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Sanders

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[54] **GOLF GAME COMPUTER INCLUDING MEANS FOR APPROXIMATING THE EFFECTS OF BACKSPIN ON RANGE**

[72] Inventor: **James W. Sanders,** Grand Haven, Mich.

[73] Assignee: **Brunswick Corporation**

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[51] **Int. Cl.** **G06g 7/48,** A63b 67/02

[58] **Field of Search** 235/151, 151.3, 151.32; 73/379; 273/183

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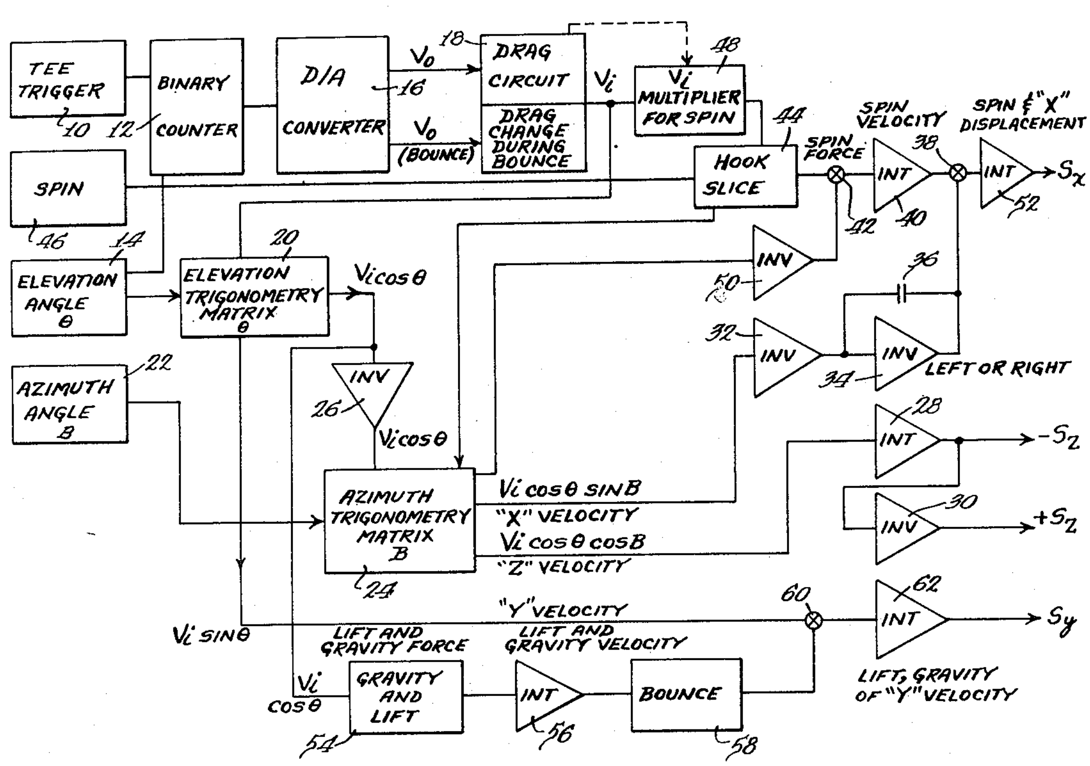
Primary Examiner—Eugene G. Botz
Assistant Examiner—Jerry Smith
Attorney—Hofgren, Wegner, Allen, Stellman & McCord

[57] **ABSTRACT**

A computing system for calculating the free flight trajectory of a golf ball struck from a tee having backspin imparted thereon including a backspin corrector therein for modifying the calculated distance of the golf ball so as to simulate the effects of backspin. A signal modifier alters the magnitude of a signal related to the distance the golf ball would travel proportionally according to a characteristic of the flight trajectory.

