

July 30, 1963

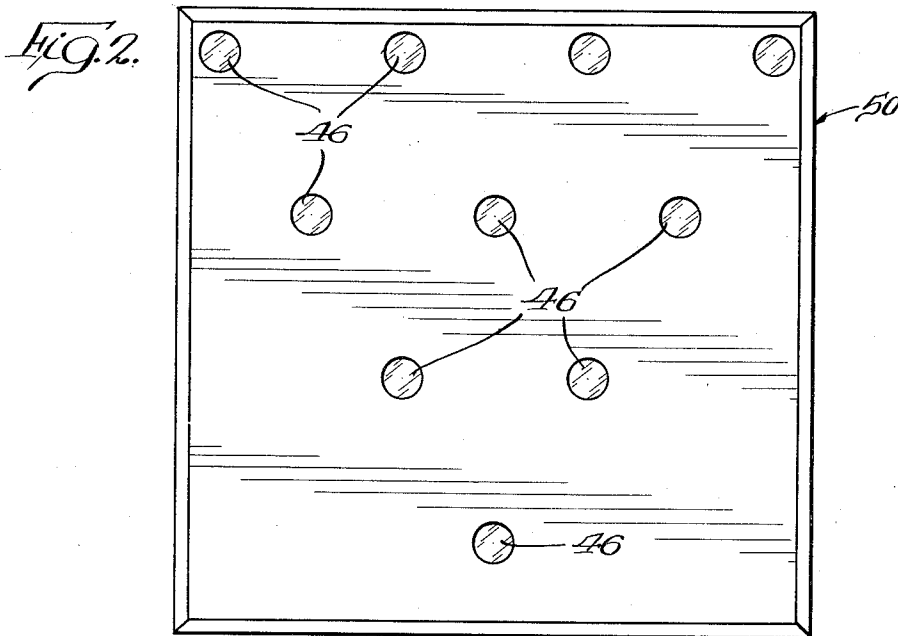
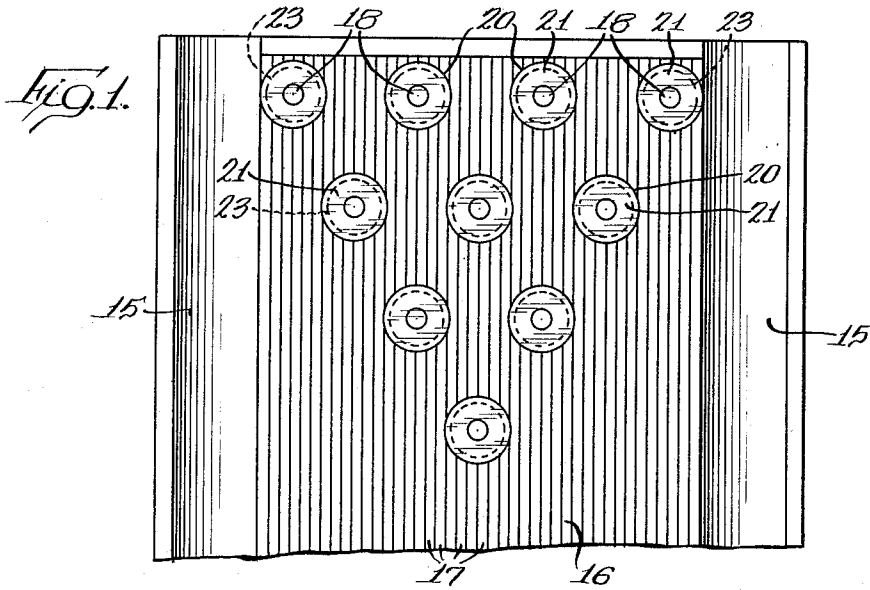
S. ISENBERG ET AL

