United States Patent [19]

Gautraud et al.

[11] **3,825,749**

[45] **July 23, 1974**

[54] **PHOTOELECTRIC PINFALL DETECTION SYSTEM**

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[73] Assignee: **Brunswick Corporation,** Skokie, Ill.

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[21] Appl. No.: **259,614**

[52] **U.S. Cl.** ..... **250/222 R,** 250/235, 273/54 E, 273/54 C

[51] **Int. Cl.** **H01j 39/12**

[58] **Field of Search** ..... 273/54 E, 54 C, 54 R; 250/221, 222, 223, 234, 235

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Assistant Examiner—D. C. Nelms
Attorney, Agent, or Firm—Sheldon L. Epstein; William G. Lawler, Jr.; Donald S. Olexa

[57] **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 cyclce. 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

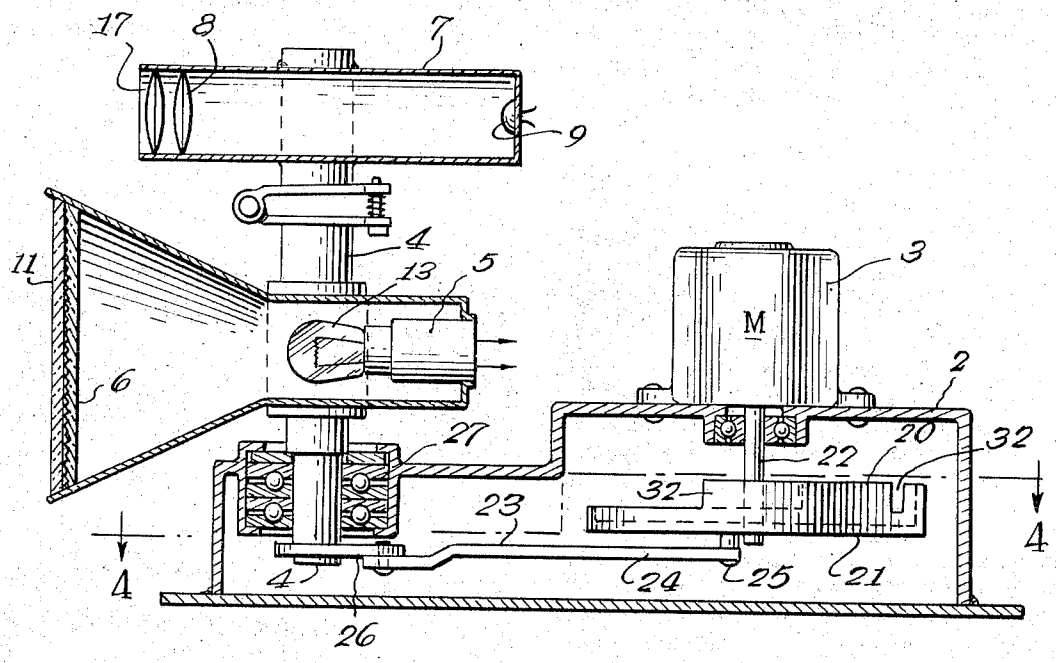


Fig. 1

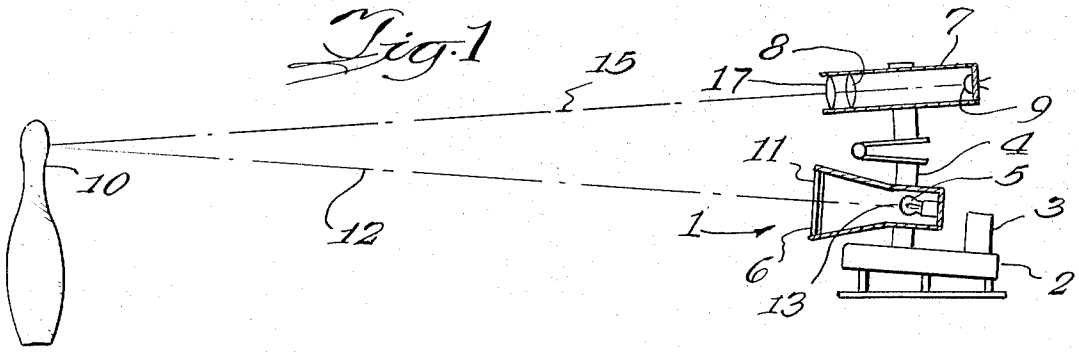

15
17
8
7
9
11
4
5
10
12
1
3
6
13
2

Fig. 2

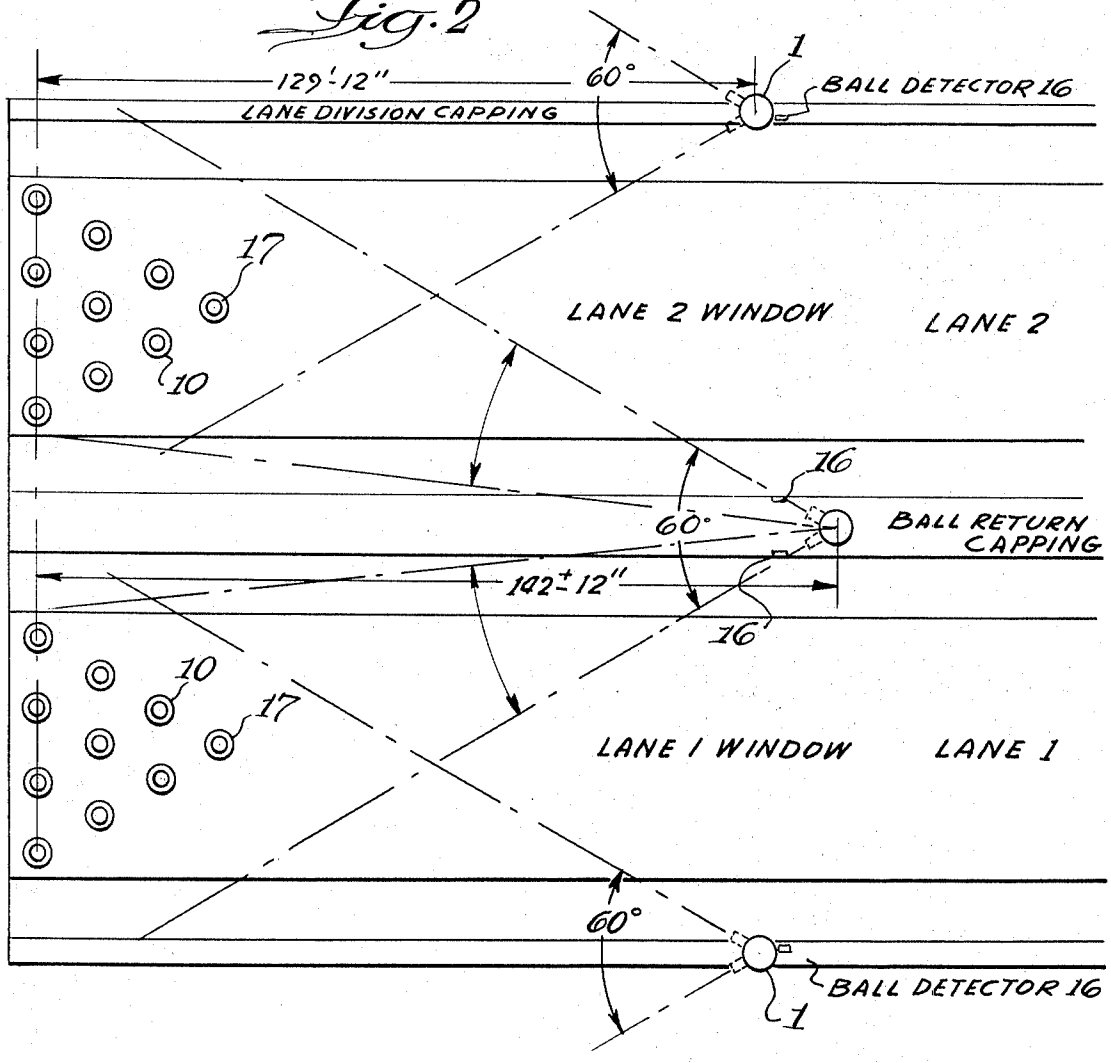

129'-12"
60°
1
BALL DETECTOR 16
LANE DIVISION CAPPING
17
LANE 2 WINDOW
LANE 2
10
16
60°
BALL RETURN CAPPING
102'-12"
16
10
17
LANE 1 WINDOW
LANE 1
60°
BALL DETECTOR 16
1

