: means for illuminating bowling pins standing upon a bowling lane so that light will be reflected therefrom, means for sensing light reflected from said illuminating means by each of said standing pins which may come to be within a detection window of the light sensing means, said light sensing means comprising a light receiving unit including a light-sensitive element and means for focusing light reflected from a standing pin upon said light-sensitive element, means for rotating said light receiving unit so as to cause said detection window to scan across the area above the bowling lane occupied by standing pins in order that light reflected by any standing pins scanned in the detection window will be focused serially upon said light-sensitive element, and circuit means including said light-sensitive element for generating an electrical signal representing each standing pin having its reflected light scanned by the light-sensitive element during the rotation of the light receiving unit.

2. The device of claim 1 wherein said illuminating means comprise: a lens focusing said light source only upon the heads of the standing pins.

3. The device of claim 2 wherein means for rotating said light receiving unit also comprise: means for rotating said light transmitting unit in unison with said light receiving unit.

4. The device of claim 1 including means for gating the output of said signal generating means in accordance with the scanning position of said light sensing means comprising: means for opening a gate at a first preselected position in a unidirectional scan of the pin area, and means for closing said gate at a second preselected position in the same scan, said first and second positions defining the sector of the scan limited to the pin-standing area.

5. The device of claim 4 wherein said gating means comprise: a first optical coupler operative to open said gate, a second optical coupler operative to close said gate, and means, having a window therein which aligns with the optical axes of said couplers and mounted for movement through said axes, for causing said couplers to conduct or not to conduct in response to movements of said window in accordance with the position of said light sensing means.

6. The device of claim 5 wherein said light receiving unit rotating means includes means for moving said window in synchronization with the scanning motion of said light transmitting and receiving units.
7. The device of claim 1 further including circuit means for connection to an automatic bowling pinsetter control mechanism for causing the pinsetter to set a full set of pins upon the detection of no standing pins.

8. The device of claim 1 wherein said light receiving unit includes only a single light sensitive element.

9. The device of claim 2 wherein the light transmitting unit contains:
   means for focusing the light incident on the standing pins into an area having a height of approximately 3 inches and a width of approximately 1 inch.

10. The device of claim 9 comprising in addition:
    means for rotating the light transmitting unit in unison with the light receiving unit.

11. The combination, for use with a bowling pinsetter on a bowling lane, of a photoelectric pin counting device and means for automatically calculating a bowling score comprising:
    a pin counting device comprising means for illuminating standing bowling pins with light, a photoelectric sensing unit responsive to light reflected from a standing pin, means responsive to said photoelectric sensing unit for generating electrical signals representing each standing pin sensed by said unit, means for rotating said sensing unit to scan across the pin deck of a bowling lane; and
    means including an electronic computer responsive to said electrical signals for calculating and displaying the resulting score.

12. The device of claim 11 further including means for activating said photoelectric pin counting device in response to the presence of a delivered ball comprising:
    means for detecting the passing of a delivered ball through a selected line across the bowling lane.

13. The device of claim 12 further including means for inactivating said counting device upon the occurrence of any one of the following events:
    a. no pins are detected standing by said photoelectric sensing unit;
    b. the pinsetter servicing the bowling lane upon which the pin count is being taken reaches a preselected position in its operational cycle;
    c. the pinsetter's rakes go into motion between its up and down positions;
    d. the expiration of a preselected period of time following the detecting of ball passage beyond the preselected line across the bowling lane; and
    e. the pin count represented by said electrical signals has been accepted by said computer.

14. A photoelectric device for counting pins standing upon a bowling lane after delivery of a ball comprising:
    means for illuminating standing pins;
    means for detecting light reflected from each individual standing pin;
    means responsive to said detecting means for generating electrical signals representing the number of pins standing upon the lane after the delivery of the ball;
    said illuminating and detecting means being fixedly aligned with each other and focused generally within the area occupied by the heads of the standing pins; and
    means for causing said illuminating and detecting means to oscillate across the area occupied by the heads of the standing pins.

15. The device of claim 14 in combination with a scoring computer responsive to said electrical signals for calculating a bowler's score.

16. The device of claim 15 further including means for connection to an automatic pinsetter control mechanism servicing the bowling lane for causing the automatic pinsetter to set a full set of pins upon the detection of no standing pins on said bowling lane.

17. The device of claim 16 further including a first electronic memory means for storing the count of pins detected standing upon the bowling lane after the delivery of a ball.

18. The device of claim 17 further including a second electronic memory coupled to said first electronic memory, and means for entering the count in said first memory into said second memory and conditioning said first memory to store pincount for the next ball, whereby the first ball and second ball pinfalls are stored within the pincount.

19. The device of claim 18 in combination with a scoring computer, including means for entering the count in said memories in the computer and wherein the counter will be inactivated when both of said memories are storing pincounts.

20. A device for counting bowling pins standing upon a bowling lane comprising:
    an illuminating device for transmitting light to the pins and an electro-optical pin detecting device, both devices mounted in the same position at one side of the lane with an unobstructed view of at least a part of the head of each standing pin, said electro-optical pin detecting device being capable of discriminating between light reflections from a plurality of standing pins; and
    means responsive to said electro-optical pin detecting device for recording the number of standing pins detected thereby.

21. The device of claim 20 wherein said electro-optical pin detecting device is mounted between a pair of bowling lanes, and at a distance of between 117 and 154 inches in front of the back row of pin spots upon the lane.

22. A method of counting bowling pins standing upon a bowling lane comprising the steps of:
    providing an optical detector capable of differentiating light reflections from a plurality of standing pins;
    illuminating pins standing upon the lane with a light source located at one side of the lane and at an elevation approximately that of the pin heads;
    viewing said illuminated pins with said detector at the same position to one side of the lane and from an elevation approximately that of the pin heads from where all standing pins can be seen; and
    counting light reflections from standing pins detected by said detector.

23. The method of claim 22 wherein the standing pins are serially illuminated and the reflections there-from are serially counted.

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