3,099,447

SONIC PIN DETECTION MEANS

Filed June 9, 1960

2 Sheets-Sheet 1



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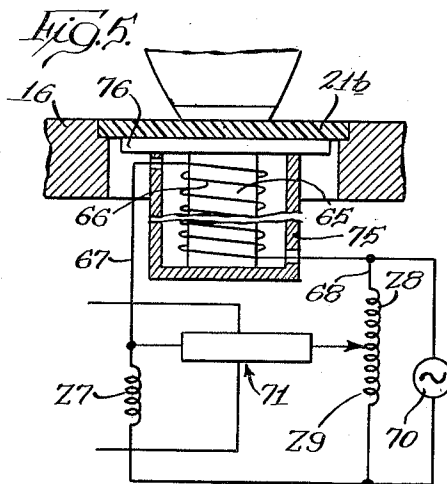
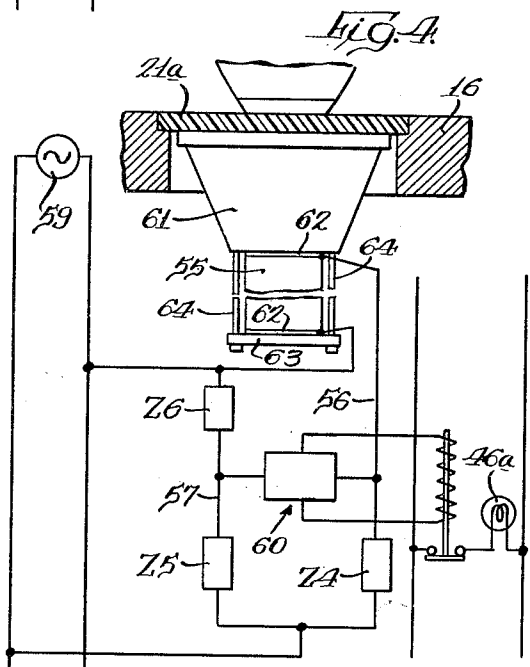
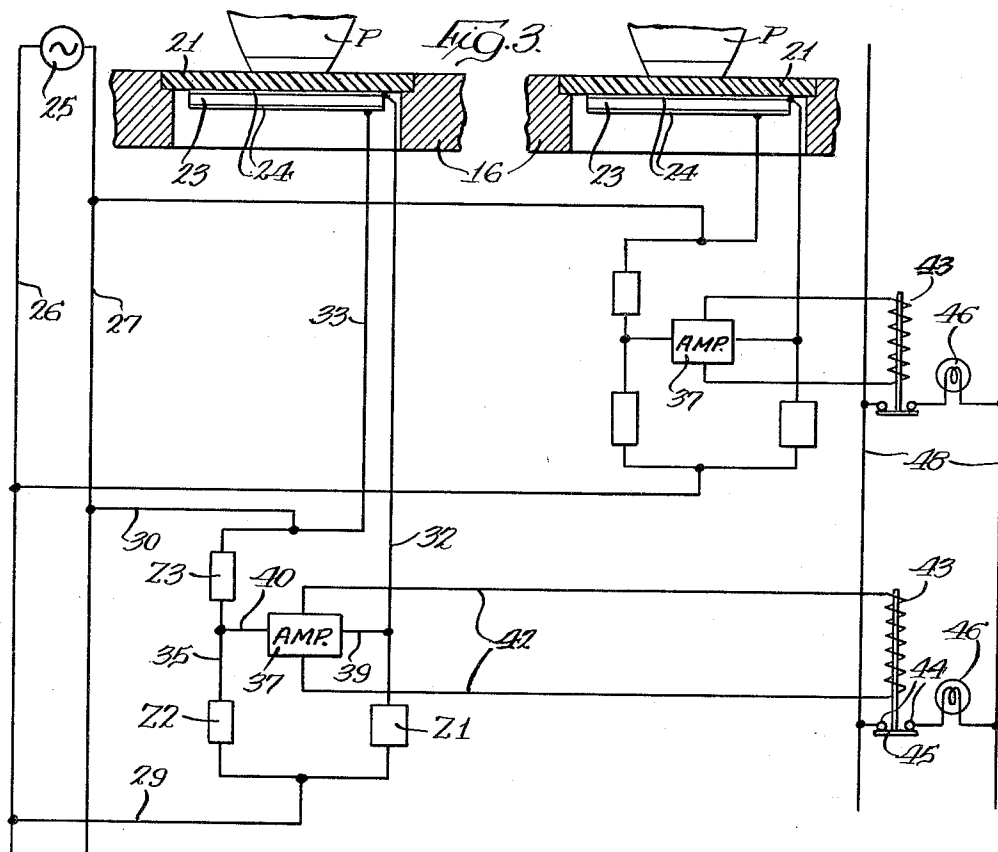
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2 Sheets-Sheet 2



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SONIC PIN DETECTION MEANS

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11 Claims. (Cl. 273—52)

This invention relates to bowling and more particularly to detection of bowling pins on a bowling alley for the purpose of providing a signal indicative of pinfall for actuating an indicating means for announcing the results of bowling.

It is a general object of the invention to provide a new and improved pinfall detection apparatus.

Another object is to provide a new and improved apparatus for distinguishing between the presence and absence of standing pins on a bowling alley and giving a signal indicative of pinfall including a system for producing sound waves which are impeded more when a pin is standing than when a pin is fallen or absent thereby to give a detectable signal indicating the presence or absence of pins.

