March 5, 1957 L. G. SIMJIAN 2,783,999

GOLF GAME

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FIG. 1

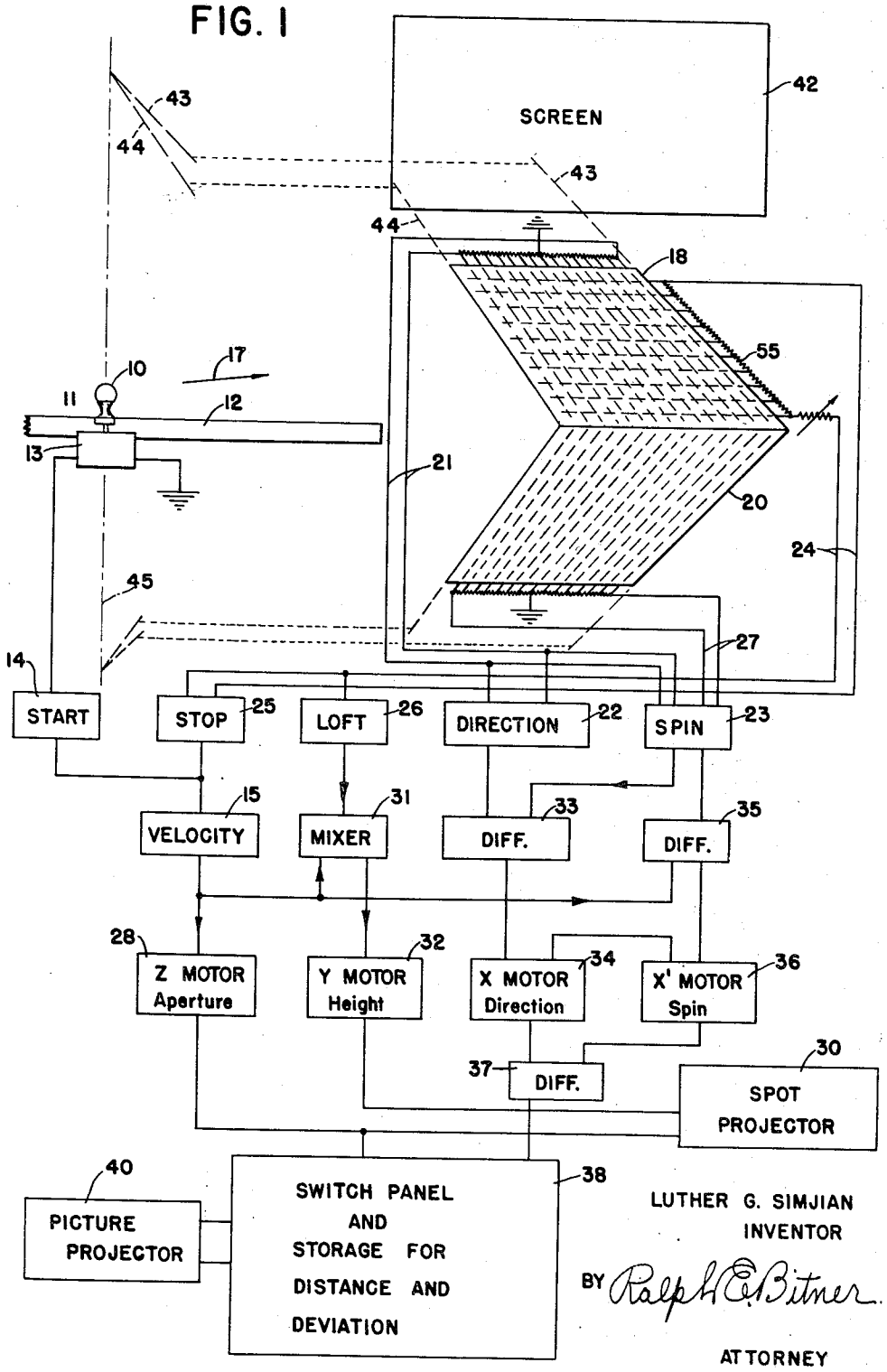

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FIG. 2

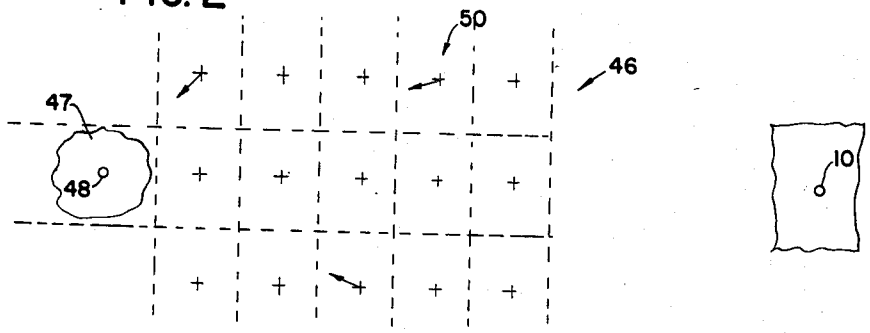

FIG. 3

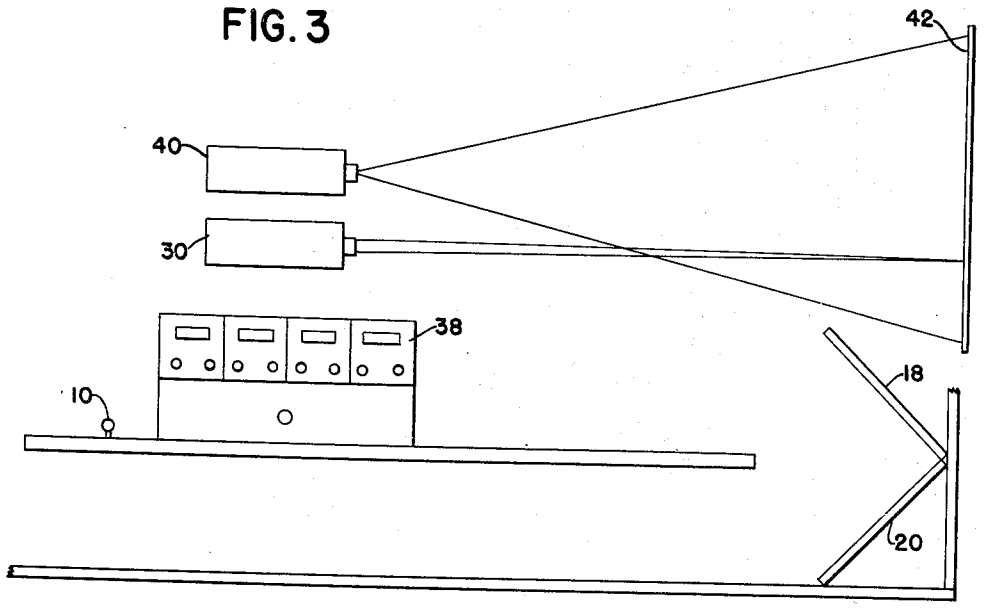

FIG. 4

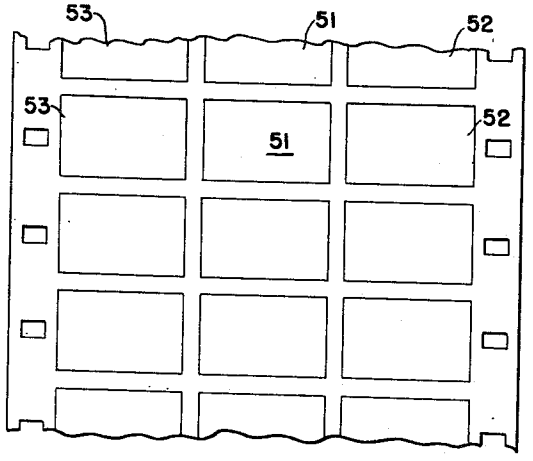

FIG. 5

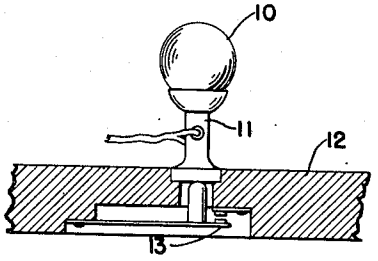

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FIG. 6