1 Claim, 2 Drawing Figures



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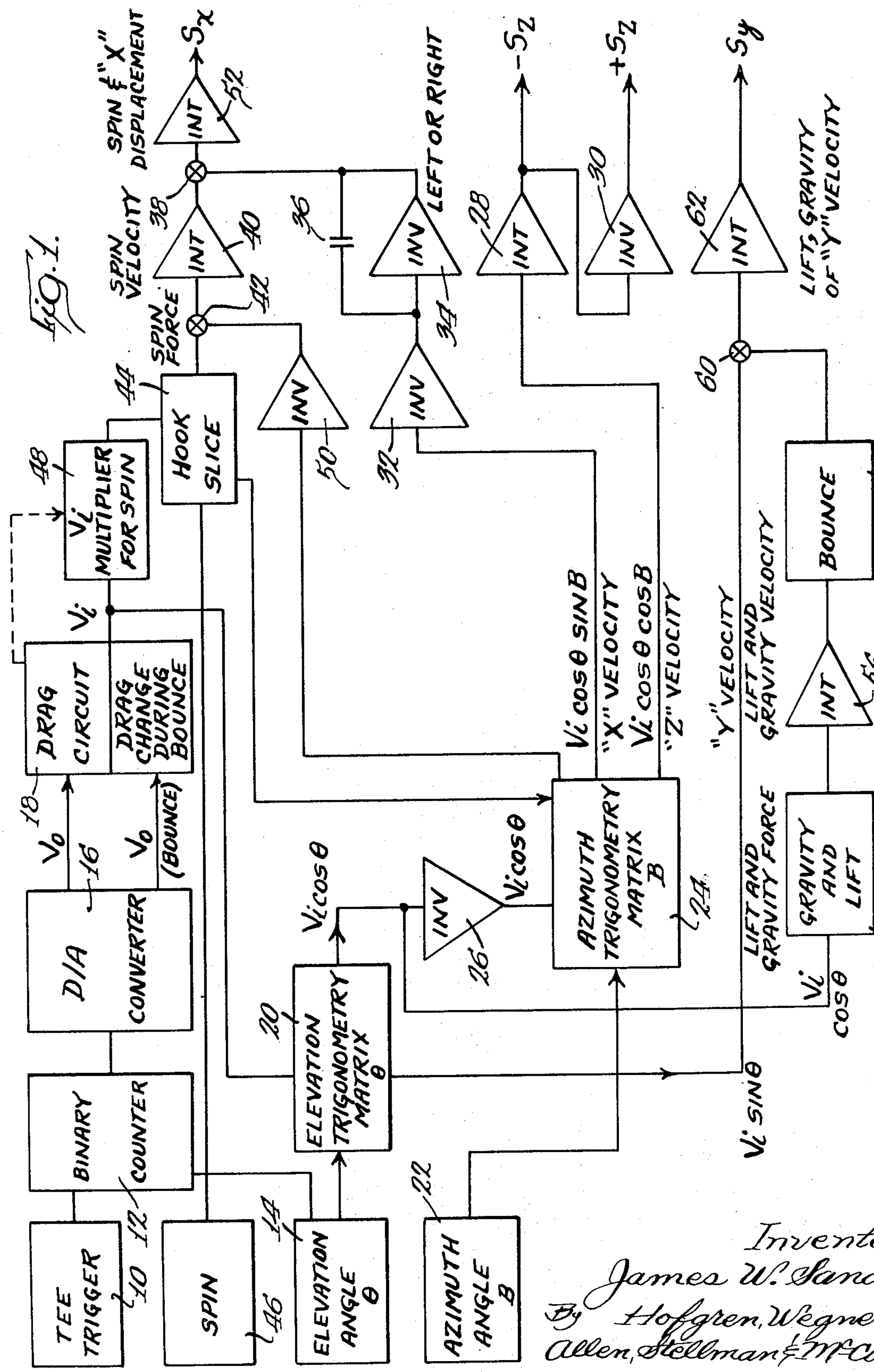