A further object is to provide a new and improved pin detection apparatus of the type described including an electromechanical transducer at each pin spot on a bowling alley supplied from an electric system and supplying an acoustic or sonic system which is altered by the presence or absence of a standing pin to thereby alter the electric system and provide a signal indicative of the presence or absence of standing pins.

In a preferred construction, at each pin spot there is mounted in or under the alley a piezoelectric transducer in the form of a thin cylindrical wafer or crystalline material, such as barium titanate or the like, forming one impedance in a bridge circuit supplied from an alternating current source and balanced in the absence of a pin. The impedance of the circuit is altered by the presence of a standing pin and a suitable indicating means connected across the parallel branches of the bridge circuit is thereby supplied with a signal indicative of the presence of a standing pin within the detection area.

The geometrical shape of the transducer may be varied and in a modification, it takes the form of an elongate rod of crystalline material.

In a further embodiment, a magnetostrictive transducer is utilized in the form of an elongate rod of nickel with a coil wound therearound.

An important advantage of the pin detection apparatus of the present invention resides in the latitude allowed in mounting the detection means in the alley thereby avoiding the necessity of providing detection means on a movable part of a pinsetter such as the pinsetting deck which requires movement of the deck into the proximity of the alley in order to be capable of detection. Another advantage lies in the ability of the detection apparatus to detect standard bowling pins without need for pin modifications which affect the pin balance or action.

Other objects and advantages will become readily apparent from the following detailed description taken in connection with the accompanying drawings, in which:

FIGURE 1 is a fragmentary plan view of a bowling alley illustrating the general arrangement in which pins are normally set on the alley adjacent the pit in preparation for bowling;

FIGURE 2 is a diagrammatic elevational view of a form of indicating means which may be controlled by pinfall detection apparatus embodying the principles of the present invention;

FIGURE 3 is a wiring diagram including fragmentary

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sectional views through pin spots at two positions on the bowling alley;

FIGURE 4 is a wiring diagram including a fragmentary sectional view through a single pin spot, illustrating a modified form of transducer; and

FIGURE 5 is a wiring diagram similar to FIGURE 4 illustrating another form of transducer.

While illustrative embodiments of the invention are shown in the drawings and will be described in detail herein, the invention is susceptible of embodiment in many different forms, and it should be understood that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiments illustrated. The scope of the invention will be pointed out in the appended claims.

Referring now to the drawings in more detail, FIG. 1 illustrates the pit end of a typical bowling alley including gutters at opposite sides of the alley as at 15 and an alley proper as at 16 providing an upper surface on which pins may be set and along which a ball may be rolled at the pin. Normally, the alley is comprised of a plurality of laminated side by side wood strips as at 17, though other materials may be utilized. It is intended that pins would be initially set on the alley at ten pin spots represented by the full line circles as at 18.

In many bowling establishments nowadays, automatic pinsetter machines are utilized for setting and resetting pins on the alley proper sequence relationship to the balls thrown. During the progress of a game, it is not unusual for a pin to "walk off" a pin spot after being nudged by a ball or another pin and still remain standing so that it must be lifted from the alley while the alley is swept and then reset upon the alley preferably in the off spot position assumed. Most modern day automatic pinsetter machines include pickup and resetting devices which are capable of lifting off spot pins within a predetermined range and resetting the pins in the off spot position.

A typical range of pin pick up is illustrated by the full line circles 20 approximately three times the diameter of the pin base, though the size may vary and the shape of the off spot area may vary from circular to rectangular or some other shape, depending upon the nature of the pin pickup devices.

In some bowling alleys, the pin spots 18 as well as the off spot areas 20 may all form an integral part of a unitary alley construction comprised solely of wood laminae 17. In other constructions, the pin spots 18 and/or the off spot areas 20, whether these define the pinsetter pickup range or not, may comprise inserts as at 21 in the otherwise wooden alley construction which prolong the life of the alley in areas where pins are sometimes dropped or handled roughly when placed. The insert may be comprised of plastic reinforced with fiber, for example.

In any automatically operating pinfall detecting apparatus, it is highly desirable to provide for detection of off spot pins within the range of the pick-up devices as well as detection of pins which remain on spots, or otherwise an inaccurate indication of results will follow. As shown in FIG. 3, a pin detecting means is provided under each pin spot for detecting standing pins either on spot or off spot within a range such as that indicated by areas 20.