Fig. 3

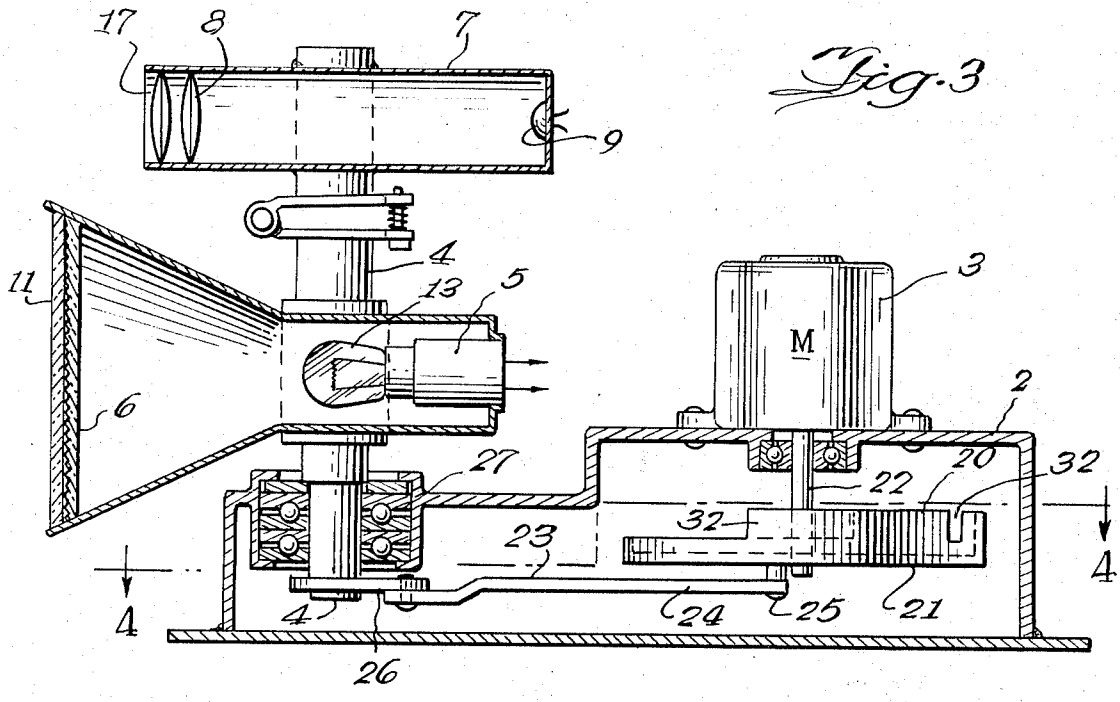

17
8
7
9
4
13
5
11
6
3
M
2
27
22
20
32
23
32
4
4
24
25
21
26

Fig. 4

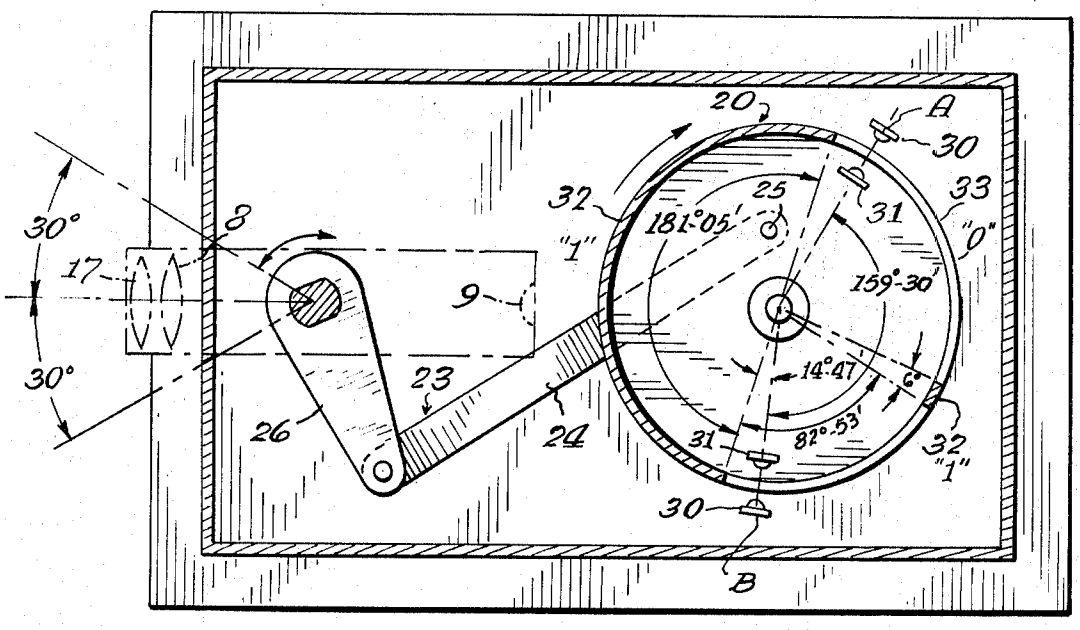
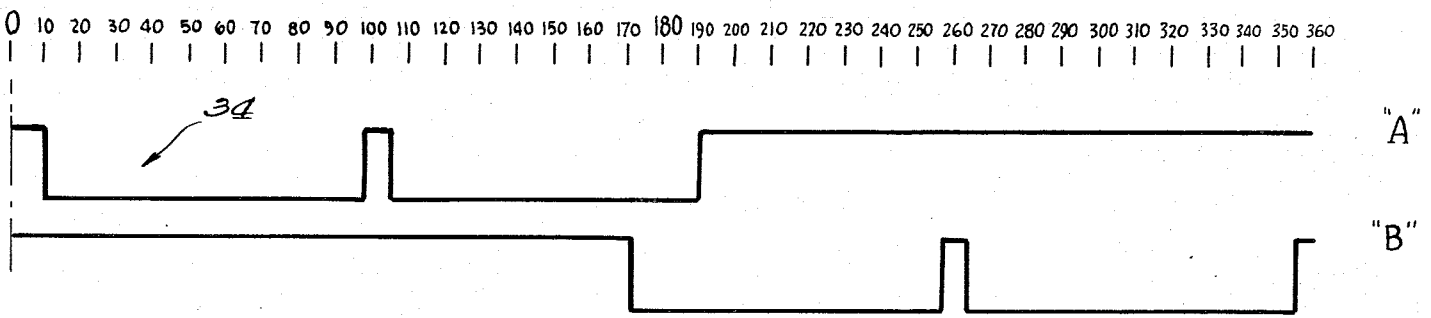