Inventor:
James W. Sanders
By Hofgren, Wegner, Allen, Stellman & McCord
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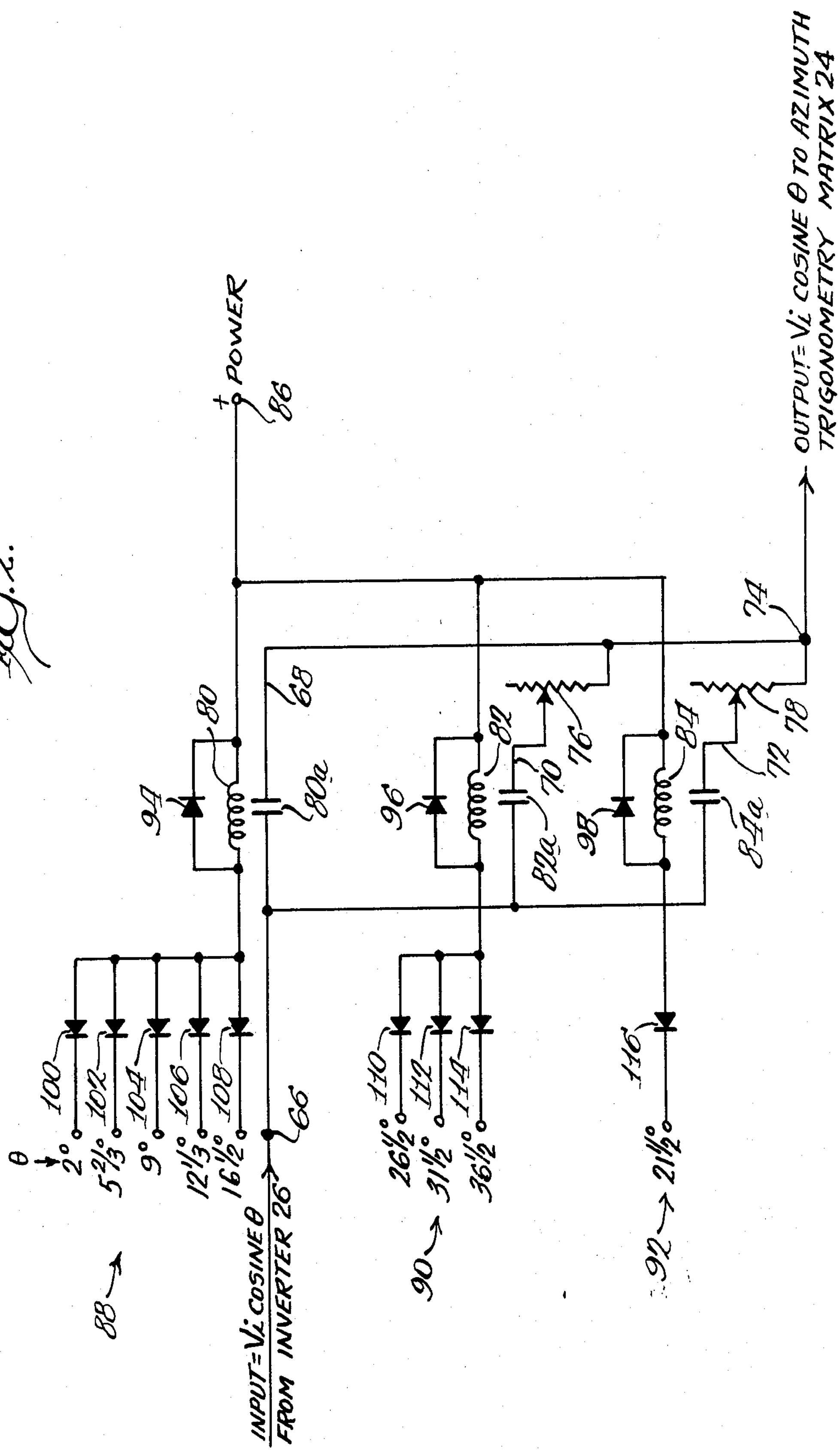
Fig. 2.



GOLF GAME COMPUTER INCLUDING MEANS FOR APPROXIMATING THE EFFECTS OF BACKSPIN ON RANGE

BACKGROUND OF THE INVENTION

The ever-increasing upsurge of the polarity in the game of golf has resulted in severe crowding of existing outdoor facilities. As a result, there have been numerous proposals for indoor golf games wherein an entire game of eighteen holes may be played indoors. Such indoor golf games customarily involve tee areas from which a ball may be hit to be intercepted by a target. Suitable data acquisition means are interposed between the tee and the target and provide information relative to the initial trajectory and speed of the ball. This information is then fed into a trajectory computing means which will, depending upon the degree of sophistication, ascertain how far the ball would have travelled had it not struck the target and may take into consideration such additional factors as the initial angle of the ball with respect to the azimuth, the initial angle of the ball with respect to the elevation and side spin, if any. While such golf games embodying the above-described computing system have been very satisfactory, they have not taken into consideration the total effect of backspin on the distance.