In a preferred construction, the pin detecting or sensing means associated with each pin spot makes use of a transducer in the form of a thin cylindrical wafer of a crystalline material such as barium titanate which as illustrated at 23 has a diameter approximately the size of the insert 21 in order to provide for detection of pins

standing on spot and off spot in an area surrounding the spot.

A transducer of this nature, having a diameter much greater than its thickness, will vibrate in a mode which produces a compressional wave in the direction of its thickness.

If such a transducer is made in the form of a cylindrical wafer in which the compressional wave is along the axis of the cylinder, it will produce standing waves at certain frequencies of the simple extensional type. If the cylindrical wafer is macroscopically homogeneous, its resonant frequency is given by the equation

$$f_n = \frac{n}{2l} \sqrt{\frac{\lambda + 2\mu}{\rho}}$$

where f_n is the resonant frequency of n standing waves, n is the number of standing waves, l is the effective axial thickness, λ is an elastic constant known as Lamé's lambda, μ is the modulus of rigidity, another elastic constant, and ρ is the density. If a thin wafer of barium titanate is caused to vibrate by means of a periodically varying electrical field applied parallel to the cylindrical axis the wafer will show resonance nearly in accordance with the equation above, the fundamental period of which is given by the case in which $n=1$. If the crystal is resonating at the fundamental period, the electrical impedance will be at a maximum or a minimum, depending on the Q of the transducer and the value of the acoustically coupled load.

According to the present invention, the electrical driving system for the transducer comprises a bridge circuit the driving frequency of which is set to the fundamental resonance of the transducer. The bridge circuit includes the transducer as one impedance and includes three additional impedances. The bridge is balanced by adjustment of the three additional impedances in the absence of a standing pin. The electric circuit thus provided may be modified by physically coupling a relatively massive load to the transducer. The effect of the coupled load upon the transducer is a function of the coupling medium, the frequency of oscillation and the mass of the load. This effect is utilized in detecting the presence of a pin standing in the area above the transducer.

If a standing pin is acoustically coupled to the wafer, energy will be absorbed by the pin thereby changing the acoustical impedance of the system as a whole which in turn is reflected back into the electrical driving circuit of the transducer as a change in electrical impedance. The change in the electrical impedance causes the bridge to become unbalanced and thus provides a signal to an indicating means connected across the parallel circuit of the bridge. There should be a radical difference in the impedance of the sonic coupling between the pin-up position and the pin-down or pin-absent positions. To this end the effect of the pin on the transducer may be maximized by employing the proper acoustical impedance parameters. If the pin is lying horizontally, it may alter the impedance of the transducer but only very slightly because of the very small area of contact and consequently the very little power absorbed thereby.

The transducer 23 may be adhesively secured to the underside of the alley insert 21 which thereby supports the transducer. The thickness of the transducer should be much less than half its diameter, and may be of the order of one-tenth of the radius. The resonant frequency of crystalline materials used lies between 300 kilocycles and one megacycle. For barium titanate, 6 inches in diameter and .25 inch thick, the resonant frequency is approximately 400 kilocycles.

The insert 21 may be of a conventional type comprised of plastic reinforced with fiber and is retained in position by a press fit in the alley. The insert comprises a coupling medium which conducts sound waves and couples the load of the pin to the transducer.

As seen in FIG. 3, the circuit includes a source of

alternating current as illustrated at 25 and two wires as at 26 and 27 connected across the source. Wires 29 and 30 are connected across the wires 26 and 27 and across the bridge circuit. The bridge circuit includes a pair of parallel circuits one represented by a wire 32 including an impedance Z1 and a second wire 33, the two wires being connected across the transducer 23 so that the latter also functions as an impedance. The other of the parallel circuits is represented by a wire 35 including impedances Z2 and Z3. With the bridge excited by the source at a driving frequency corresponding to the resonant frequency of the transducer 23, the bridge may be balanced by adjusting the impedances Z1, Z2 and Z3 when there is no pin on the insert 21. The crystalline wafer 23 may include silver coatings on opposite surfaces as at 24 to which wires 32 and 33 may be soldered.

A suitable indicating circuit is connected across the parallel circuits 32 and 35, and as illustrated this comprises an amplifier 37 which may take the form of a conventional commercially available type connected as by wires 39 and 40 to the wires 32 and 35 and having an output represented by wires 42 connected across the amplifier and across a relay coil as at 43. The relay includes normally open contacts as at 44 adapted to be bridged by a movable contact 45 controlled by the coil 43. Contacts 44 are in circuit with a lamp as at 46 connected across a source represented by the wires 48.