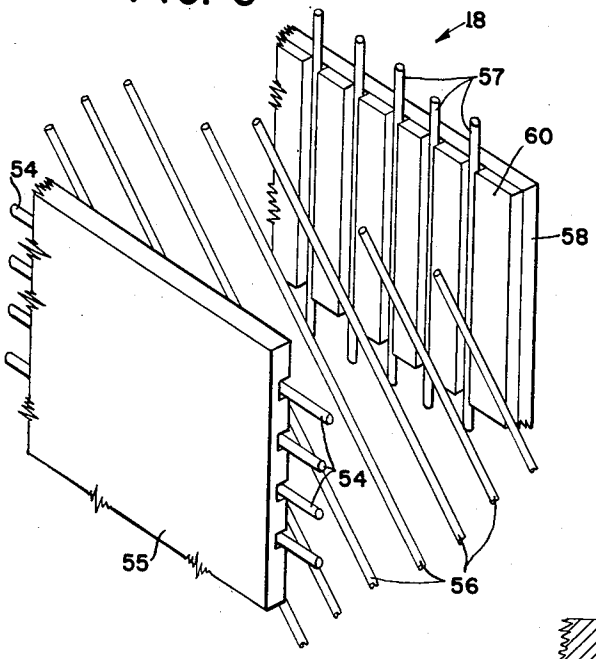


FIG. 7

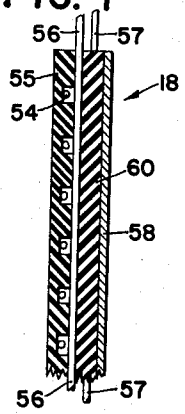


FIG. 8

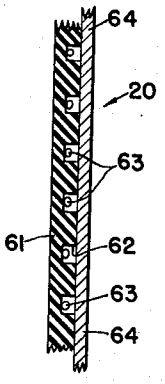


FIG. 9

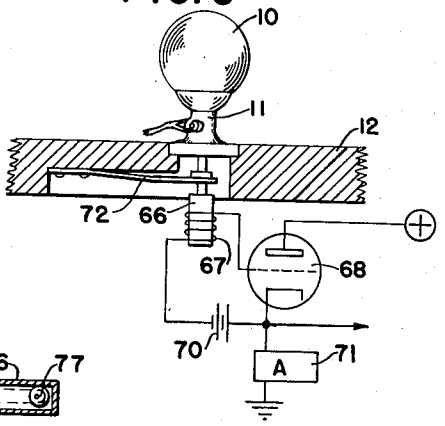


FIG. 10

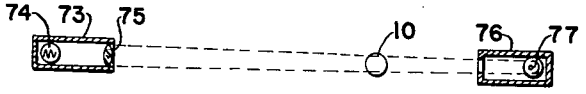
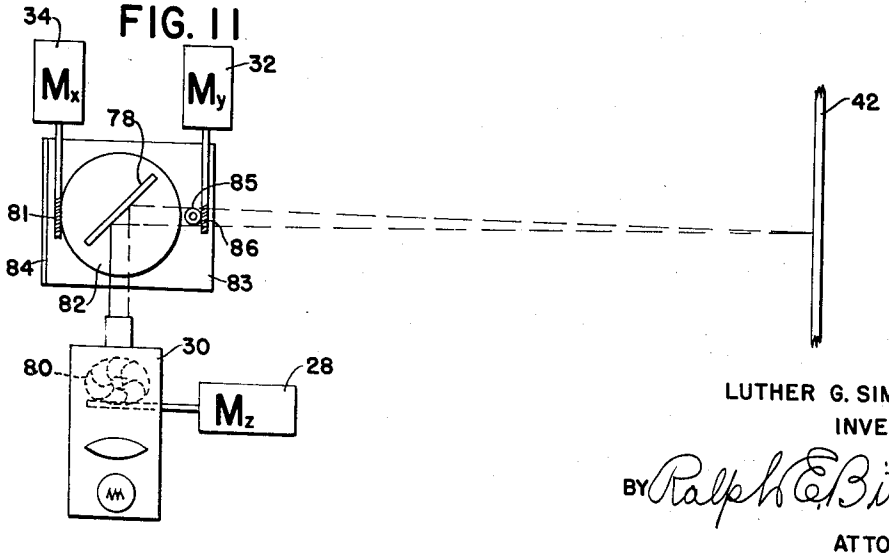


FIG. 11



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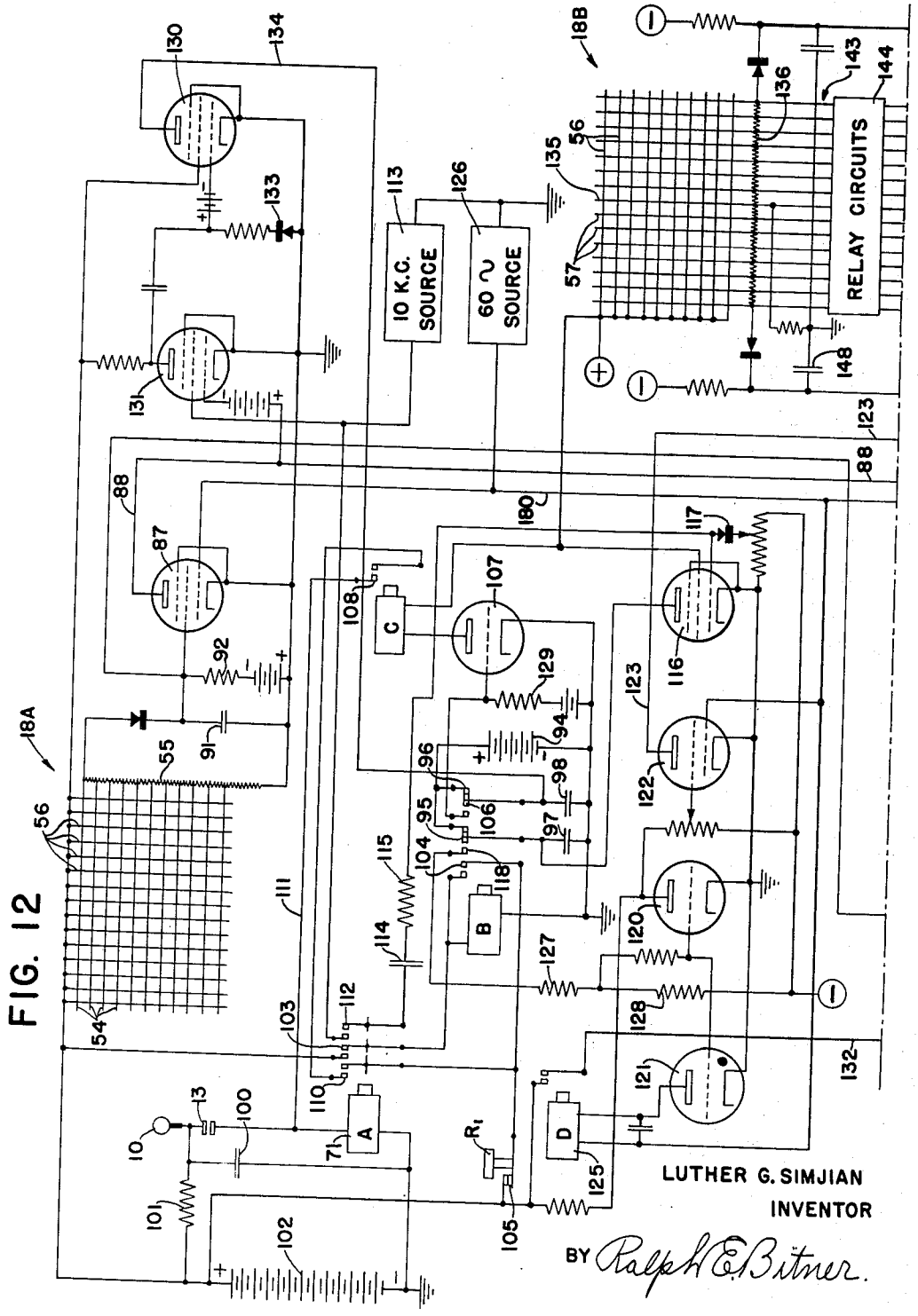

FIG. 12

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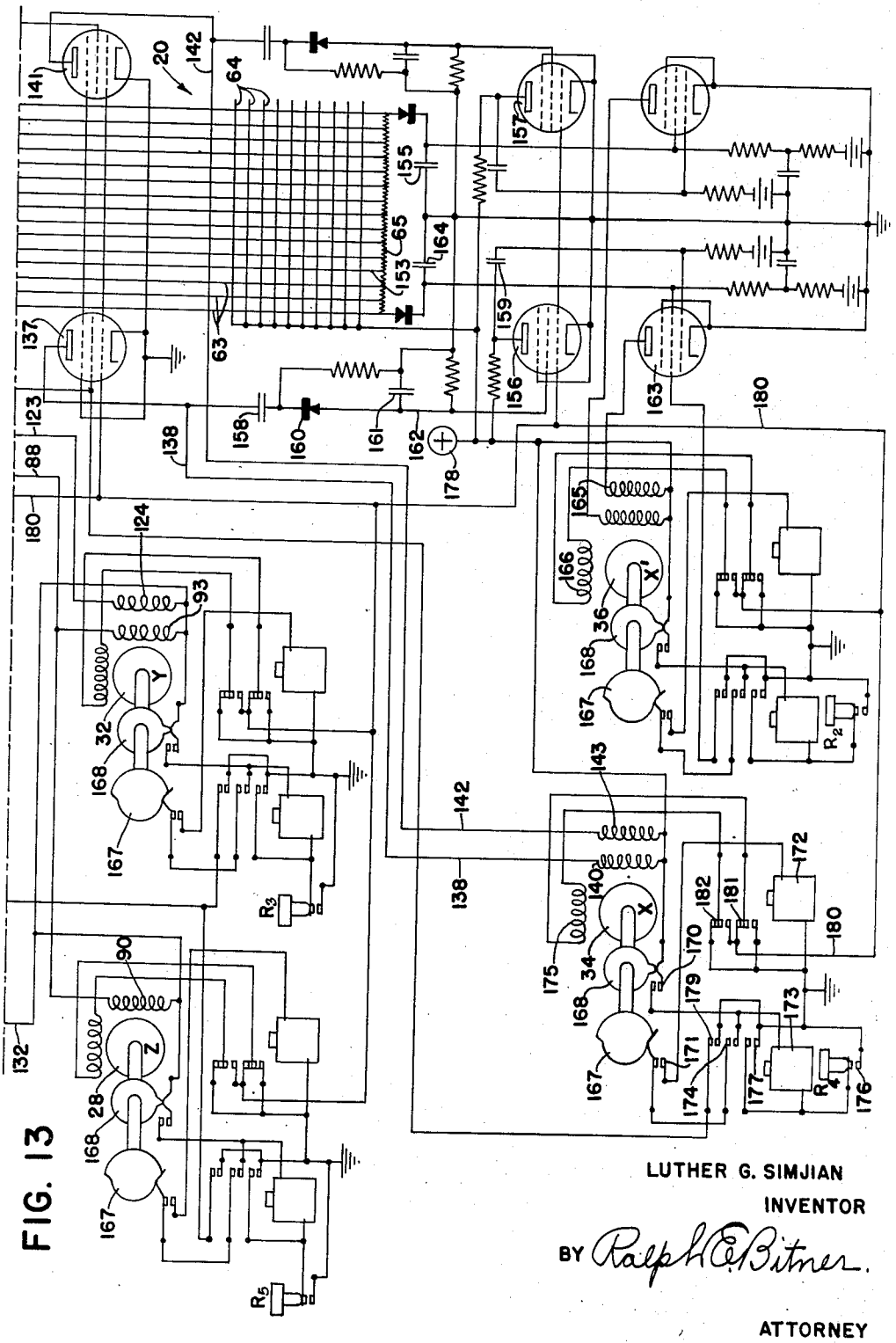