SUMMARY OF THE INVENTION

The principal object of this invention is to provide in a system for calculating the flight of a golf ball struck from a tee having backspin imparted thereon, a novel backspin corrector for altering the calculated distance of the golf ball thereby more completely simulating the effect of backspin.

The system in which the backspin corrector forms a part thereof includes: a source of signal representing the nominal distance of the flight of the golf ball struck from the tee; means for measuring a characteristic of the flight of the golf ball, it being assumed that the characteristic being measured is a function of the distance-modifying effects of backspin; and means for modifying the signal so as to represent an alteration of the distance of the flight of the golf ball as a function of the backspin imparted to the ball.

The exemplary embodiment of the invention employs means for determining the initial angle of elevation as the measuring means, on the assumption that the amount of backspin on the ball is proportional to the initial elevation angle of the golf ball hit from the tee. In this system, the signal modifier alters a signal so as to effect change in the nominal distance of the flight of the golf ball as a function of the initial angle of the elevation of a golf ball hit from a tee.

The signal source employed in the invention is a means for determining the instantaneous velocity of the golf ball hit from a tee at any point in the theoretical time of flight thereof. The exemplary embodiment of the invention provides a signal that is a function of the elevation angle and the instantaneous velocity of a golf ball hit from a tee.

The signal modifier includes a plurality of resistors each corresponding to a different group of initial elevation angles and means responsive to the elevation angle determining means for switching the signal across the appropriate resistance thereby altering the signal in appropriate amount. The switching means in the exemplary embodiment includes a plurality of "OR" gates operably connected to the elevation angle determining means, each gate representing a different group of initial elevation angles.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram illustrating the trajectory computing means; and

FIG. 2 is a schematic diagram of a signal modifier.

DESCRIPTION OF THE PREFERRED EMBODIMENT

One form of golf game computer in which the inventive improvement constituting this invention is susceptible to use is basically that disclosed in the copending application of Russell et al., Ser. No. 588,922, filed Oct. 24, 1966, now U.S. Pat. No. 3,513,707, and assigned to the same assignee as the instant application, the details of which are incorporated herein by reference.

Before proceeding with the discussion of the basic operation of the computer, it is to be understood that the same computes, throughout the theoretical time of flight (including bouncing and rolling) of the ball, three coordinates of the ball in space. The coordinates represent the displacement of the ball in three directions from the tee point and, as is known in the art, are referred to as the "X," "Y" and "Z" directions. The Y direction is vertical and thus, the instantaneous Y displacement represents the height of the ball in flight above the ground. The Z direction is horizontal and straightaway from the tee point so that the instantaneous Z displacement represents the distance of the ball from the tee point in a direction straightaway therefrom. The X direction is also horizontal and is transverse to the Z direction. Thus, the instantaneous X displacement represents the location of the ball to either side of the line defining the Z direction. Further, since the displacement can be to either side of the Z direction, it may be either positive or negative while the Y and Z displacements will always be positive or zero.

The computer is illustrated in block form in FIG. 1 and includes a tee trigger **10** which is adapted to sense when a ball has been hit by a golfer from a tee area to start a binary counter **12**. The binary counter **12** is stopped when the ball has travelled a predetermined distance from the tee by any suitable means. For example, in the Russell et al application, there is provided an arcuate arrangement of photocells for sensing the initial angle of elevation of the ball and when the ball passes through the photocell matrix, a signal is generated thereby to stop the binary counter. Alternatively, the predetermined distance may be set by the location of a target for stopping the ball such as that disclosed in the copending application of Conklin et al., Ser. No. 820,558, filed Apr. 30, 1969, and assigned to the same assignee as the instant application, the details of which are herein incorporated by reference. When the latter system is used, the means contained within the target for sensing elevation angle may also be used to stop the binary counter.

In any event, elevation angle detecting means **14** are provided and the same, in addition to detecting the initial angle of elevation θ of a ball hit from the tee, are operative to stop the binary counter **12**.

The count contained in the binary counter **12** is inversely representative of the initial velocity of the ball hit from the tee. That is, the higher the count in the binary counter **12**, the longer it will have taken for the ball to pass the predetermined distance from the tee point to the elevation angle detecting means **14** and thus, the slower will be its velocity.