In operation, the bridge circuit is excited by the source 25 at a driving frequency corresponding to the resonant frequency of the transducer 23, and the impedances Z1, Z2 and Z3 are adjusted so that the bridge is balanced in the absence of a pin on the alley insert 21. In this case, there would be no output signal at the amplifier 37, the coil 43 would be de-energized and the lamp 46 unlit. If a pin is now placed on the insert 21 over the transducer 23, as illustrated at P, the acoustical impedance of the sonic system is altered and this is reflected in the bridge circuit by a change in electrical impedance which unbalances the bridge, thereby providing an output signal at the amplifier 37. The signal thus produced is suitably amplified and results in energization of the coil 43 and the lamp 46.

Preferably the bridge circuits at each of the pin spots are all energized from a common source represented by the wires 26 and 27, as illustrated in FIG. 3, and the lamps 46 are all preferably energized from a common source represented by the wires 48. While the circuits associated with only two pin spots have been shown, it will be understood that others may be provided in similar fashion.

The indicating lamps 46 are preferably arranged on an indicating panel as illustrated at 50 in FIG. 2 in a triangular arrangement corresponding to the triangular arrangement of pins when set properly on the alley for bowling so that the energized lamps indicate standing pins and the unlit lamps indicate the absence of standing pins. An indicating device of this nature is helpful to bowlers particularly the uninitiated or the novice, when only a few pins remain standing and one of these is directly behind another such as the #8 and #2 pins or the #9 and #3 pins, because the rearmost pin in these cases is not readily visible to the bowler at the approach end of the alley.

It should be understood that the indicating means illustrated herein in the form of lamps for indicating that standing pins are present or absent at the ten pin spot positions on the alley is only one form of indicating means that may be controlled by the mutual inductance detecting system, and that other forms of indicating devices may be controlled by the detecting means, if desired, such as a pinfall indicator for giving the number of pins felled after each ball rolled in a frame, or a scoring device for keeping a running score frame by frame, in the manner taught, for example, in the pending application of Robert Torresen, filed March 26,

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1959 as Serial No. 802,152, now Patent No. 3,011,785 (assigned to the assignee of this application), and through the medium of a suitable scanning switch and/or other switching devices as disclosed in said copending application.

Referring now to the modification of FIG. 4, the transducer may assume a geometrical shape different from that illustrated in FIG. 3. As seen in FIG. 4, the transducer is in the form of an elongate rod 55 having a length greater than its diameter, for example, five times greater. In this modification, the transducer is comprised of a crystalline material such as barium titanate and functions as an impedance in a bridge circuit similar to that described in connection with FIG. 3, including parallel circuits represented by wires 56 and 57, the former including an impedance Z4 and the transducer 55, and the latter including impedances Z5 and Z6. The bridge circuit is driven by an alternating current source as at 59, and a suitable indicating means which may be similar to that illustrated in FIG. 3 is connected across the bridge as illustrated at 60.

With this form of transducer, the resonant frequency is given by the equation

$$f_n = \frac{n}{2l} \sqrt{\frac{\mu(3\lambda + 2\mu)}{\rho(\lambda + \mu)}}$$

where the parameters are defined in the same way as set forth in connection with the description of FIG. 3. Since

$$\frac{\mu(3\lambda + 2\mu)}{\lambda + \mu} = E$$

where E is Young's modulus, f_n for compressional waves is given by

$$f_n = \frac{n}{2l} \sqrt{\frac{E}{\rho}}$$

Transducer 55 is coupled to the pin load by a coupling medium such as a solid horn or cone as illustrated at 61 which tapers from a small diameter at the lower end corresponding approximately to that of the transducer to a larger diameter at the upper end corresponding generally to the area in which it is desired to detect standing pins. The horn or cone 61 may be comprised of aluminum, for example. Transducers of the type illustrated in FIG. 4 may be used at a much lower frequency than those illustrated in FIG. 3. For example, satisfactory results have been obtained with a circuit operating at 43 kilocycles. The axial dimensions of the coupling horn are proportioned so that an integral number of axial standing waves occur therein.

The transducer 55 is coated at opposite ends with silver as at 62 to enable attachment of the wires thereto and may be supported by a plate as at 63 held by rods 64 suspended from cone 61. The assembly 55, 61, 62, 63, 64 may be supported in the position illustrated by suitable means (not shown) including, for example, a spring biasing means which insures contact of the upper end of cone 61 with insert 21a.

Referring now to FIG. 5, this modification makes use of a magnetostrictive transducer in the form of an elongate rod-like metallic core 65 of nickel or the like having a length greater than its diameter, about three and one half times greater for example, and having a coil 66 wound thereon. The coil 66 is connected in a bridge circuit including parallel circuits one represented by wire 67, the coil 66 and impedance Z7, and the other represented by wire 68 and impedances Z8 and Z9. The bridge circuit is excited by a source as illustrated at 70, and indicating means which may be similar to that described in FIG. 1 is connected across the bridge as illustrated at 71.