FIG. 13

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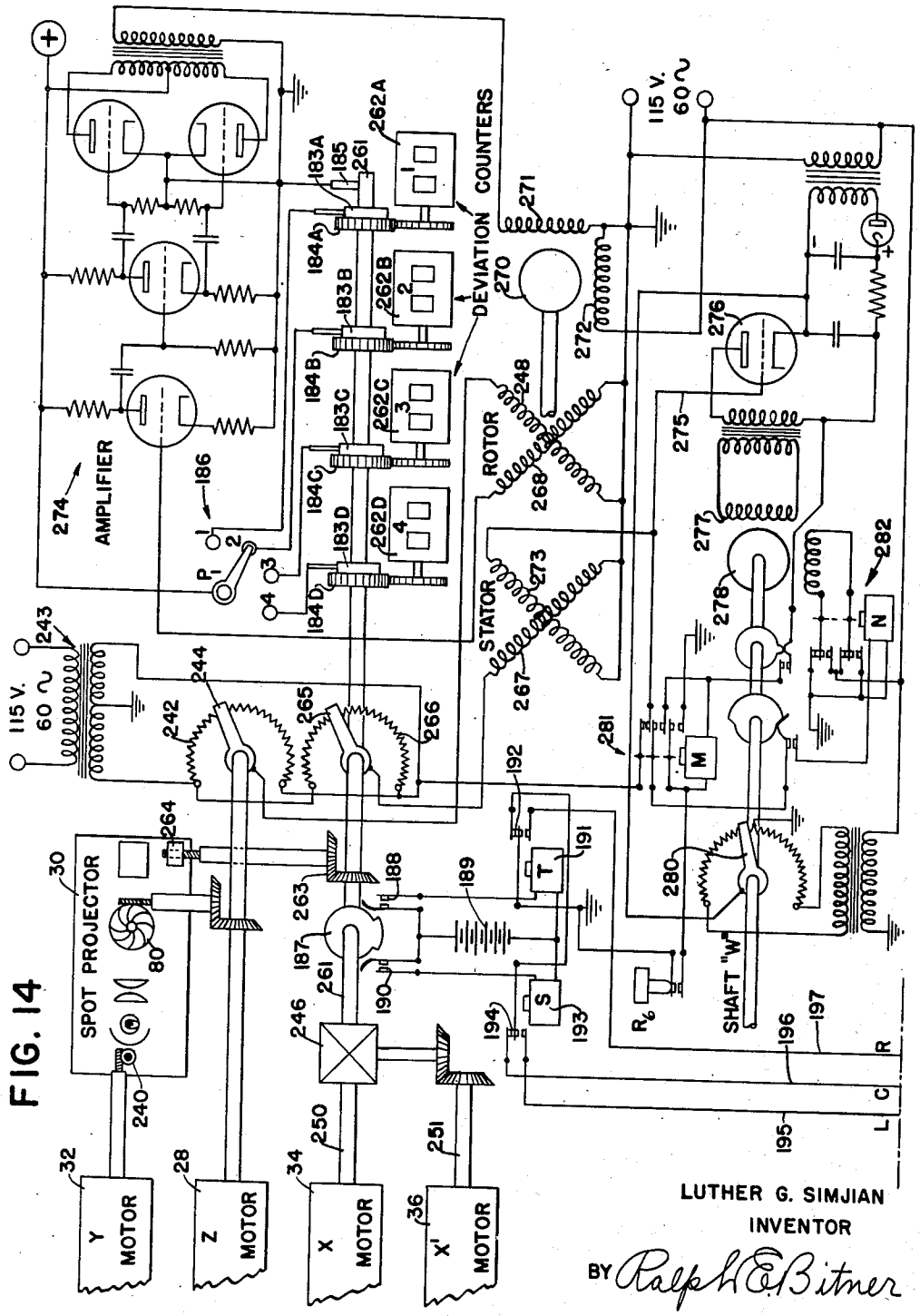

FIG. 14

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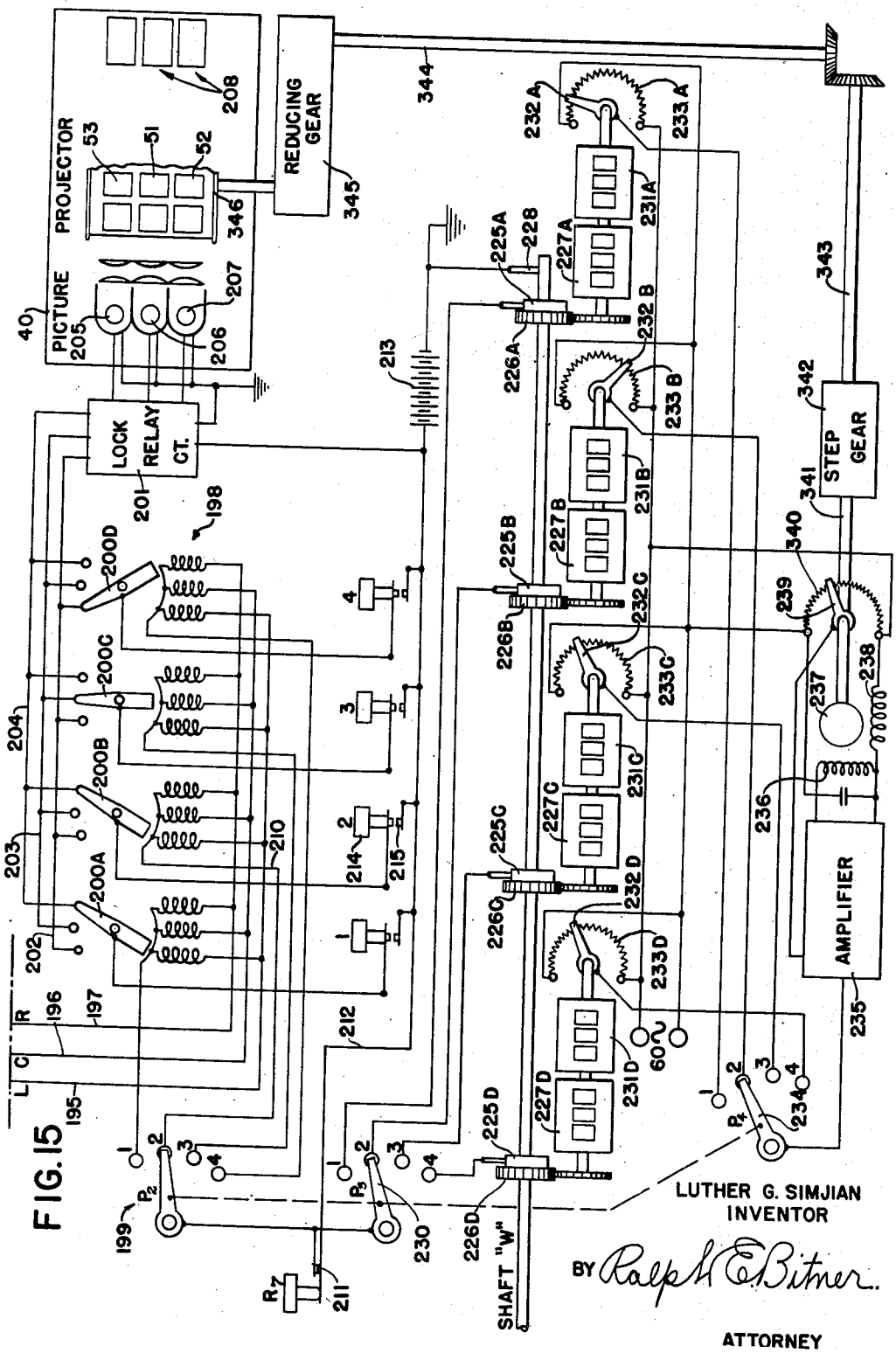