The count contained in the binary counter **12** is then decoded by a digital to analog conversion matrix **16** which is operative to convert the digital time quantity contained in the binary counter to an analog velocity quantity designated V_o for initial velocity. This information is then fed to a drag circuit **18** which is operative to ascertain from the initial velocity V_o, the instantaneous velocity V_i of the ball at any point in its theoretical time of flight.

The digital to analog converter **16** also provides a second V_o (bounce) signal to the drag circuit **16** which is operative to increase the drag or decay rate of the instantaneous velocity V_i after the free flight of the ball has terminated and the same is bouncing or rolling on the ground.

Returning to the elevation angle detecting means, the same provides a signal to an elevation trigonometry matrix **20** which has two outputs. On one output, there is placed a signal having a magnitude which is proportional to the product of the instantaneous velocity V_i and the cosine of the initial angle of elevation of the shot, $\cos\theta$, or $V_i \cos\theta$. On the other output, there is placed a signal having a magnitude proportional to the product of the instantaneous velocity V_i and the sine of the initial angle of elevation of the shot, $\sin\theta$, or $V_i \sin\theta$.

The system also includes an azimuth angle detecting means 22 for detecting the initial angle B of the shot with respect to the azimuth. The azimuth angle detecting means 22 may be in the form of the photocells disclosed by Russell et al or incorporated in the target in the manner disclosed by Conklin et al. The azimuth angle information provided by the azimuth angle detecting means 22 is then fed to an azimuth trigonometry matrix 24.

The $V_t \cos \theta$ output from the elevation trigonometry matrix 20 is fed through an inverter 26 as an input to the azimuth trigonometry matrix 24. The azimuth trigonometry matrix then converts the signal to be proportional to the product of the instantaneous velocity V_t, the cosine of θ and the sine of B, $V_t \cos \theta \sin B$, which, as will be appreciated from the reading of the Russell et al application, corresponds to the instantaneous velocity of the ball in the so-called "X" direction without regard to the effects of side spin.

The azimuth trigonometry matrix 24 also provides a second signal which corresponds to the product of the instantaneous velocity V_t, the cosine of θ and the cosine of B, $V_t \cos \theta \cos B$, which correspond to the instantaneous velocity of the ball in the so-called "Z" direction.

The $V_t \cos \theta \cos B$ signal is then used as an input for an integrating circuit 28 which provides as an output, a signal proportional to the instantaneous displacement of the ball in the Z direction, S_z. As shown in FIG. 1, such a signal is of negative polarity and, for purposes explained in the Russell et al application, this signal is also fed to an inverter 30 which provides as an output the same signal but with the opposite polarity.

The V_t cos sin B output of the azimuth trigonometry matrix 24 is fed as an input to a first inverter 32 which, in turn, provides an input to a second inverter 34. Shunting the inverter 34 is a pair of relay contacts 36 which are operative to cut the inverter 34 in or out of the circuit.

As described in the Russell et al. application, the output of the azimuth trigonometry matrix 24 is of the same polarity regardless of whether the ball is travelling to the left or right in the X direction. However, means are also provided in association with the matrix 24 for distinguishing whether the ball is travelling to the left or the right and such means are employed or open or close the contacts 36 appropriately. For example, if the polarity of the output inverter 32 is arbitrarily such as to indicate that the ball is travelling to the right, and in fact, the ball was sensed as travelling to the left, the distinguishing means would leave the contacts 36 open so that the inverter 34 would provide a signal having an opposite polarity of that provided by the inverter 32 thereby indicating that the ball was in fact travelling to the left. On the other hand, if the ball was in fact travelling to the right, the distinguishing means would cause the contacts 36 to be closed to thereby shunt the inverter 34 to provide a signal having a polarity indicating that the ball was in fact travelling to the right.

