

Jan. 14, 1964

DE LA VERNE RAY ETAL

3,117,451

BATTER'S SWING ANALYZING APPARATUS

Filed Dec. 5, 1960

2 Sheets-Sheet 1

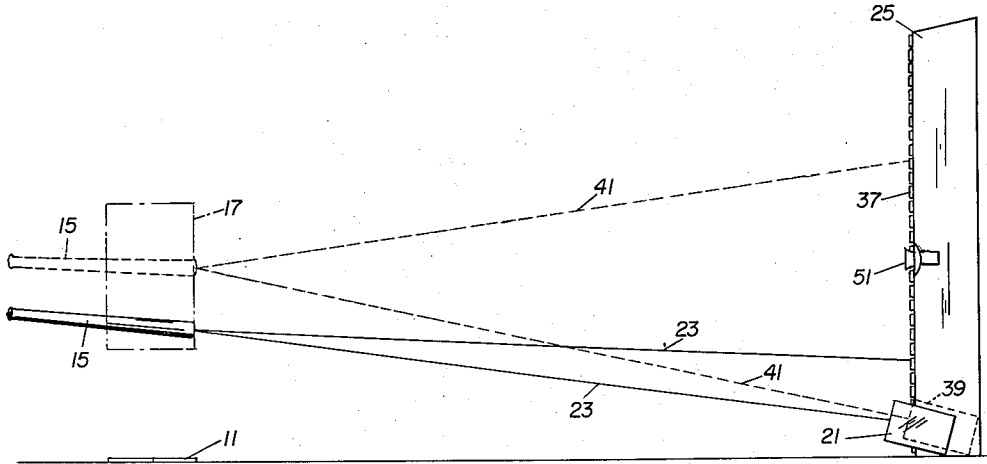


Fig. 1

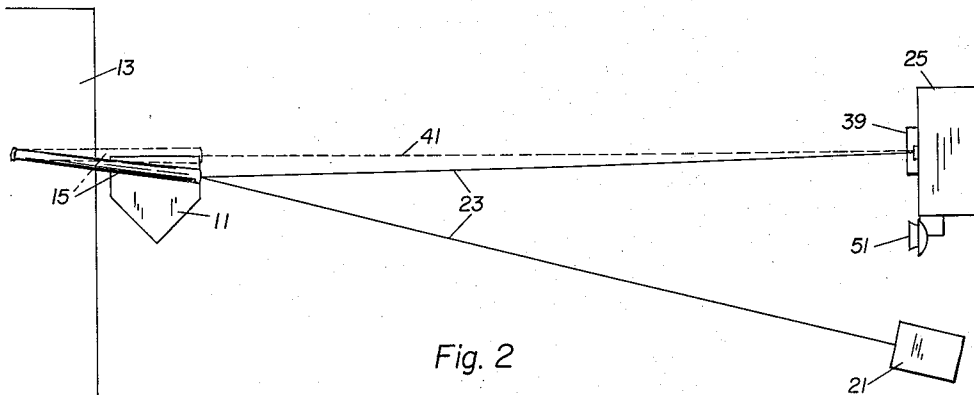


Fig. 2

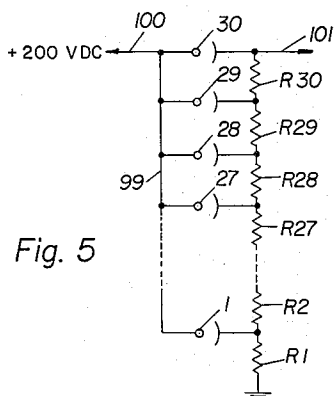


Fig. 5

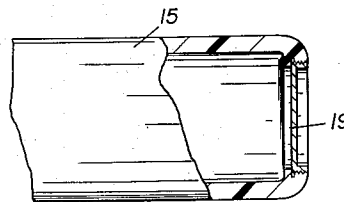


Fig. 4

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BATTER'S SWING ANALYZING APPARATUS
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Filed Dec. 5, 1960, Ser. No. 73,760
7 Claims. (Cl. 73—379)

This invention relates to a method of and apparatus for analyzing a batter's swing.

A main object of the invention is to provide an apparatus for indicating bat speed, plane of the bat swing, and point of impact of the bat with the ball during the bat swing. With these three results, defects in the batter's swing can readily be determined, analyzed and corrected.

Another object of the invention is to provide an apparatus of the type above indicated for indicating any one of the conditions above named.