FIG. 15

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FIG. 16

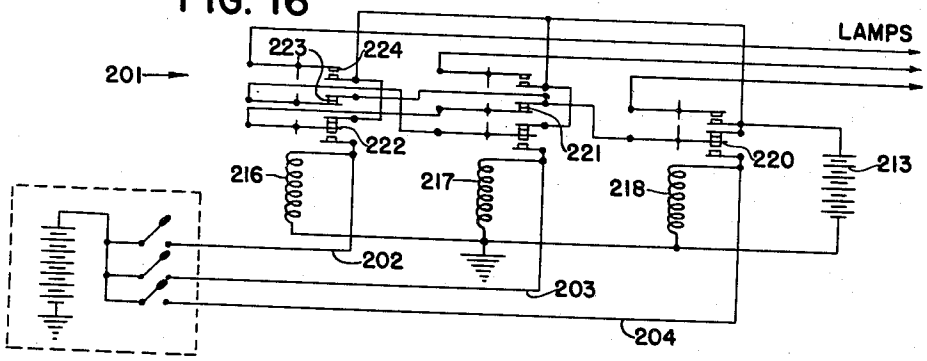

FIG. 17

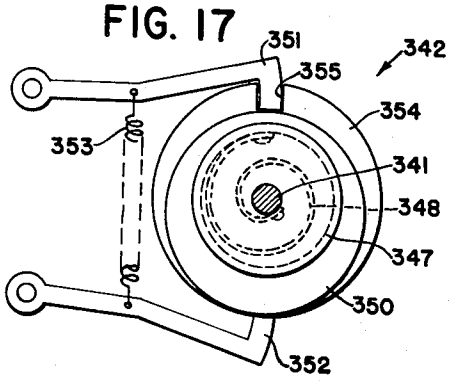

FIG. 18

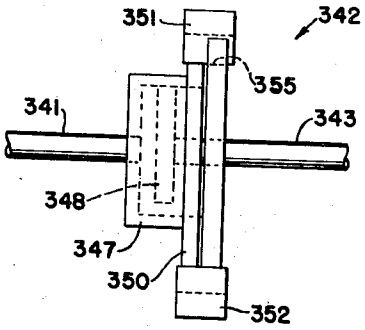

FIG. 19

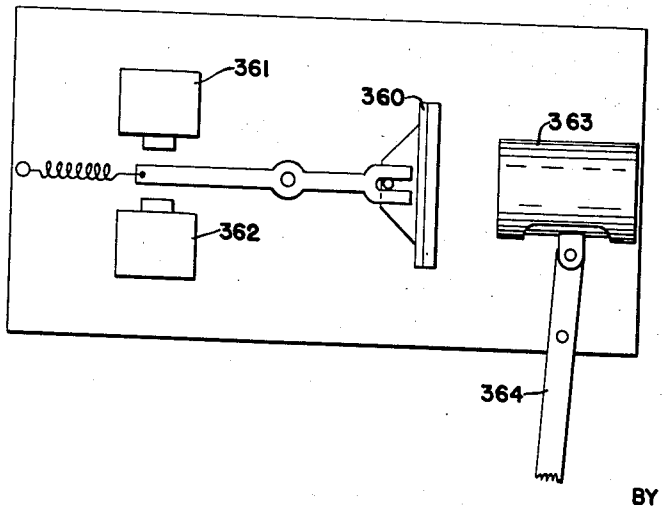

FIG. 20

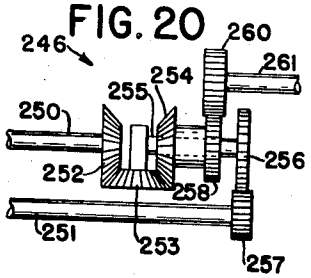

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FIG. 21

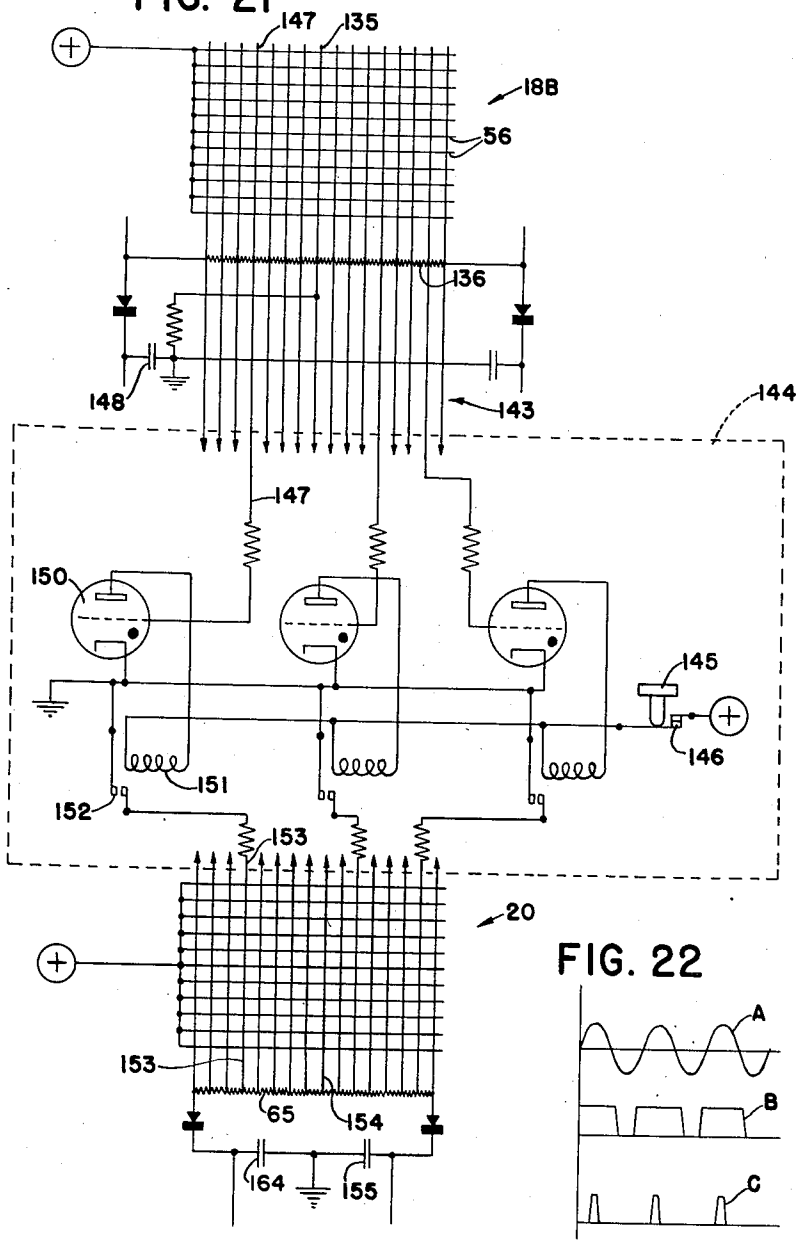

FIG. 22

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BY Ralph E. Bitner

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United States Patent Office

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Patented Mar. 5, 1957

2,783,999

GOLF GAME

Luther G. Simjian, Greenwich, Conn., assignor to The Reflectone Corporation, Stamford, Conn., a corporation of Connecticut

Application February 25, 1954, Serial No. 412,436

8 Claims. (Cl. 273—181)

This application is a continuation-in-part of my co-pending application, now abandoned, Serial No. 341,410, filed March 10, 1953, for a Golf Game.

The invention relates to a golf game which may be played indoors and includes a computing system for determining the velocity of a struck ball and a means for determining and recording the ball's final position. The invention also includes a projection system which shows a picture of the golf course and indicates the trajectory and final position of the struck ball.

Several simple devices have been designed and marketed to permit golf players to practice indoors. These devices have not been accurate in measuring the velocity of the ball and they have not been capable of measuring all the characteristics of the propelled ball. The present invention measures velocity, vertical and horizontal direction, and the spin given to the propelled ball. From these measured values the approximate path is determined and the path of the ball, as viewed from the tee is shown on a screen. In addition, the length of the drive is computed and stored in a counter. Provision for more than one player is built into the storage unit so that a more competitive game may be played.

One of the objects of this invention is to provide an improved golf game which avoids one or more of the disadvantages and limitations of prior art games.

Another object of the invention is to increase the accuracy of velocity measuring systems so that a prediction can be made in regard to the missile's final position.

Another object of the invention is to determine the direction of a struck ball both horizontally and vertically so that the resultant trajectory may be determined.

Another object of the invention is to measure the time interval between two positions at the start of the trajectory in order to determine the initial velocity.

Another object of the invention is to determine the spin given a golf ball so that the curve during flight may be recorded.

Another object of the invention is to make the indoor game more like a game played on an outdoor course by showing successive pictures of the approximate position for each shot.

Another object of the invention is to show the flight of a golf ball by one projection system while a picture of the golf course is supplied by a second projection system.

Another object of the invention is to record the position and length of each stroke in a memory system, thereby permitting several persons to engage in a competitive match.

One feature of the invention comprises a sensing system for accurately determining the trajectory of a golf ball and includes the equivalent of three target mats and a computing system for determining all the trajectory characteristics.

Another feature of the invention includes two projection systems for showing a picture of a golf course on a large screen and the position of the ball during and after its flight.

Another feature of the invention comprises a recording system containing digital counters which show the length of the drive and the deviation to the right or left of the desired direction.

For a better understanding of the present invention together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawings.

Fig. 1 is a schematic diagram of connections of a golf game showing the circuits and other components in block form.

Fig. 2 is a plan view of a golf course marked off in areas which indicate the final position which may be taken by a golf ball.

Fig. 3 is a side view of the complete golf game indicating the target mats, the two projectors, and the control board with the recording counters.

Fig. 4 is a plan view of a strip of picture film showing the positions of the views of the golf course.

Fig. 5 is a cross sectional view of the golf ball tee.

Fig. 6 is an exploded isometric view of part of a double target mat showing the details of its construction.

Fig. 7 is a cross sectional view of the double mat shown in Fig. 6.

Fig. 8 is a cross sectional view of a single target mat having a single array of contact conductors and a conductive base.

Fig. 9 is a cross sectional view, partly schematic, of a tee and a golf ball showing one method of sensing the departure time of the ball.

Fig. 10 is a plan view, with some parts in section, of an alternate means determining the time of departure of the golf ball.

Fig. 11 is a schematic plan view of a projector and movable mirror which shows the trajectory of a ball on a viewing screen.

Figs. 12 and 13 when viewed together form a schematic diagram of connections of the sensing and computing circuits which determine the ball's trajectory.

Figs. 14 and 15 when viewed together form a schematic diagram of connections of part of the computing circuit together with control and memory circuits used when four players are competing.

Fig. 16 is a schematic diagram of connections of a lamp control circuit used with the picture projector.

Fig. 17 is an end view of a step gear, shown in Fig. 15 in block form.

Fig. 18 is a side view of the step gear shown in Fig. 17.

Fig. 19 is a plan view of an alternate system of picture control.

Fig. 20 is a detailed view of the differential gearing shown diagrammatically in Fig. 14.

Fig. 21 is a schematic diagram of connections of the relay circuits shown in block form in Fig. 12, together with two adjacent target mats.