In this circuit, the magnetic properties of the nickel core 66 are altered by the load of a standing pin positioned thereon. Thus, the circuit may be balanced in

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the absence of a pin and unbalanced by the presence of a standing pin to supply a signal to the indicating means 71. With a transducer of this type, the circuit may be operated at frequencies as low as 25 kilocycles.

The core 65 with coil 66 may be supported in a case 75 of aluminum, for example, having a cover 76 engaging the top of core 65 and the case may be in turn supported by a spring biased means (not shown) for insuring contact of the cover 76 with insert 21b. The area of detection is determined by the diameter of coil 66 and this may be large enough to detect on spot or off spot pins or a horn similar to that at 61 in FIG. 4 may be used to detect pins in an area larger than that encompassed by the circumference of coil 66.

It will be appreciated that the pin detection apparatus of the present invention provides an important advantage in facilitating location of the pin sensing elements in or under the alley rather than requiring pin detection means on the movable deck structure of an automatic pin setter which requires movement of the pin setter deck down to a position adjacent the alley to be capable of pin detection. Installations of the type last mentioned require deck movement after the last ball in a frame in order to give pinfall results but this movement is not necessary to the pinsetting operation and is therefore time consuming and wearing. Another important advantage resides in the capacity of the detection apparatus of this invention to detect standing pins without actually engaging the pins and yet without requiring modification of the pins to be electrically conductive or magnetic. This obviates the need for incorporating material in the pin which may upset its balance or action.

We claim:

1. In combination with a bowling alley having a plurality of pin spots at positions where pins are set upright on the alley for bowling: apparatus for detecting the presence of standing pins on the alley at each pin spot and in a predetermined annular area surrounding each pin spot, comprising, a plurality of sensing means one associated with each pin spot for distinguishing between a first condition represented by the presence of a standing pin on spot or off spot in said predetermined surrounding area and a second condition represented by the absence of a standing pin from the spot and surrounding area, each sensing means comprising an insert in the alley at each pin spot having a diameter as great as that of the pin spot and surrounding annular area providing an upper surface flush with the alley and comprising a coupling medium for conducting sound waves, a thin generally cylindrical crystalline wafer of barium titanate secured to the underside of the insert and having a diameter equal that of said pin spot and surrounding area, and an electrical bridge connected with the wafer to cause the latter to produce axial sound waves including a pair of parallel circuits one including a pair of impedances in series and the other including a first impedance in series with said wafer which functions as a second impedance, an alternating current source connected in series circuit with said parallel circuits, and a signalling circuit connected across the parallel circuits between the impedances therein, said parallel circuits being balanced when said second condition exists so that no signal is produced in the signalling circuit and being unbalanced when said first condition exists to provide a signal in the signalling circuit due to a change of electrical impedance in the bridge as a result of a change in the acoustical impedance; and an indicating means connected with each of said signalling circuits for utilizing the signals from each of the sensing means to give a visible indication of the results of bowling as represented by the conditions sensed.

2. In combination with a bowling alley having a plurality of pin spots at positions where pins are set upright on the alley for bowling: apparatus for detecting the presence of standing pins on the alley at each pin spot, comprising, a plurality of sensing means one associated with each pin spot for distinguishing between a first condi-

tion represented by the presence of a standing pin and a second condition represented by the absence of a standing pin, each sensing means comprising an insert in the alley at each pin spot having a diameter as great as that of the pin spot providing an upper surface flush with the alley and comprising a coupling medium for conducting sound waves, a thin crystalline wafer at the underside of the insert having a diameter as great as that of said pin spot, means for coupling the wafer to the insert such that vibrations produced by the wafer are transmitted to the insert, and an electrical bridge connected with the wafer to cause the latter to produce axial sound waves including a pair of parallel circuits one including said wafer as an impedance, an alternating current source connected in series circuit with said parallel circuits, and a signalling circuit connected across the parallel circuits, said parallel circuits being balanced when said second condition exists so that no signal is produced in the signalling circuit and being unbalanced when said first condition exists to provide a signal in the signalling circuit; and means connected in each of said signalling circuits for utilizing the signals from each of the sensing means to give a visible indication of the conditions sensed.