Various other objects will be apparent from the following description taken in connection with the accompanying drawings wherein:

FIG. 1 is an elevational view in diagrammatic form showing part of the apparatus of the invention and its relation to a bat, batter's plate and the strike zone;

FIG. 2 is a plan view of the arrangement disclosed in FIG. 1;

FIG. 3 is a block diagram of a circuit which constitutes part of the present invention;

FIG. 4 is a fragmentary sectional view of a baseball bat showing part of the present invention; and

FIG. 5 is a circuit diagram of the photoelectric cell unit.

Referring to FIGS. 1 and 2, there is a home plate 11 and a batter's box 13 for a right-handed batter. A baseball bat 15 is shown as being swung upwardly through a strike zone 17, the full lines indicating a first position and the dotted lines showing a subsequent position. FIG. 4 shows that the end of the bat 15 is equipped with a reflector 19 for reflecting a beam of light directed at the end of the bat.

Referring now to FIG. 1, a source 21 of infrared light is shown as directing a beam of light 23 toward the strike zone 17 so as to project light onto the end of the bat. The reflector 19 will reflect a spot of light toward a vertical photoelectric cell unit 25 which includes a plurality of vertically arranged photoelectric cells 37 so connected, as will be presently set forth, that the higher the cell, the greater the amplitude of the pulse produced by the cell.

As is evident from FIG. 2, the first light source 21 is disposed in a clockwise direction from the photoelectric cell unit 25 an angular extent of less than 90° and in fact an angular extent of a minor acute angle. The distance of the first light source 21 and the photoelectric cell unit 25 from the batter's plate is the same. The photoelectric cell unit 25 has a second light source 39 for directing a beam of light 41 toward the strike zone. The light source 39 directs the beam in an upwardly inclined angle the same as does light source 21.

Referring to FIG. 2, assuming that the bat 15 is in the full line position in FIG. 2, the beam 23 from the source 21 will strike the reflector 19 and be reflected onto the photoelectric cell unit 25. This creates a first pulse of electrical energy. As shown in FIG. 1, it is assumed that the bat is pointed somewhat downwardly and occupies a low position and hence the beam 23 will strike a lower cell 37 to create a pulse of electrical energy having an amplitude less than if a higher cell were struck.

Now returning to FIG. 2, as the bat assumes the dotted line position in FIG. 2, the light beam 41 will be reflected directly back to the photoelectric cell unit to strike the unit. From FIG. 1, it is apparent that the beam of light

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41 is going to strike the upper part of the photoelectric cell unit 25 and create a second pulse of greater amplitude than that of the first pulse.

The box 25 also contains a microphone 51 which will generate a pulse of electrical energy when the bat strikes the ball.

For convenience hereinafter, the pulse of light created because of the light source 21 will be referred to as pulse A, whereas the pulse created by the beam issuing from the source 39 will be referred to as pulse B, and the pulse created by the microphone 51 as pulse C.

Referring to FIG. 5, the circuit diagram of the photoelectric cell unit is disclosed fragmentarily and the circuitry is located in the unit 25. In a typical installation, there may be thirty cells of the constant current type, that is, where the output current is a function of light intensity only and independent of applied voltage. The cells are designed to have maximum response to infrared light.

Only five of the thirty cells are shown in FIG. 5 and labeled cell 30, 29, 28, 27 and 1. The left-hand sides of the cells are connected to a common conductor 99 and the right-hand sides of the cells are connected to a common resistance line containing a resistor for each cell, resistances R30, R29, R28, R27, R2, R1 being shown. The resistance R1 is grounded, and there is a supply conductor 100, which in a typical installation may be at 200 volts D.C.

The output conductor is numbered 101. It is apparent that the amplitude of an output pulse at 101 will vary from a low value for a low cell to a progressively higher value for progressively higher cells.

In a typical installation, the thirty cells may be arranged in a vertical row commencing approximately one inch above the ground and extending to slightly more than eighty-three inches above the ground. If each cell has a vertical dimension of approximately two and five-eighths inches, it is apparent that there will be little space between cells.

With the above relationship, the output from the unit 25 will vary substantially linearly even though the light spot reflected from the bat passes between the cell centers. In fact, if the spot size is made to have a diameter equal to the diameter of a cell plus the distance of the space between cells, or a multiple of these combined dimensions, the output of the unit 25 will be linear.