Fig. 22 is a graph showing some wave forms.

Referring now to Fig. 1 a ball **10** is positioned on a tee **11** which is supported by a base **12**. Directly underneath the tee is a pair of contacts **13** which closes a circuit when the ball **10** is struck. Details of the tee are shown in Fig. 5. In series with contacts **13** is a start circuit **14**, the output of which is applied to a velocity computing circuit **15**.

The ball **10** is struck in a general direction indicated by arrow **17** and strikes a target mat **18**. The mat is composed of an insulating base which supports a first array of vertical conducting wires insulated from each other. The wires are held in place by strips of resilient material such as sponge rubber. Mat **18** also includes a second array of horizontal wires, also equally spaced and held in place by channels formed in a sheet of sponge rubber. A third set of contact wires (not shown in

Fig. 1) is mounted in a plane between the other two series of conducting wires. When the ball **10** strikes the mat **18** one of the vertical wires and one of the horizontal wires make contact with the intermediate set which is connected to a positive potential supply. A second mat **20** is positioned directly below the first mat **18** and contains a single set of contact wires arranged in a vertical manner. These wires are equally spaced and are mounted close to a conducting base. When the ball **10** strikes target mat **20** after first hitting target mat **18** one of the wires in mat **20** makes contact with the conducting base which is connected to a positive potential supply.

The contacts made as a result of the impact of the golf ball cause three voltage pulses to be sent to a computing system. The contact made by one of the vertical wires in mat **18** sends a voltage pulse over one of the wires **21** to a direction circuit **22**. The contact made between one of the horizontal wires in mat **18** and the wires connected to the positive potential sends a voltage pulse over wires **24** to a stop circuit **25** and a loft circuit **26**. The contact made by one of the vertical wires in target mat **20** sends a voltage pulse over one of the wires **27** to the spin circuit **23**.

The difference in time between the start pulse received by circuit **14** and the voltage pulse received by circuit **25** is a measure of the velocity of the golf ball and determines the probable distance the ball would have gone had the shot been made outdoors. The information derived from the velocity circuit **15** is applied to a motor **28** (called the Z motor). This motor controls the aperture of a spot projector **30** which projects the image of the ball on a large screen.

The information received by the loft circuit **26** is applied to a mixer circuit **31** which applies this information and information received from the velocity circuit **15** to a second motor **32** (called the Y motor). This motor controls the spot projector **30** and moves the projector up and down to indicate the vertical component of the flight of the golf ball.

The information received from the direction circuit **22** is applied to a differential circuit **33** which also receives information from the spin circuit **23**. Differential circuit **33** is connected to a third motor **34** (X motor) which moves a shaft an amount which is proportional to the horizontal direction of the golf ball to the right or left of the desired direction. The information received from circuit **23** is applied to a differential circuit **35** which also receives information from the velocity circuit **15** and the resultant voltage pulse is applied to a fourth motor **36** (X^1 motor) which moves a shaft an amount which is proportional to the spin given to the ball. Motors **34** and **36** are connected to a mechanical differential system **37** which is connected to a switch panel **38** which controls storage facilities for distance and deviation amounts. The switch panel controls the picture which is projected by projector **40** onto a viewing screen. This projector **40** shows a picture of the golf course and gives an approximate showing of the terrain the golf player would be playing if he had made his shots on the course.

Target mats **18** and **20** may be flat but for a more accurate computation of the velocity and distance they should be constructed as parts of a cone which has its apex on a center line which passes vertically through the golf tee. This construction is indicated in Fig. 1 by the converging marginal lines **43** and **44**. In a similar manner mat **20** is a part of a cone whose apex is directly below the golf tee on center line **45**.

All the circuits referred to above are shown in detail in Figs. 12, 13, 14, and 15.

Referring now to Fig. 2 part of a golf course is indicated showing the position of the ball **10** ready for the first shot, the fairway **46**, the green **47**, and the cup **48**. This fairway is divided into areas which may be

15 yards wide and 10 yards deep. In order to obtain pictures which will represent the views of an actual golf fairway a camera is set up at each of the positions indicated by the small crosses. The camera in each case is directed toward the cup **48** in such manner that the resultant picture when projected on the screen **42** shows the cup in the exact center of the screen. A picture is taken from the first tee and the picture shown on the screen when each player makes his first drive. If a player's first drive, as computed by the circuits, indicates that the ball would have landed somewhere in area **50** if played on course **46** then the machine will automatically show the picture which was taken from the cross in the center of this area. It will be obvious that the fairway shown in Fig. 2 is not part of the game apparatus which is played indoors but only furnishes the means of obtaining pictures of an actual golf course which are shown on a screen for indoor play.

Fig. 3 shows the approximate layout of the apparatus described above. The golf ball **10** is positioned at the left side of the figure. Target mats **18** and **20** are supported in an angular position a short distance on the right. The computing and recording system **38** for four players is shown to one side of the tee within easy reach of the players. Screen **42** is mounted above the target mats and indicates the fairway to the golfer who is about to make a drive. The spot projector **30** shows a single spot on the screen indicating the flight and final position of the golf ball. The picture projector **40** carries all the pictures which were taken on the actual fairway and also includes some of the control means for showing the right picture.

Fig. 4 shows a section of the film used in camera **40** and contains areas **51** for pictures which have been taken at the center of the fairway. At the right of these areas are a similar set of areas **52** for pictures which have been taken to the right of the fairway and a similar set **53** for pictures which were taken to the left of the fairway.

Fig. 5 shows the details of the tee **11** and contact points **13** which are made when the ball is first struck. The weight of the ball and the tee is sufficient to open contacts **13**. As soon as the ball is struck the contacts are closed and a pulse is sent to the computing system.

Referring now to Figs. 6 and 7, the double target mat **18** comprises a first set of horizontal conductors **54** cemented in channels in a deformable pad **55**. The pad may be made of sponge rubber or its equivalent and is designed to absorb the energy of the golf ball and cause one of the conductors to be moved to make contact with a second set of conductors **56** arranged at substantially 45 degrees with the horizontal conductors **54**. A third set of conductors **57** is mounted on a conductive base plate **58** to which is secured a plurality of deformable strips **60** which normally retain conductors **57** a small distance away from conductors **56** but which permit contact when a ball is driven against the face of the mat.

Fig. 8 shows the details of target mat **20** and includes a deformable pad **61** which contains horizontal channels **62**, each of which contains a conductor **63** secured to the pad a short distance from a conductive plate **64**. When the ball strikes this mat one of the conductors **63** makes contact with the plate **64** thereby raising the potential of one of the wires **63** and sending a voltage pulse to an associated voltage divider **65**.

Referring now to Fig. 9, an alternate sensing device is illustrated which does not use contacts. It has been found that contact points positioned directly below a driving tee are in a position to accumulate dirt and other nonconductive material which prevents the normal circuit operation. In the arrangement shown in Fig. 9 the ball **10** is held by the usual tee **11** mounted on its base **12** but the extension below the tee is connected to a small magnet **66** which has one of its poles surrounded by an induct-

ance coil 67. The ends of the coil are connected to the control electrode and cathode of a triode 68. A suitable bias battery 70 is connected in series with the coil and the cathode so that there is normally no current flowing in the anode-cathode circuit. A relay winding 71 is connected in series with the cathode conductor and its relay contacts are closed only when current flows through the tube 68.

When the ball 10 is hit by a club and removed from tee 11 magnet 66 is moved upwardly by flat spring 72 and a voltage pulse is induced in coil 67 which is applied to triode 68. This action causes the tube to be conductive and the relay winding 71 receives current which closes its contacts.

The sensing device illustrated in Fig. 10 includes a lamp housing 73 which encloses an electric lamp 74 and a lens system 75. This device projects a beam of light toward a second housing 76 which contains a photoelectric cell 77 or other suitable light responsive component. The gold ball 10 is placed in alignment with the beam and cuts off all the light until driven from the tee by a player. A suitable amplifier, well known in the art, is connected between the light responsive means and relay winding 71 so that the relay contacts are closed when the ball is hit.

The arrangement illustrated in Fig. 11 shows an alternate means of moving a spot of light on the screen 42 by moving a small mirror 78 instead of the entire light projector 30. In this device the diameter of the spot is controlled by an iris diaphragm 80 which is in turn controlled by the Z motor 28 in the usual manner. However, the horizontal deflection is controlled by motor 34 which operates a worm gear 81 which meshes with a turntable 82 which holds mirror 78. The turn-table 82 is rotatably mounted on a base 83 which is secured to a hinge 84, permitting the base to be tilted by a nut and screw combination 85 operated by a worm gear 86 secured to the shaft connected to the Y motor 32.

Referring now to Figs. 12 and 13, the entire computing circuit is shown together with the target mats which are shown separately in this circuit. One-half the target mat 18 which is shown at the top of Fig. 12 contain horizontal contact wires and a set of vertical wires which are connected together and supplied with a source of positive potential. The horizontal wires 54 are connected to points on a voltage divider 55 which is connected between ground and one of the control electrodes of a pentode electron tube 87 (modulated by 60 cycle voltage on its first control electrode). The anode of this tube is connected directly, by means of conductor 88, to motor winding 90 on the Z motor which controls the aperture size in projector 30. The voltage received from the contact in target mat 18*a* is a momentary pulse but is long enough to charge capacitor 91 to the full voltage of the pulse. The charge received by this capacitor slowly leaks off through resistor 92 and during this discharge period tube 87 sends a current of diminishing value, modulated by a 60 cycle wave, through its anode circuit and causes the contraction of the aperture, first decreasing rapidly, and then slowly to indicate the approximate size of a golf ball as viewed by the player who has just hit the ball. The current through conductor 88 also supplies motor winding 93 on the Y motor 32 and this motor turns to move the projected spot representing the ball position in a vertical direction on the screen 42.