20
A
30
32
25
33
"1"
181°05'
31
"0"
159°30'
30°
8
17
9
14°41'
30°
23
26
24
31
82°53'
32
"1"
30
B

Fig. 5



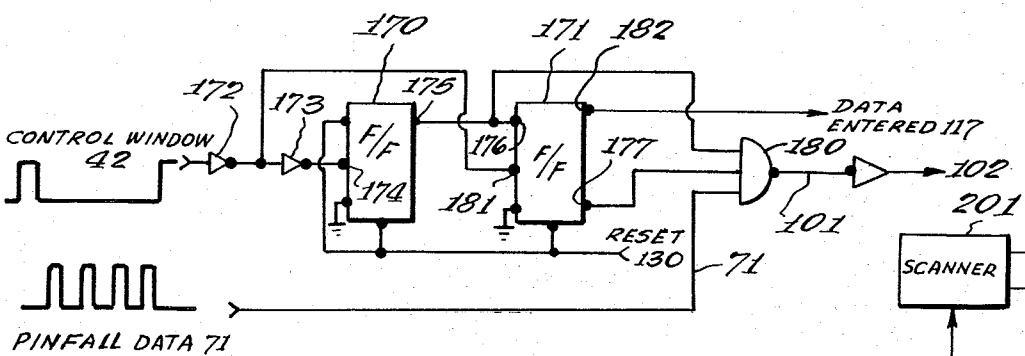


Fig. 8

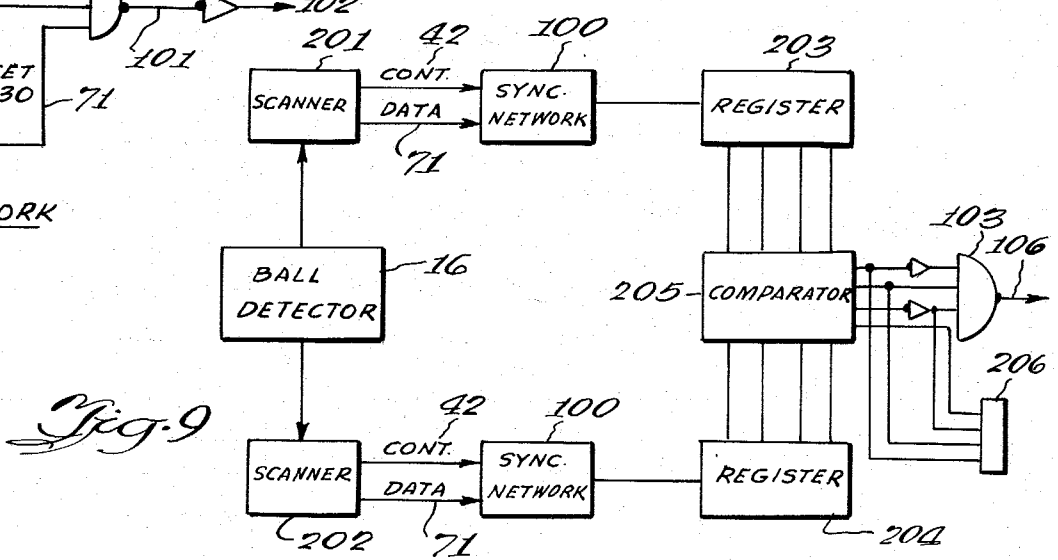