Level Stroke Determination

As the player swings at a ball, a spot of light passes over the photoelectric cell unit 25 and generates the first voltage pulse, pulse A, of approximately 250 to 500 microseconds duration and of an amplitude corresponding to how high on the cell group the spot passage occurred. This pulse is then amplified at 202 to bring its amplitude between the measuring range of 10 to 50 volts. Next, the pulse passes through a gate driver 203a (cathode follower) and a first pulse gate 204 to a pulse rectifier 205, where it is rectified and the peak voltage of the pulse is stored on a capacitor.

From a decoupler 203b (cathode follower) a second use of this pulse (actually the timing part of the double pulse) is made by routing it through a squaring amplifier 210 (Schmitt-Trigger) where it is squared into a 100 volt pulse with short rise and fall times. This output is then differentiated into sharp positive and negative pulses. These are then fed to a speed control counter 215 in the form of an Eccles-Jordan bistable multivibrator in such a manner that the multivibrator responds only to the negative pulse which occurs at the end of pulse A. The Eccles-Jordan speed counter control 215, in responding to this negative pulse reverses its condition and via con-

control buffers 216 (cathode followers) turns the first pulse gate 204 off and opens a second pulse gate 311 preparing it to accept pulse B from the photoelectric cell unit 25.

Approximately 3,000 to 6,000 microseconds following pulse A, dependent on the speed of the bat, the angles involved between the bat and the infrared sources and the photoelectric cell unit 25, a second light spot will cross the photoelectric cell unit 25 and an output voltage pulse B of 250 to 500 microseconds duration and an amplitude dependent on the height of the light spot will be developed in the photoelectric cell group common output. Pulse B will follow the same path as pulse A, that is through the amplifier 202 and the gate driver and decoupler 203a and 203b, but due to the switching action of the control multivibrator 215 previously described, will now pass through the second pulse gate 311 and thence to a pulse rectifier and storage circuit 312 where it is rectified and stored in the same manner as pulse A.

The two stored voltages are then fed simultaneously to a comparator 406 where they are subtracted and a positive and a negative difference signal appear in the output. If the two storage voltages are equal, no output results. If pulse A is larger than pulse B, the positive difference output rises and the negative difference output falls. Where pulse B is the greater, the positive difference output falls and the negative difference output rises.

These signals then pass to a combiner-inverter 407 which is a combination of two tubes operating at a point approaching cutoff so that they only respond to rising signals on their grids. Thus, no matter which pulse exceeds the other, a unipolar error signal proportional to the difference appears at the plates of the combiner-inverter 407. This error signal is then amplified in a differential D.C. amplifier 408 and passes to a decision relay keyer 409 (Schmitt-Trigger). If the error signal exceeds a predetermined potential, the decision relay will be triggered to condition a red light to go on. If not, it will condition a green light to go on. If desired, the error may be fed to a meter to give an indication of the magnitude of the error.

As in the case of pulse A, pulse B from the photoelectric cell unit 25 also passes from the decoupler 203b through the squaring amplifier 210 to the speed counter control 215 which once again reverses its condition, returning to the initial state at the end of pulse B. This action of the speed counter control, passing through the control buffers 216 is fed to a readout control circuit 440 (bistable Eccles-Jordan multivibrator) and thence to a readout relay 441 (Schmitt-Trigger). The readout relay 441 now applies voltage to the decision relay 409 causing the appropriate light to light in accordance with the decision made as above. Additional contacts on the readout and decision relays lock the decision keyer 409 for the readout period.

Speed of Stroke Measurement

As mentioned above, the speed counter control multivibrator 215 was caused to "flip" by the trailing edge of pulse A, and to "flop" by the trailing edge of pulse B. This time-between-events signal is fed through the control buffers 216 to control a count pulse gate 517. Pulse A causes this gate to open and feed 100 microsecond pulses (100 microseconds apart) from a 10 kc. oscillator 525 (Wien bridge) and a squaring amplifier 526 (Schmitt-Trigger) into a five-stage binary counter chain 618. Pulse B causes the gate 517 to close, stopping the count. The condition of the various stages in the binary chain will then indicate the number of 100 microsecond intervals which elapsed between the two cell pulses A and B.