At the start of the operation before either one of the three relays is operated, a battery 94 is connected through two contacts 95 and 96 of a B relay to charge two capacitors 97 and 98. The charge on these capacitors is used in the computing circuit after the B relay is actuated.

When the ball 10 is hit contacts 13 are closed and the charge on capacitor 100 is applied to relay A and actuates it momentarily. Resistor 101 is adjusted so that the current from battery 102 passing through the resistor and the winding 71 of relay A is not enough to hold the relay in its actuated condition. However, the surge of current from the capacitor 100 holds the A relay in its actuated condition for a short time interval and during this interval relay B is actuated by a circuit which includes contacts 103 on the A relay and the battery 102. As soon as the B relay is closed it is held in its actuated condition by a locking circuit which includes contacts 104, closed contacts 105 under reset button R_1 and the battery 102. The B relay remains in this condition until the locking circuit is broken by the manual depression of button R_1.

When the B relay is actuated contacts 106 are closed and the charge on capacitor 98 is applied to the control electrode of amplifier tube 107 which is normally non-conducting due to its biasing battery. Conduction results and current is supplied from the anode through the winding of C relay and a source of positive potential. This action closes contacts 108 which complete a locking circuit for relay A and hold that relay in its actuated condition until the C relay is opened. This locking circuit may be traced from the positive terminal of battery 102, through normally closed contacts 105, contacts 110 on the A relay, conducts 108 on the C relay, over conductor 111, through the A relay winding 71 to ground.

The actuation of the A relay also closes contacts 112 which supply a 10 kilocycle voltage from source 113, through a blocking capacitor 114 and a resistor 115, to the control electrode of an amplifier tube 116. A rectifier 117 protects the tube from surges.

The actuation of the B relay also closes contacts 118 which connect a capacitor 97 to the control electrodes of amplifier tubes 120 and 121. This action renders both tubes conductive, at a diminishing current rate, and the outputs of these tubes are applied to two other circuits. One of these circuits includes the anode conductor of tube 120 and an inverter tube 122. The anode circuit of this tube is connected, by means of conductor 123, to motor winding 124 of motor 32 which causes the projected spot on screen 42 to be moved up. Another circuit connected to the anode of tube 121 includes a relay winding 125 and a source of alternating current 126.

When relay B is in its unactuated condition, capacitor 97 is chaged to the full potential of battery 94 through contacts 95. When relay B is actuated, capacitor 97 is disconnected from potential source 94 and connected to a circuit which includes resistors 127 and 128 and a negative terminal which is connected to a source of potential (not shown) maintaining this terminal at a potential below ground. A small current flows through resistors 127 and 128 (which are in series with capacitor 97) from the time the relay B is actuated until the charge is drained off. However, during the first time interval after the relay B is actuated, tube 116 is made conductive by the application of pulsations from the 10 kc. source 113 through contacts 112 of the A relay, blocking capacitor 114, resistor 115, and rectifier 117. During the time the A relay is actuated, tube 116 discharges capacitor 97 at a fast rate. When the A relay is normalized, tube 116 is again made non-conductive by the opening of contacts 112, this action occurring when the missile strikes the first target array 18A.

After the fast discharge through tube 116, the charge continues to leak off through resistors 127 and 128 until the capacitor voltage is reduced to the cut-off voltage of tubes 120 and 121. At this time the D relay 125 is normalized, opening the contacts in series with conductor 132 and cutting off the power supply to motors 28 and 32 and stopping the projector movement. Tubes 120 and 121 are made conductive for a time interval which is proportional to the missile's velocity and its probable range in free flight.

It will be noted, however, that the target mat 18A is set at an angle to the ball's general direction and the top edge of the mat is closer to the tee than the bottom edge. If a correction were not introduced, this condition would produce an error. Amplifier tubes 130

and 131 are arranged to provide this correction which is applied as follows:

The anode circuit of tube 87 is connected to the control electrode of tube 131 through a biasing battery so that when a positive potential is applied to the control electrode of tube 87, the control electrode of tube 131 will receive a more negative potential. Amplifier tube 131 modulates this applied voltage with a 10 kilocycle wave applied to a control electrode and as a result the anode current through tube 131 transmits a series of direct current pulses to the control electrode of tube 130. These pulses are rectified by a rectifier 133 and only the positive halves of the wave are impressed on the control electrode which is normally biased at the anode cut off voltage. Since a blocking capacitor is in series between the anode of tube 131 and the rectifier 133, a biasing potential accumulates on the control electrode which is proportional to the voltage received from tube 87.

The anode of tube 130 is connected to capacitor 98 by means of conductor 134 and when the B relay is actuated contacts 96 are opened and contacts 106 are closed at the same time tube 130 is made conductive by the series of positive pulses from tube 131. This permits capacitor 98 to discharge through the anode-cathode circuit of tube 130 at a rate which is proportional to the potential impressed on the control electrode of tube 87. The voltage of the 10 kilocycle source 113 is adjusted so that tube 130 is always overloaded and always produces a square topped wave in its anode circuit having a constant amplitude. Under these conditions, if the ball hits the target array 18A near the top edge a large positive voltage is applied to the control electrode of tube 87 and a small D. C. bias voltage is transmitted to tubes tubes 131 and 130. The 10 kc. pulses then make tube 130 conductive for a small part of the cycle as indicated by curce C in Fig. 22. The charge on capacitor 98 then leaks off slowly and relay C is not normalized until several milliseconds after the ball hits target mat 18A. If the ball hits target mat 18A at the bottom of the mat (after traveling a greater distance) the voltage applied to tube 87 is small and the D. C. bias voltage applied to tube 131 is large providing 10 kc. pulses which make tube 130 conductive for a much greater part of the cycle (see curve B, Fig. 22) causing the C relay to be normalized in a short time. The type of pulses transmitted are shown in the graph in Fig. 22 where curve A represents the 10 kc. wave; B, the pulses in the anode circuit of tube 130 when the ball hits near the bottom of the mat; and curve C, the pulses in the anode circuit when the ball hits near the top of the mat. Curve A is drawn with its amplitude greatly reduced as compared to curves B and C.

The two windings 93 and 124 on the Y motor 32 (Fig. 13) are wound in opposite directions so that current through winding 93 causes the motor to raise spot projector 30 and lift the projected image of the ball on the screen 42. When current is applied to winding 124 the motor turns in a reverse direction to lower the image of the ball. Current for winding 93 is derived directly from the anode of tube 87 over conductor 88 and is proportional to the charge delivered to capacitor 91, decreasing in a logarithmic manner. Current for winding 124 is derived from the anode of tube 122, which acts as a phase inverter for the voltage applied to the control electrode of tube 120, and increases from a minimum value at the time the B relay operates. The result is a rising and falling motion of the projector as the current first is applied to winding 93 and then as this current becomes less and the current through winding 124 increases the projector is moved down to ground level to show the final resting place of the ball.

Target mat 18B determines the direction of the ball. If the ball should happen to strike the mat at the exact center, contact will be effected between wire 135 and the horizontal wires which are connected to a source of positive potential. Such a contact causes no action because contact wire 135 is connected to ground through a small ballast resistor and no voltage pulse is transmitted to the computing circuits. However, if the ball is hit to the left and contact is made between the positive horizontal wires and one of the conductors 57 a potential is impressed on a voltage divider 136 and this value is applied to amplifier tube 137 to cause it to conduct current through conductor 138 and send a modulated current through winding 140 of the X motor 34 causing this motor to revolve and moving the projected spot to the left. The current sent through conductor 138 is always modulated with a 60 cycle wave because one of the control electrodes in tube 137 is connected to the 60 cycle source 126. If the ball had struck the mat on the right side, tube 141 would have been made conducting and a modulated current would then flow over conductor 142 to winding 143 on the X motor thereby turning it to the right and moving the projected spot to the right on the screen.

After the ball hits the first target mat 18 which contains both mat components 18A and 18B it then bounces down and strikes the third target mat 20 which determines the spin given to the ball and computes the probable curve taken by the ball if it had been similarly struck outdoors.

Contact arrays 18B and 20 are joined by a plurality of wires and a relay circuit 144 which is shown in more detail in Fig. 21. The relay circuit includes one relay and one gas triode for each of the vertical wires in arrays 18B and 20. The contact wires 18B are each connected to a control electrode in a tube, the anode circuit of such tube being connected to a relay winding. The contacts operated by the relay connect one of the contact wires 20 to ground. Since the tubes are gas filled they will continue to conduct and keep the relay operated after the ball bounces away. The circuit is normalized by depressing button 145 and opening contacts 146 thereby breaking the anode supply.

In order to show the operation of this circuit let it be assumed that the ball strikes contact wire 147, making contact with one of the high potential cross wires 56 and sending a current over the voltage divider to charge capacitor 148. The potential on wire 147 fires tube 150 causing it to pass current and actuate relay 151, closing contacts 152 and connecting contact wire 153 to ground through a small ballast resistor. Contact wire 153 is directly in line with contact wire 147 and if the ball has no spin it will bounce from wire 147 to 153 and no spin voltage will be generated by the third contact array. If, however, the ball has spin to bounce it from mat 18 at an angle and strike contact wire 154 a voltage will be transmitted by the voltage divider to capacitor 155 and its connected elements. Relay circuit 144 thereby connects ground to a contact wire in mat 20 when its corresponding aligned wire is hit in mat 18B. This insures the correct addition or subtraction of the spin voltage regardless of the points of contact. Target mat 20 is similar to target mat 18B and has similar circuit connections except that a connection is made, through a rectifier and filter, from the anodes of tubes 137 and 141 to the second control electrodes of tubes 156 and 157, one of which is thereby blocked each time the ball hits mat 18B to the right or left of the central conductor. This coupling circuit between tubes 137 and 156 includes a blocking capacitor 158, a rectifier unit 160, and a shunt capacitor 161. When tube 137 is made conductive by the application of a charge on capacitor 148 a modulated voltage is applied to the filter circuit and a negative voltage (D. C.) is transmitted over conductor 162 to the second control electrode of tube 156 blocking it and preventing anode conduction. This action also prevents conduction in tube 163 since its first control electrode is biased be-

low the cut-off point and as it receives no signal from tube 156 it will not conduct in its anode circuit.