The parallel combination of the contacts 36 and the inverter 34 is connected to a summing point 38 whereat the effect of side spin is also considered in determining total velocity in the X direction. A second input to the summing point 38 is taken from the output of an integrator 40 which has its input connected to a summing point 42. The summing point 42 receives information from two sources. Firstly, the same receives information from a hook-slice matrix 44 which in turn receives information from a spin detector 46 which provides an indication of side spin on the ball. The spin detector 46 may be either of the form disclosed by Russell et al. or that disclosed by Conklin. The hook-slice matrix 44 also receives an input from a circuit 48 which is representative of a power of the instantaneous velocity V_t received from the drag circuit 18.

The hook-slice matrix 44 also provides an output to the azimuth trigonometry matrix 24 which in turn provides an output to an inverter 50 which is connected to the summing point 42. The reasons for the foregoing connections are not material to the invention, but are explained in detail in the Russell et al. application. For the purposes of this application, it is sufficient to note that at the summing point 42, there will be a signal having a magnitude indicative of spin force or spin acceleration.

This signal is then fed to the integrator 40 which provides an output having a magnitude characteristic of the velocity in the X direction due to side spin which, in turn, is summed at the summing point 38 with the velocity in the X direction due to the initial angle with respect to the azimuth, B.

The resulting signal is then fed as an input to an integrator 52 which provides an output representative of the instantaneous displacement in the X direction, or S_x.

An output from the elevation trigonometry matrix having the signal $V_t \cos \theta$ impressed thereon is utilized as an input to a gravity and lift circuit 54. The gravity and lift circuit 54 provides an input to an integrator 56 which is representative of the acceleration in the Y direction due to the effects of lift and gravity on the golf ball in flight. The integrator 56 in turn converts this signal to a lift and gravity velocity signal which is fed to a bounce circuit 58 which, by the means disclosed by Russell et al, is ineffective while the ball is in free flight but comes into play when the ball would begin its bouncing or rolling along the ground.

The output of the bounce circuit 58 is in turn fed to a summing point 60 which receives the $V_t \sin \theta$ output from the elevation trigonometry matrix 20 which is representative of the velocity in the Y direction without regard to the effects of lift and gravity. At the summing point 60, the two signals are combined and the resulting signal is then fed as an input to an integrator 62 which provides an output representative of the instantaneous displacement in the Y direction, S_y. Of course, when the ball has encountered the ground for the first time, a bounce signal will be impressed upon the summing point 60 by the bounce circuit 58 and until such time as the ball would be motionless.

The signals representative of the displacements in the X, Y and Z directions, S_x, S_y and S_z, may be used as inputs to a display device such as a ball spot projector for displaying the flight of the ball to the golfer.

The computer shown in FIG. 1 does not take into consideration the total effect of backspin on a golf ball struck from a tee although backspin is considered in part. Specifically, the factor of lift, which is due to backspin, introduced by the gravity and lift circuit 56 introduces the effect of backspin into the computation of S_y, which indirectly affects the computation of S_x and S_z.

More specifically, the nature of the Russell et al computation system is such that computation of S_x and S_z will not be complete until bounce and roll computation is complete and bounce and roll computation, while dependent upon a variety of factors, is not initiated until S_y is equal to zero for the first time following the hitting of the ball by the golfer corresponding to the first time the ball encounters the ground.

Accordingly, the total time period during which S_x and S_z are computed is, in a large part, dependent upon the computation of S_y from the time the ball is hit until bounce and roll computation is initiated. This time period is in part dependent upon the factor of lift due to backspin, to the extent that the more lift force applied to a ball, the longer the ball will theoretically remain in the air before its first touchdown thereby increasing the aforementioned period of computation of S_y preceding bounce and roll computation. Therefore, for a greater amount of backspin on the ball, more lift will be applied thereby increasing the time of computation of S_y and S_z and therefore the final values of S_y and S_z.

However, backspin has an effect on the computation of S_y and S_z apart from that indirectly indicated in the computation of those values by the factor of lift. Specifically, the amount of drag is affected by the ratio of spin to velocity and, accordingly, the instantaneous velocity of the ball which, of course, is employed in computing each of the foregoing displacements, and while a suitable displacement correction could be obtained with the measurement of backspin imparted to the ball, the interrelations between spin and drag are exceedingly complex and as a result, the hardware required to effect such a measurement and corresponding computation is very costly. As a substitute for a direction backspin measurement and appropriate computation, an assumption in computation is made which results in computed data closely following empirically obtained data relative to the flight of the ball. Specifically, it is assumed that the ratio of backspin imparted to a ball to the velocity of the ball is proportional to the initial angle of elevation of a shot and means are employed in the computational system for utilizing this assumption in computation so that the results of computation will be realistic.