It will be noted that the maximum count of the counter chain is 32 or 3,200 microseconds, while the interval of interest (time between bat positions) is 3,500 to 6,000 microseconds. Thus, the counter will cycle completely once before pulse B arrives and consequently take its count on the second cycle, so that 3,200 microseconds are absorbed in the first cycle and the measurement occurs

between 3,200 and 6,400 microseconds. A series of 2-to-1 ratioed resistors (not shown) feeds the conditions of the binary stages into a common readout buss thence via a readout amplifier 623 (cathode follower) to a meter 624, the meter being calibrated to directly convert the time measurements to equivalent miles per hour.

Circuitry for accomplishing the functions of the various blocks of FIG. 3 is known to those skilled in the art. However, novel circuitry is being devised for accomplishing the functions of certain of the blocks, for instance the comparator 406, and will be made the subject matter of a subsequent application.

Circuitry for conversion of the digital information of the binary counter 618 to an analog signal for the meter 624 is shown at page 214 of Digital Counters and Computers by Bukstein (Rinehart & Company).

Impact Timing

It is assumed that the proper point of impact of the ball with the bat should occur at the instant that the bat reaches a line perpendicular to the line of flight of the ball. It is apparent from FIG. 2 that the second light source 39 is located so that its beam 41 is perpendicular to a line extending through the plate 11 and the pitcher's mound (not shown). Thus when the bat reaches a position coinciding with the beam 41 as the parts are shown in FIG. 2, the bat should, in an ideal situation, strike the ball. By comparing pulse B with a pulse produced by the sound of the impact, in respect to timing, an indication of the actual point of impact may be obtained.

Since the speed counter control 215 returns to normal with the trailing edge of pulse B, this action is used via the control buffers 216 to activate a timing counter control 629 (Eccles-Jordan bistable multivibrator) to on. This opens a count gate 630 allowing 100 microsecond pulses to pass from the 10 kc. oscillator 525 and squaring amplifier 526 to a six stage binary counter chain 631 and counting action starts.

The sound of the impact is picked up by the microphone 41 and the pulse C thus created is suitably amplified at 727, squared at 728 (Schmitt-Trigger) and used to trigger the timing counter control 629 to off, to terminate the count. Since, the microphone 41 is located approximately 12 feet from the actual point of impact, there is a delay while the sound travels through the air and this must be accounted for. This delay is of the order of 10,000 microseconds and thus while the impact may occur before pulse B, the sound will arrive at the microphone 41 after the light cell pulse has arrived at the count pulse gate 630. The counter chain is capable of 64 counts or total time of 6,400 microseconds. The counter chain thus cycles one time before pulse C arrives and takes measurement in the second cycle. Thus the arc of measurement is from 6,400 to 12,800 microseconds.

The binary chain readout is here accomplished identically with that in the speed counter chain, a readout amplifier 737 (cathode follower) and an impact timing meter 738 being provided for the chain 631 to indicate proper impact or early or late impact and to what extent.

Reset

For fully automatic operation, it is necessary that the machine accomplish all functions and return itself to the idle "no reading" condition after one second or other predetermined time. To accomplish this, pulse A is fed from the squaring amplifier 210 to an automatic reset timer circuit 814. This circuit is a one second duration monostable multivibrator (Schmitt-Trigger) which pulse A triggers to the "off normal" condition. Triggering to the "off normal" has no effect on the rest of the circuitry, but at the expiration of one second when the reset timer 814 returns to normal, its output is differentiated and fed via a switch 838 to a reset amplifier 839 and then to both counter chains 618 and 631, to erase the counts, to the speed counter control 215, to insure idle condition (in case there is no pulse B, for instance) to the readout

control 440 to terminate readout of the level swing and unlock the level swing decision 409, and to a comparator and storage reset circuit 913 to discharge the pulse storage capacitors to zero.

In the manual condition of the reset switch 838 the reset timer 814 is disconnected and the reset pulse manually generated by the operation of the switch.

Further Explanation

It is contemplated that different batters may assume different positions in the batter's box, and while the unit 25 and the light source 21 may be moved to accommodate this, or mounted on tracks for ready in unison adjustment, this will not be necessary in most instances because the speed and the level stroke indications will be unaffected and the point of impact indication will still be meaningful. If desired, the meter 738 can have an adjustable zero or ideal indicator and the person checking the batter can merely adjust the indicator according to the position of the batter.

For left-handed batters, a second unit 25 and source 21 may be provided, or the unit 25 and source 21 shifted to the other side of home plate.

Having described the invention in what is considered to be the preferred embodiment thereof, it is desired that it be understood that the invention is not to be limited other than by the provisions of the following claims.