If the ball first hits conductor 135 in mat 18B and then, because of a spin, bounces at an angle to hit a conductor in mat 20 to the left of the center there will be no blocking voltage and a charge is given to capacitor 164 which is applied directly to the second control electrode in tube 163. In the absence of a blocking voltage from tube 137, tube 156 is conducting and supplies a 60 cycle wave to the first control electrode of tube 163, thereby modulating any anode current which may pass through that tube. The resulting current passes through winding 165 in the X^1 motor 36 and provides the necessary energy, in combination with the 60 cycle current in winding 166, to move the motor armature and turn the shaft an amount which is proportional to the horizontal spin trajectory.

If the ball hits to one side of the central conductor on target mat 18B and then, because of spin, moves farther to the same side on target mat 20, the first contact generates a blocking voltage which is applied to tube 156 and indirectly to tube 163. However, the additional variation from the central path on mat 20 generates a voltage which is larger than the blocking voltage, therefore when this voltage is applied to the second control electrode of tube 163 the tube conducts by an amount which is proportional to the difference between the two voltages or the amount of spin. Because of the delay in starting conduction in tube 163 the X motor moves first and the X^1 motor later moves the spot on the screen to apply the result of the ball's spin.

The above description has included the tubes and circuits which are on the left side of their central conductors. It will be obvious from the wiring diagram that the tubes and circuits on the right side of the central conductor are similar and produce the same results which are finally applied to the windings on motors 34 and 36, which move the image to the right. Because of this similarity it will be unnecessary to describe the remaining circuits.

After a play has been made and the four motors have rotated their shafts to record the ball's deviation, loft, and length of drive, the motors must be reset and the computing circuit zeroized for the next player. This is done by depressing a common switch button which controls all of the reset contacts R_1 to R_5, inclusive. Button R_1 opens the locking circuits of the A and B relays, restoring them to their unactuated normalized condition if they had not been normalized previously. Buttons R_2 to R_5, inclusive, operate relays which connect the control electrodes of tubes 87, 137, and 163 to ground and thereby energized the four motors and turn them back to the zero or start position.

In order to reset the motors properly two cams 167 and 168 are placed on each motor shaft. These cams operate contacts 170, 171. Associated with these contacts are two relays 172 and 173. Relay 172 is operated when contacts 171 and 170 are both closed by cam action and contacts 174 are closed by the operation of relay 173. Relay 172 reverses the current through an auxiliary winding 175 on the X motor. These circuits are operable only when button R_4 is depressed closing contacts 176. The action of this reset circuit is as follows: Let it first be assumed that the X motor has not moved during the first drive. This happens every time the ball strikes the central conductor 135 and applies zero voltage to each tube 137 and 141. In this condition the cam 168 will not have moved from its zero position and contacts 170 will be held open. When contacts 176 are closed there will be no action since the winding 173 is in series with contacts 170. If the motor X has been moved from its zero position in a counterclockwise direction to move the spot to the right on the screen because of modulated current in winding 143, contacts 170 will be closed and contacts 171 will remain open. When contacts 176 are closed relay 173 is operated and locked into its operated condition by contacts 177. Current will then flow through the circuit which may be traced from the positive terminal 178 through contacts 170, through winding 173, through contacts 177 to ground. The reversing relay winding 172 is not operated because contacts 171 are still open but winding 175 on the motor is energized by a 60 cycle potential which may be traced from the source 126 over conductor 180 through closed contacts 181, through winding 175, then through closed contacts 182 and back to ground. The X motor has operating current in winding 175 and when the reset button 176 is depressed, contacts 179 are closed, connecting the control electrode of tube 137 to ground and thereby sending a modulated current through winding 140 which causes it to turn back to its zero position until contacts 170 are open and relay 173 is normalized. When this happens contacts 179 are broken and the control electrode in amplifier tube 137 is disconnected from ground potential, thereby reducing the anode current over conductor 138 to zero and stopping the rotation of the motor.

If the X motor 34 has been moved in a clockwise direction to move the spot to the left on the screen because of modulated current in winding 140, contacts 170 and 171 will both be closed. Relay 173 is operated as before, grounding the control electrode in tube 137 and sending modulated current through winding 140. However, this time the reversing relay 172 is operated and alternating current of a reversed phase is sent through winding 175 to turn the motor armature in a counterclockwise direction to its zero position. When the zero position is reached, contacts 170 and 171 are both opened and the rotation stops.

It will be noted that identical reset circuits are connected to all four motors, each of these circuits operating in an identical manner to return the motor to its initial position. Because of their identities the other three reset circuits will not be described. It should be pointed out that, while the reset circuits are identical, the resetting action of the motors varies in some details. Motor 28 always moves in one direction to close iris 80 and move arm 244. When reset it will be reversed and brought back to its zero position. Motor 32 is first moved to elevate the spot on the screen and then to lower it. When reset, the motor is not reversed but continues its downward rotation until the zero position is reached. Motor 36 is operated similar to motor 34, described above.

The result of the above described action, before the reset operation, is to position the shafts of the four motors at various positions depending upon the results provided by the computer circuit. These four shafts are shown in Fig. 14 attached to motors 32, 28, 34, and 36. Fig. 14 should be viewed in conjunction with Fig. 15, both figures forming part of a single circuit which receives the results of the computer circuit and uses these results to control the actions of the spot projector 30, the picture projector 40, and to present the results achieved by each of four players on counters which are part of the player panel 38.

The shaft of the Y motor 32 is connected directly to an elevating device 240 which may be a worm screw meshing with an elevating nut. This mechanism first lowers and then raises the rear part of the projector (by suitable reversing action of the motor) to cause the projected image of the ball to be first raised and then lowered.

The shaft of the Z motor 28 is connected by suitable means to an iris diaphragm 80 to progressively close it, thereby indicating the approximate distance the ball travels away from the player. The Z motor shaft is also connected to a potentiometer 242 the end terminals of which are supplied with alternating current with the center point of the supply connected to ground. Transformer 243 is indicated in Fig. 14 as supplying this energy. A movable contact arm 244 is turned by the shaft of the Z motor and is connected to winding 248 of a two phase rotor. The movements of arm 244 cause a change in the phase and the voltage with respect to ground. The use of this volt-

age will be considered later when used in conjunction with the rotation of the shaft of the X motor 34.

The shaft of the X motor 34 is rotated an amount which is proportional to the direction as recorded in the computing system from data which is obtained from the impact of the ball striking the first mat 18. As has been explained above the X^1 motor is turned an amount which is proportional to the spin. In order to combine these two motions a differential adding system 246 is employed. This system is shown diagrammatically in Fig. 14 and in Fig. 20 a similar system is shown in a detailed arrangement. The purpose of this system is to add the motions of the two shafts 250 and 251. A differential gear is mounted with one bevel gear 252 secured to the end of shaft 250 (Fig. 20). A beveled pinion 253 meshes with gears 252 and 254 and is rotatably mounted on a stub shaft which is splined to shaft 255 which is secured to a gear 256. This latter gear meshes with another gear 257 which is secured to shaft 251 and is driven by it. Gear 254 drives gear 258 which in turn meshes with a gear 260 secured to shaft 261. When shaft 250 moves alone it turns gears 252, 253, 254, 258 and 260. When shaft 251 moves alone it turns gears 257, 256, 253, 254, 258, and 260. When both shafts move, all the gears turn and the movement of shaft 261 is the algebraic sum of the movements of shafts 250 and 251.

Shaft 261 is rotated an amount, to the right or left, which represents the horizontal component of the ball's direction. This rotation is employed to turn the deviation counters 262 to indicate the number of yards the ball has digressed from the desired direction. The amount of rotation of shaft 261 is also used to move the spot projector 30 to the right or left to indicate the horizontal movement of the ball on the projection screen. This is accomplished by a suitable mechanical coupling 263 and a screw means 264 secured to the projector mechanism. The rotation of shaft 261 is further used to turn a contact arm 265 which makes electrical contact with a potentiometer resistor 266. This resistor is in parallel with resistor 242, both being connected by transformer 243 to a supply of alternating current. The arm 265 is connected to a winding 267 on a two phase stator which encloses a similar two phase rotor containing windings 248 and 268. The rotor is connected to a motor armature 270 which includes field windings 271 and 272. The stator also includes a second winding 273.

The voltage applied to arm 244 is connected to winding 248 and is proportional to the total length of the trajectory. The voltage applied to arm 265 is connected to winding 267 and is proportional to the deviation or the quadrature component of the length vector. To determine the component which lies in a direction between the tee and the cup the quadrature voltage induced on winding 268 must be reduced to zero by turning the rotor an angular amount by motor armature 270. For this purpose the voltage on winding 268 is applied to the input of a power amplifier 274, the output of which is connected to winding 271 which acts on the armature 270. Another winding 272 is permanently connected to the alternating current supply. As long as the voltage on winding 268 is other than zero the motor armature will turn, moving windings 248 and 268. When the voltage on winding 268 is zero the motor will stop and at this position the voltage delivered by winding 273 represents the difference between the distance vector and the quadrature deviation vector. For a complete description of this type of resolver and other resolvers which could be used in its place reference is made to volume 21, Electronic Instruments, M. I. T. Radiation Laboratory Series, by Greenwood, Holdam, and MacRae, published by McGraw-Hill Book Co. Inc.