3. In combination with a bowling alley having a plurality of pin spots at positions where pins are set upright on the alley for bowling: apparatus for detecting the presence or absence of standing pins on the alley at each pin spot, comprising, a plurality of sensing means one associated with each pin spot for distinguishing between a first condition represented by the presence of a standing pin and a second condition represented by the absence of a standing pin, each sensing means including an insert in the alley at each pin spot providing an upper surface flush with the alley and comprising a coupling medium for conducting sound waves, a waferlike electroacoustical transducer beneath the insert, means coupling the transducer to the insert such that vibrations produced by the transducer are transmitted to the pin spot, a bridge circuit connected with the transducer to cause the latter to produce sound waves including a pair of parallel circuits one including the transducer, and a signalling circuit connected across the parallel circuits, said parallel circuits being balanced when said one of said conditions exists so that no signal is produced in the signalling circuit and being unbalanced when the other of said conditions exists to provide a signal in the signalling circuit; and means for utilizing the signals from each of the sensing means to give an indication of the results of bowling.

4. In combination with a bowling alley having a plurality of pin spots at positions where pins are set upright on the alley for bowling, apparatus for detecting the presence or absence of standing pins on the alley at each pin spot, comprising, a plurality of sensing means one associated with each pin spot for distinguishing between a first condition represented by the presence of a standing pin and a second condition represented by the absence of a standing pin, each sensing means comprising an insert in the alley at each pin spot providing an upper surface flush with the alley and comprising a coupling medium for conducting sound waves, an electroacoustical transducer beneath the insert, means coupling the transducer to the insert such that vibrations produced by the transducer are transmitted to the pin spot, and an electrical bridge connected with the transducer to cause the latter to produce sound waves including a pair of parallel circuits one including a pair of impedances in series and the other including a first impedance in series with said transducer which functions as a second impedance, an alternating current source connected in series circuit with said parallel circuits, and a signalling circuit connected across the parallel circuits between the impedances therein, said parallel circuits being balanced when one of said conditions exists so that no signal is produced in the signalling circuit and being unbalanced when the other of said conditions exists to provide a signal in the signalling circuit

due to a change of electrical impedance in the bridge circuit as a result of a change in the acoustical impedance.

5. In combination with a bowling alley having a plurality of pin spots at positions where pins are set upright on the alley for bowling, apparatus for detecting the presence or absence of standing pins on the alley at each pin spot, comprising, a plurality of sensing means one associated with each pin spot for distinguishing between a first condition represented by the presence of a standing pin and a second condition represented by the absence of a standing pin, each sensing means comprising an elongate rodlike electroacoustical transducer beneath the alley at each pin spot, means providing a coupling medium for conducting sound waves from the transducer to the surface of the alley including a solid frusto conic member, and a bridge circuit connected with the transducer to cause the latter to produce axial sound waves including a pair of parallel circuits, one including a pair of impedances in series and the other including a first impedance in series with said transducer which functions as a second impedance, an alternating current source connected in series circuit with said parallel circuits, and a signalling circuit connected across the parallel circuits between the impedances therein, said parallel circuits being balanced when one of said conditions exists so that no signal is produced in the signalling circuit and being unbalanced when the other of said conditions exists to provide a signal in the signalling circuit due to a change of electrical impedance in the bridge circuit.

6. In combination with a bowling alley having a plurality of pin spots at positions where pins are set upright on the alley for bowling, apparatus for detecting the presence or absence of standing pins on the alley at each pin spot, comprising, a plurality of sensing means one associated with each pin spot for distinguishing between a first condition represented by the presence of a standing pin and a second condition represented by the absence of a standing pin, each sensing means comprising a plastic insert in the alley at each pin spot, a solid frusto conic horn having an upper surface engaging the insert and comprising a coupling medium for conducting sound waves, an elongate rodlike electroacoustical transducer of crystalline material engaging the horn, and a bridge circuit connected with the transducer to cause the latter to produce axial sound waves including a pair of parallel circuits one including a pair of impedances in series and the other including a first impedance in series with said transducer which functions as a second impedance, an alternating current source connected in series circuit with said parallel circuits, and a signalling circuit connected across the parallel circuits between the impedances therein, said parallel circuits being balanced when one of said conditions exists so that no signal is produced in the signalling circuit and being unbalanced when the other of said conditions exists to provide a signal in the signalling circuit due to a change of electrical impedance in the bridge circuit.