We claim:

1. An apparatus for indicating bat speed, plane of bat swing, and point of ball impact during the bat swing, comprising means including vertical photoelectrical cell means to face a batter's plate in spaced relation thereto, said photoelectric cell means creating a pulse of electrical energy which varies in amplitude in accordance with the height of a beam of light crossing said means, light beam means responsive to the swing of a bat across the batter's plate for projecting a first beam on said photoelectric cell means as the bat passes a first predetermined place to create a first pulse of electrical energy, and for projecting a second beam on said photoelectric cell means as said bat passes a second predetermined place to create a second pulse of electrical energy, said light beam means being arranged so that the first light beam strikes said photoelectric cell means at a height proportional to the level of said bat when said bat is at said first predetermined place, and so that the second light means strikes said photoelectric cell means at a height proportional to the level of the bat when said bat is at said second predetermined place, whereby if the bat level is different at said places, the amplitudes of said first and second pulses will be different, means for comparing the amplitude of said first and second pulses and indicating when the difference exceeds a predetermined value, means for indicating the difference in time between the two pulses to indicate the speed of the batter's swing, means responsive to the impact of the bat with a ball to create a third pulse of electrical energy, and means for indicating the difference in time between the third pulse and one of the first two named pulses.

2. An apparatus for indicating the plane of swing of a bat comprising means including vertical photoelectric cell means to face a batter's plate in spaced relation thereto, said photoelectric cell means creating a pulse of electrical energy which varies in amplitude in accordance with the height of a beam of light crossing said means, light beam means responsive to the swing of a bat across the batter's plate for projecting a first beam on said photoelectric cell means as the bat passes a first predetermined place to create a first pulse of electrical energy, and for projecting a second beam on said photoelectric cell means as said bat passes a second predetermined place to create a second pulse of electrical energy, said light beam means

being arranged so that the first light beam strikes said photoelectric cell means at a height proportional to the level of the bat when said bat is at said first predetermined place, and so that the second light means strikes said photoelectric cell means at a height proportional to the level of the bat when said bat is at said second predetermined place, whereby if the bat level is different at said places, the amplitudes of said first and second pulses will be different, means for comparing the amplitude of said first and second pulses and indicating when the difference exceeds a predetermined value.

3. An apparatus for indicating the plane of swing of a bat and bat speed comprising means including vertical photoelectric cell means to face a batter's plate in spaced relation thereto, said photoelectric cell means creating a pulse of electrical energy which varies in amplitude in accordance with the height of a beam of light crossing said means, light beam means responsive to the swing of a bat across the batter's plate for projecting a first beam on said photoelectric cell means as the bat passes a first predetermined place to create a first pulse of electrical energy, and for projecting a second beam on said photoelectric cell means as said bat passes a second predetermined place to create a second pulse of electrical energy, said light beam means being arranged so that the first light beam strikes said photoelectric cell means at a height proportional to the level of the bat when said bat is at said first predetermined place, and so that the second light means strikes said photoelectric cell means at a height proportional to the level of the bat when said bat is at said second predetermined place, whereby if the bat level is different at said places, the amplitudes of said first and second pulses will be different, means for comparing the amplitude of said first and second pulses and indicating when the difference exceeds a predetermined value, means for indicating the difference in time between the two pulses to indicate the speed of the batter's swing.

4. An apparatus as in claim 1 in which said light beam means includes reflector means on the bat.

5. An apparatus as in claim 2 in which said light beam means includes reflector means on the bat.

6. An apparatus as in claim 3 in which said light beam means includes reflector means on the bat.

7. An apparatus for indicating bat speed, plane of bat swing, and point of ball impact during the bat swing, comprising means to face a batter's plate in spaced relation thereto and creating a pulse of electrical energy which varies in amplitude in accordance with the height of a bat and operative as the bat passes a first predetermined place to create a first pulse of electrical energy and operative as said bat passes a second predetermined place to create a second pulse of electrical energy, whereby if the bat level is different at said places, the amplitudes of said first and second pulses will be different, means for comparing the amplitude of said first and second pulses and indicating when the difference exceeds a predetermined value, means for indicating the difference in time between the two pulses to indicate the speed of the batter's swing, means responsive to the impact of the bat with a ball to create a third pulse of electrical energy, and means for indicating the difference in time between the third pulse and one of the first two named pulses.

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