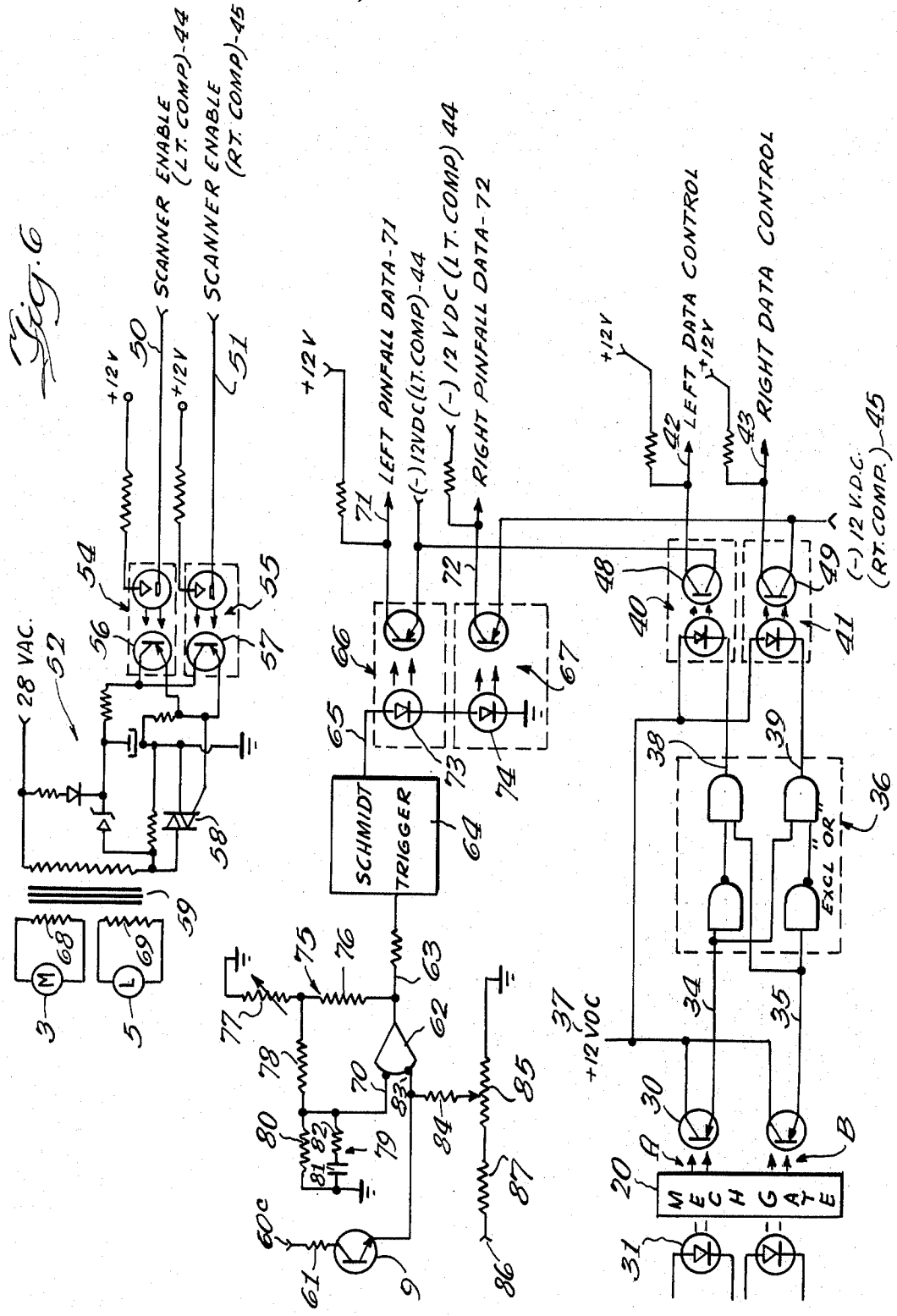
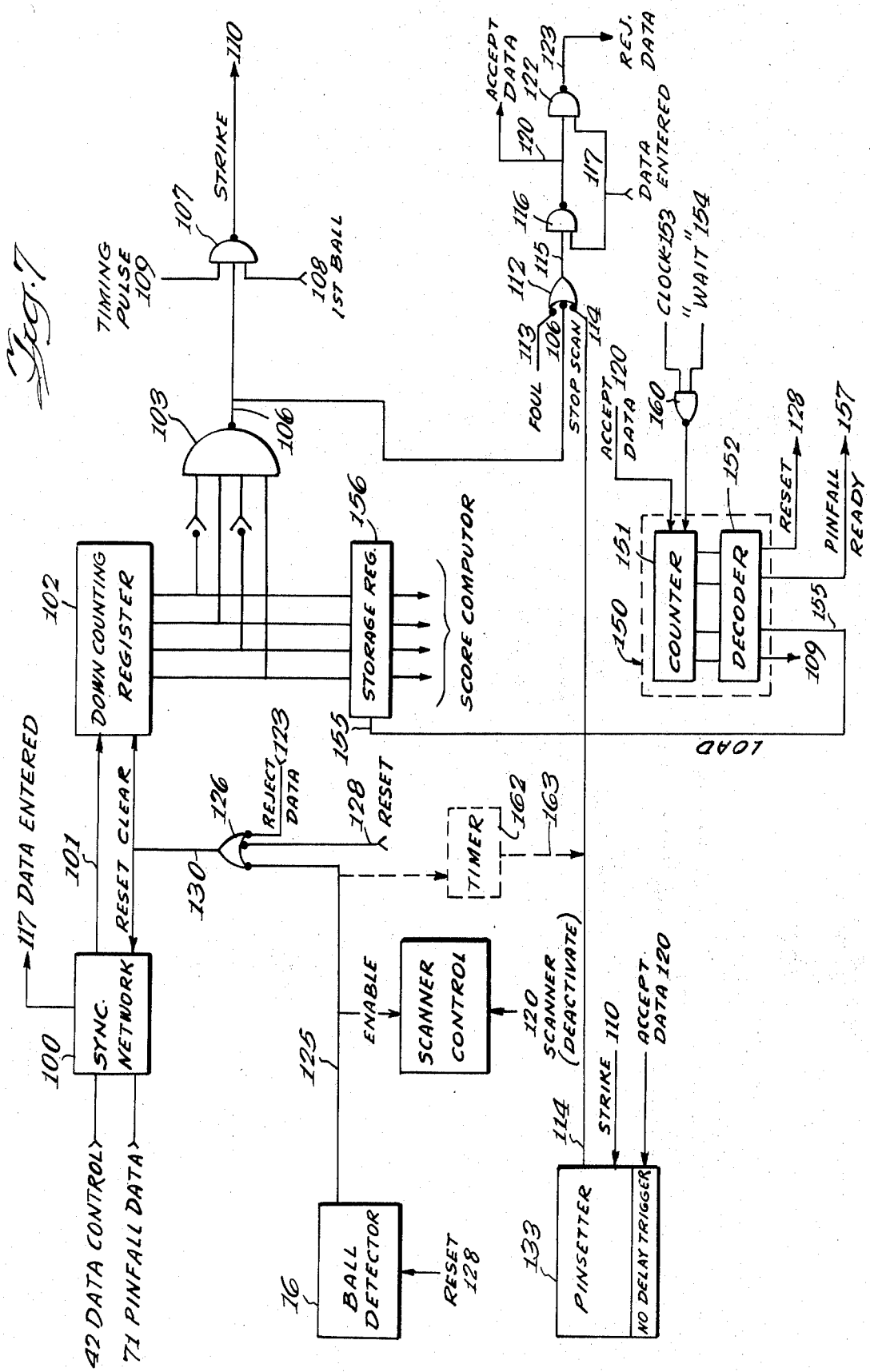