7. In combination with a bowling alley having a plurality of pin spots at positions where pins are set upright on the alley for bowling, apparatus for detecting the presence or absence of standing pins on the alley at each pin spot, comprising, a plurality of sensing means one associated with each pin spot for distinguishing between a first condition represented by the presence of a standing pin and a second condition represented by the absence of a standing pin, each sensing means comprising an insert in the alley at each pin spot having an upper surface flush with the alley and comprising a coupling medium for conducting sound waves, an elongate rodlike magnetostrictive transducer comprised of a metallic core and a coil therearound beneath the insert, means coupling the core to the insert such that vibrations produced by the transducer are transmitted to the pin spot, and a bridge circuit connected with the transducer to cause the latter to produce axial sound waves including a pair of parallel circuits one including a pair of impedances in series and the other in-

cluding a first impedance in series with said transducer which functions as a second impedance, an alternating current source connected in series circuit with said parallel circuits, and a signalling circuit connected across the parallel circuits between the impedances therein, said parallel circuits being balanced when one of said conditions exists so that no signal is produced in the signalling circuit and being unbalanced when the other of said conditions exists to provide a signal in the signalling circuit due to a change of electrical impedance in the bridge circuit.

8. In combination with a bowling alley, apparatus for detecting the presence or absence of a standing bowling pin on the alley by distinguishing between a first condition represented by the presence of a standing pin and second condition represented by the absence of a standing pin, comprising, an acoustical system including an electro-mechanical transducer adjacent a pin spot on the alley for producing sound waves, means coupling the transducer to the material of the alley at the pin spot such that vibrations of the transducer are transmitted to the pin spot, said acoustical system being responsive to a bowling pin and having a predetermined acoustical impedance when one of said conditions exists and a different acoustical impedance when the other condition exists, and an electrical system connected for supplying power to the transducer and having an electrical characteristic which is altered by the change in acoustical impedance thereby to provide a signal indicative of the change.

9. In combination with a bowling alley, apparatus for detecting the presence or absence of a standing bowling pin on a pin spot on the alley by distinguishing between a first condition represented by the presence of a standing pin and a second condition represented by a fallen pin or the absence of a pin, comprising, an accoustical system including a sound conducting coupling medium in the alley at the pin spot, an electroacoustical transducer comprised of a metallic core beneath the coupling medium and a coil around the core, means coupling the core to said medium such that vibrations produced by the transducer are transmitted to the pin spot and a bridge circuit connected with the transducer coil to cause the transducer to produce sound waves including a pair of parallel circuits one including a pair of impedances in series and the other including a first impedance in series with the transducer which functions as a second impedance, an alternating current source connected in series circuit with said parallel circuits, and a signalling circuit connected across the parallel circuits between the impedances therein to distinguish between the existence of said first condition and the existence of said second condition.

10. In combination with a bowling alley having a plurality of pin spots at positions where pins are set upright on the alley for bowling, apparatus for detecting the presence or absence of standing pins on the alley

at each pin spot and in a predetermined annular area surrounding each pin spot, comprising a plurality of sensing means one associated with each pin spot for distinguishing between a first condition represented by the presence of a standing pin acoustically coupled with the alley on spot or off spot in said predetermined surrounding area and a second condition represented by the absence of a standing pin from the spot and surrounding area, each sensing means comprising an insert in the alley at each pin spot having a diameter as great as that of the pin spot and surrounding annular area providing an upper surface flush with the alley and comprising a coupling medium for conducting sound waves, an electro-acoustical transducer comprised of a nickel core disposed beneath the insert and a coil around the core, and a bridge circuit connected with the transducer to cause the latter to produce axial sound waves including a pair of parallel circuits one including a pair of impedances in series and the other including a first impedance in series with said transducer coil so that the transducer functions as a second impedance, an alternating current source connected in series with said parallel circuits, and a signalling circuit connected across the parallel circuits between the impedances therein, said parallel circuits being balanced when one of said conditions exists so that no signal is produced in the signalling circuit and being unbalanced when the other of said conditions exists to provide a signal in the signalling circuit due to a change of electrical impedance in the bridge circuit.

11. In an apparatus for detecting the presence or absence of standing bowling pins at predetermined pin spots on a bowling alley, a plurality of sensing means one for each pin spot for distinguishing between a first condition represented by the presence of a standing pin physically coupled to the pin spot and a second condition represented by the absence of a standing pin, each sensing means including an electroacoustical generator for producing sound waves, means for physically coupling the generator to the material of the alley at the pin spot such that vibrations produced by the generator will be transmitted to the pin spot, said generator being responsive to a bowling pin and having a predetermined acoustical impedance when one of said conditions exists and a different acoustical impedance when the other condition exists, and having an electrical characteristic which is altered by the change in acoustical impedance, and an electric circuit connected with the generator for energizing the latter and responsive to the alteration in the electrical characteristic for producing a signal indicative thereof.

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