The assumption finds its basis in the fact that a golf club tending to direct a golf ball at a high initial angle of elevation, such as a high iron, will impart a good deal of backspin thereto but will not impart as high an initial velocity to the ball as would a relatively straight faced club such as a wood or a low iron. That is, while a wood or a low iron may impart less backspin to a shot than a high iron, the ratio of backspin to velocity increases as more lofted clubs are used. Accordingly, a signal modifier made according to the invention is responsive to the elevation angle detecting means **14** so as to modify a signal which is related to the nominal distance of the flight of a golf ball in such a manner as to approximate the effect of backspin on the computed S_x and S_z displacements.

As the exemplary embodiment of the invention is specifically intended for use in a computational system such as that disclosed in the Russell et al application, although not limited thereto, the exemplary embodiment requires the computed distance in the X and Z directions to be diminished as the ratio of backspin to velocity increases. This is due to the fact that the Russell et al computational system includes virtually every factor relating to the flight of the ball in computation and when such is the case, the computed distance must be somewhat reduced as increasing angles of elevation are encountered. However, were the system herein described to be employed with another form of computation system wherein computation was less comprehensive, the proposals to be described herein could be incorporated in such a way as to increase the computed distance. That is, the Russell et al. computation system computes "long" and accordingly, distance should be reduced; but if a system that computed "short" were to be modified according to the invention, computed distance would be increased using the same general principles, as for example, by increasing computed distance as decreasing angles of elevation are encountered.

It is well known that the distance a ball will travel is a function of its instantaneous velocity V_i and, therefore, any modification of a signal having V_i as a component thereof would likewise have the same effect on the ultimate distance of the golf ball hit from the tee which is a function of both S_z and S_x. Therefore, it can be appreciated by those skilled in the art, that a signal modifier of the kind contemplated can be placed anywhere in the computing circuit shown in FIG. **1** to modify a signal that is a function of the instantaneous velocity, V_i, and which is utilized in computing S_z or S_x. In the present embodiment, the signal modifier is located between the inverter **26** and the azimuth trigonometry matrix **24** and the signal modifier modifies the signal V_i cosine θ.

Technically speaking, each initial elevation angle corresponds to a different proportional decrease in the distance a golf ball hit from a tee having backspin imparted thereon as the decrease is a function of the initial angle of elevation. For simplicity's sake, however, groups of angles may be assigned different constant values rather than having a different one for each angle. This has been found to closely approximate the ideal situation.

Switching means, which will be discussed in greater detail hereinafter, are employed in the signal modifier to route the incoming signal over the appropriate means which cause the proportional reduction in the signal according to the predetermined reduction constant as above described. Therefore, the signal as characterized by V_i cosine θ will be diminished according to the initial angle of elevation.

Turning now to FIG. **2** in greater detail, an exemplary embodiment of the signal modifier receiving an input signal representing V_i cosine θ on a lead **66** is illustrated in schematic form. The modifier is seen to comprise three electrically parallel circuits generally designated **68**, **70** and **72**, over which the signal may be transmitted before leaving the modifier at **74** to enter the azimuth trigonometry matrix **24**. Circuits **70** and **72** each include a potentiometer **76** and **78** respectively, while, as can be seen, circuit **68** has no resistance.

Included in each circuit **68**, **70** and **72** are switching means for allowing the signal to be transmitted over the appropriate circuit. This means is seen to comprise three relay coils **80**, **82** and **84** respectively connected in common to one side of a power source at **86** and having normally open contacts **80a**, **82a** and **84a** respectively. The relays **80**, **82** and **84** are connected to the other end of the power source through three corresponding groups of diodes generally designated **88**, **90** and **92**. The groups of diodes **88**, **90** and **92** are operably connected to the elevation angle detecting means **14** and act as a plurality of "OR" gates. In parallel with the relay coils **80**, **82** and **84** are three diodes **94**, **96** and **98** which preclude inadvertent energization of their respective relay coils by transient currents.