Fig. 9


Fig. 6
+12 V
SCANNER ENABLE (LT. COMP)-44
SCANNER ENABLE (RT. COMP)-45
28 VAC.
LEFT PINFALL DATA-71
(-) 12VDC(LT.COMP)-44
(-) 12 VDC (LT. COMP) 44
RIGHT PINFALL DATA-72
SCHMIDT TRIGGER
LEFT DATA CONTROL
RIGHT DATA CONTROL
(-) 12 V.D.C. (RT. COMP.)-45
EXCL "OR"
+12VDC
MECHANISM GATE


Fig. 1
42 DATA CONTROL
71 PINFALL DATA
117 DATA ENTERED
100 SYNC. NETWORK
101 RESET CLEAR
102 DOWN COUNTING REGISTER
103
106
107 STRIKE
110
108 1ST BALL
109 TIMING PULSE
112
113 FOUL
114 STOP SCAN
115
116
117 DATA ENTERED
120 ACCEPT DATA
122
123 REJ. DATA
120 ACCEPT DATA
160
CLOCK 153
"WAIT" 154
150 COUNTER
151
152 DECODER
RESET 128
PINFALL READY 157
155
109
LOAD
156 STORAGE REG.
SCORE COMPUTOR
155
126
REJECT DATA 123
128 RESET
130
TIMER
162
163
125
ENABLE
SCANNER CONTROL
120 SCANNER (DEACTIVATE)
114
STRIKE 110
ACCEPT DATA 120
16 BALL DETECTOR
RESET 128
133 PINSETTER
NO DELAY TRIGGER

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 also 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 programed 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;

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 capping.

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 nonconductive; 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:

A	B	
0	0	NO SCAN (Between Lanes)
1	0	OUTWARD SCAN RIGHT LANE
1	1	NO SCAN (Outside Edge of Right Lane)
1	0	RETURN SCAN RIGHT LANE
1	1	NO SCAN (Between Lanes)
0	1	OUTWARD SCAN LEFT LANE
1	1	NO SCAN (Outside Edge of Left Lane)
0	1	RETURN SCAN LEFT LANE

The optical axis of each detector is aligned between the adjacent bowling lanes when units A and B are in the "0"–"0" or "1"–"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 megaohm 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 network **100** 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 those 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 react as described to the "data control" 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 fed 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 light transmitting unit including a light source, and

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 occurence 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 rake goes 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 pincounter.

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 therefrom are serially counted.

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