Each of the potentiometers **76** and **78** will cause a voltage drop in the incoming signal depending upon which circuit the signal is transmitted through. Of course, there is no voltage drop through circuit **68** since the resistance there is zero. Each resistance is such that it will represent distance reducing constant according to the sensed initial angle of elevation and according to one embodiment, the potentiometer **76** has its wiper adjusted to cause a 10–12 percent decrease while the potentiometer **76** may be adjusted to provide a lesser decrease.

Each group of diodes **88**, **90** and **92** which act as OR gates correspond to a different group of initial angles of elevation. More particularly, the groups of diodes **88**, **90** and **92** are made up of diodes having the following designation and corresponding sensitivity to the elevation angle detecting means **14**: 100°–2°; 102°– 5 ⅜°; 104°–9°; 106–12 ⅛°; 108°–16° ½°; 110°–26 ½°; 112°–31 ½°; 114°–36° ½°; and 116°–21 ½°, respectively. Thus, group **88** is sensitive to angles ranging generally from 2° to 16 ½° and will cause the relay switch **80** to close thereby allowing no drop in voltage; group **90** is sensitive to angles ranging generally from 26 ½° to 36 ½° and will cause relay switch **82** to close thereby allowing a voltage drop according to the resistance of potentiometer **76**; and group **92** is sensitive to generally angles of 21 ½° and will cause relay switch **84** to close thereby allowing a voltage drop according to the resistance of potentiometer **78**. The arrangement is such that when the elevation detecting means ascertains the initial angle of elevation of a shot, power will flow from point **86** through the diode **100–116** corresponding to the angle sensed and energized the associated one of the relay coils **80–84** to close the corresponding ones of the contacts **80a–84**.

Therefore, it can be seen that when an input signal characterized by V_i cosine θ enters at point **66**, one relay of the coils **80**, **82** or **84** will be activated by the corresponding one of the groups of OR gates **88**, **90** and **92** depending upon the angle sensed from the elevation angle detecting means **14**. Depending upon which relay coil is activated, the signal will be routed through either circuit **68**, **70** or **72**, thereby causing an appropriate voltage drop decreasing the output signal to point **74** to effectively "rescale" the ultimate outputs to the "X" and "Z" mechanisms in a ball spot projector.

I claim:

1. A golf game computing system comprising:

means for acquiring data relative to the initial trajectory of a ball hit from a tee and including means for determining the initial angle of elevation of the ball;

means responsive to said data acquisition means for providing a first signal having a characteristic proportional to the instantaneous velocity of a ball hit from a tee at any point during its theoretical time of flight;

means for receiving said signal and computing therefrom the theoretical distance that the ball would travel and providing a second signal having a characteristic representative of the theoretical distance;

means responsive to said elevation angle determining means and interposed between said instantaneous velocity determining means and said theoretical distance computing means for changing the characteristic of said first signal generally proportionally to the initial angle of elevation determined by said elevation angle determining means to thereby effect a change in the computed theoretical distance proportional to the amount of backspin imparted to a ball hit from the tee;

said data acquisition means further including

means for determining the initial angle with respect to the azimuth of a ball hit from the tee, and

first and second matrices respectively responsive to said elevation angle determining means and said azimuth angle determining means operative to receive said first signal and to provide third and fourth signals with said third signal having a characteristic representing the theoretical instantaneous velocity of the golf ball in a direction straightaway from the tee and said fourth signal representing the theoretical instantaneous velocity of the golf ball in a direction transverse to said first direction;

said changing means being operatively associated with said matrices;

said theoretical distance computing means being operative to receive said third and fourth signals to compute the distance the ball would travel in both of said directions;

said first matrix being connected to receive said first signal and provide a fifth signal that is a function of the instantaneous velocity and the initial angle of elevation to said second matrix;

said second matrix in turn being operative to receive said fifth signal and provide said third signal as a function of the instantaneous velocity, the elevation angle and one function of the azimuth angle and said fourth signal as a function of the instantaneous velocity, the elevation angle and a different function of the azimuth angle; and

said changing means comprising a plurality of parallel circuits each including respective impedances interposed between said first matrix and said second matrix, and

means for selectively directing said fifth signal through a predetermined impedance, said directing means being operable to select an impedance in response to elevation angle information provided by said elevation angle determining means.

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