The resultant voltage is applied over conductor 275 to the control electrode of amplifier tube 276 and the output of this tube is delivered to one of the field windings 277 of a servomotor whose armature 278 turns a shaft W which controls the position of a contact arm 280. This arm is connected to the cathode of tube 276 and applies an alternating voltage to this electrode when the system is unstabilized. If no A. C. voltage is received over conductor 275 only direct current flows through the anode circuit and motor armature 278 will not turn from its zero position. If a voltage is received on this conductor the motor is energized and armature 278 turns until the A. C. voltage applied to the cathode by arm 280 is equal and opposite to the voltage on the control electrode. This setting is proportional to the length of the trajectory measured along a line between the ball and the cup. Shaft W is continued in Fig. 15 where couplings are shown which turn counters and control a picture projector, the details of which will be described later. Motor shaft W which is run by armature 278 may be reset to its zero position by depressing button R_6. This reset circuit contains relays 281 and 282 which have similar connections and identical functions as the relays 172 and 173 in Fig. 13. Because of their identical functions they will not be described.

Shaft 261 also turns four electromagnetic clutches 183A, B, C, and D which are designed to connect gears 184A, B, C, and D to the shaft when current is supplied to the clutch windings. Gears 184 mesh with similar gears on the counters 262 which are arranged to show the deviation in yards from the desired direction. A common ground connection is made by brush 185 which makes contact on the shaft 261 and the other brush contacts are made on the peripheries of the clutch units and connected to a player switch 186 which is set manually by the players as they are about to make their stroke.

Shaft 261 is also connected to a cam 187 which closes contacts 188 when the shaft is turned counterclockwise and closes contacts 190 when the shaft is turned clockwise. Contacts 188 are connected in series with a relay winding 191 and a source of potential 189 and when the relay is actuated contacts 192 on the relay armature are operated. Contacts 190 are connected in series with the same source of potential and a similar relay winding 193 which controls contacts 194. Three conductors 195, 196, and 197 connect the relay contacts with a series of magnets 198 (Fig. 15) which operate four dial switch arms 200A, 200B, 200C, and 200D. These switches are selectively connected in the operating circuit by a second dial component 199 of the player switch and they constitute a selective arrangement and a memory for the deviation computer to select the proper picture of the fairway. The three contact points on the dial switches which are connected to arms 200 are also connected to a locking relay circuit 201 which is shown in detail in Fig. 16 and which will be described later. Current flowing over one of the three conductors 202, 203, or 204 operates the relays and selects one of the projector lamps 205, 206, or 207 and lights it to project one of the series of pictures 51, 52, or 53. These pictures are focussed by one of a series of three lenses 208 onto the screen 42.

In order to explain the operation of this portion of the circuit, let it first be assumed that the ball is driven to the center, or near the center, of target mat 18A, and the resultant action does not turn shaft 261 sufficiently to cause cam 187 to close contacts 188 or 190. In this condition a circuit may be traced from ground through the normally closed contacts 192, then through normally closed contacts 194, then over conductor 196 to all the four central magnetic windings of the magnet system 198. If player number 2 has made the stroke and if the player dial has been set as indicated in the drawing (Fig. 15), the current then is traced over conductor 210 to the contact arm in dial switch 199, thence through reset contacts 211, over conductor 212, to a source of potential 213, to ground. This circuit causes the arm 200B to be turned to its central position and make contact on

the central point, thereby storing this information for the next stroke of the number 2 player. When this player is ready for his next stroke he depresses button 214 closing contacts 215 and sending current from source 213 through the contacts, through the arm 200B, over conductor 203 to the relay circuit 201 and then to ground. This action lights the central lamp 206 and shows one of the series of pictures 51 on the screen.

If shaft 261 is moved so that cam 187 closes contacts 188 the resulting circuit may be traced from ground, through the normally open contacts 192 on relay 191, thence over conductor 197 to one in the series of right hand magnet windings in magnets 198, then through player switch 199, contacts 211, battery 213 and ground. This circuit positions the selected contact arm to send current over conductor 202 to the relay circuit when button 214 is depressed and to light lamp 207.

If shaft 261 turns so that cam 187 closes contacts 190 and actuates relay 193 a circuit may be traced from ground, through the normally closed contacts 192, through the normally open contacts 194, to conductor 195. The remainder of this circuit is similar to the ones described above.

The relay circuit 201 shown in detail in Fig. 16 comprises three windings 216, 217, and 218. When current is supplied over conductor 202, winding 216 is actuated and a locking circuit may then be traced from battery 213, through closed contacts 220, then through contacts 221, then through normally open contacts 222, through the winding 216 to ground. It should be noted that the actuation of the 216 relay opens contacts 223 which are in series with the locking circuits of the other relays, therefore when relay 216 is actuated both the other relays must be in their unactuated condition. The top contacts 224 connect the battery 213 with the first lamp. If either one of the other two relays is actuated, a locking circuit is closed similar to the locking circuit just described and at the same time the locking circuits of the other two relays are opened.

As has been described above, shaft "W" (Fig. 14) is rotated an amount proportional to the length of the ball's trajectory, measured along the desired path. This same shaft is continued in Fig. 15 and has secured to it four clutches 225A, B, C, and D. These clutches are arranged to make mechanical contact with four gears 226A, B, C, and D which in turn mesh with gears connected to counters 227 to indicate the number of yards the ball travels in the desired direction. The clutch windings are connected to a common ground connection by brush 228 and the other terminals of the windings are connected through brushes to a dial switch arm 230 which is one of the components of the player dial switch. When the ball is hit the computing circuits determine its trajectory and turn shaft W the amount which represents the distance component measured along a path between the ball and the pin. While shaft W is turning one of the clutches 225 is actuated due to the fact that the player switch arm 230 is set on one of the contact points. This action turns the associated counter 227 to show the number of yards traversed. This counter is all that is necessary to tell the player how far his ball is away from the tee but it has been found convenient and informative to show a second counter 231 which is turned in a reverse direction, that is; the numbers are subtracted instead of added. This counter is adjusted to show the total yardage between the tee and the cup, then one counter will show the total yards traversed and the other counter shows the remaining distance between the ball and the cup.

On each counter shaft a contact arm 232 is secured which makes sliding contact with a voltage divider resistor 233. The end terminals of the voltage dividers are all connected to a source of a constant voltage, sixty cycle wave and the contact arms 232 are each connected to points on a fourth player switch 234. The arm of this switch is connected to the input to a power amplifier 235. The output of the amplifier is connected to one winding 236 of a two phase motor 237. A second winding 238 is supplied at all times with a current which is not in phase with the current delivered by the amplifier 235 and the motor shaft carries a contact arm 239 which makes sliding contact on a voltage divider resistor 340. The contact arm 239 is connected to the input circuit of the amplifier to form a closed servo loop or a bridge circuit with self-adjusting balance means. When the voltage on the connected arm 232 is the same as the voltage on arm 239 the resultant voltage at the amplifier input is zero and there will be no current delivered to winding 236 and no motor rotation. If the voltages are not the same there will be a resultant input voltage and current will be supplied to winding 236 to turn the motor armature and shaft to reposition arm 239 until the voltage difference is zero. In this manner shaft 341 assumes the same angular position as the counter shaft arm 232 which is connected by arm 234.

Shaft 341 is also connected to a step-gear 342 which transforms the uniform circular rotation of shaft 341 into a series of incremental steps which are applied to shaft 343. The step gear mechanism is shown in detail in Figs. 17 and 18 and will be described later. Shaft 343 is coupled to another shaft 344 which in turn is connected to a reducing gear 345 and then applied to a film roller 346 which carries the film containing pictures 51, 52, and 53. The reducing gear 345 is designed to transfer from one picture to another whenever the step gear moves a complete revolution. This advance shows adjacent pictures which have been taken every ten yards from the cup (or some other convenient distance) and the transfer of pictures is made each time the shaft W turns an amount equivalent to that distance.

The step-gear 342, shown in detail in Figs. 17 and 18, comprises a cupped shaped compartment 347 secured to shaft 341 and inclosing a spiral spring 348 the outer end of which is secured to the periphery of cup 347. An eccentric cam 350 is secured to the cup and controls the position of two pawls 351 and 352. These pawls are pivotally mounted to a base member and are urged toward the shaft position by a spring 353. A circular disk 354 is secured to shaft 343 and contains a single cut-out portion 355 on its periphery. The inner end of spiral spring 348 is secured to shaft 343.

The operation of the step gear is as follows: When the shaft 341 starts rotating in either direction the spring 348 exerts tension to move shaft 343 but the latter shaft cannot move because pawl 351 holds disk 354. As shaft 341 continues to rotate the eccentric cam 350 lifts the pawl out of the cut-out portion and when the shaft 341 has rotated about one-half revolution the pawl is lifted entirely out of engagement with disk 354 and it turns one-half revolution under the urge of spring 348 until the lower pawl 352 enters the cut-out portion and stops the disk motion.

After any one of the players has made his stroke and recorded his score the system must be reset so that the next player can start off from the zero or tee condition if it is his first stroke, or from the previously scored position made on his last stroke. All the reset buttons R_1 to R_7 are depressed, but the contacts 211 must be separated first and kept open until the four motors 28, 32, 34, and 36 have been zeroized. The resetting of the motors has been described above. As motors 34 and 36 are returned to their start position the player switch 186 is not moved and the deviation counter 262 which had previously turned to show the ball's deviation is returned to zero. This action wipes out the storage of the deviation amounts which might have been kept on the counters. It has been found, however, that after each stroke the deviation distance is eliminated by the simple expedient of showing the tee at the center of the picture for the next shot and the player naturally aims at the tee, such

an aim being at an angle to the first shot if there has been any deviation distance recorded.

When motors **34** and **36** are returned to their normal position cam **187** is also returned to its zero position but this has no influence on the arms **200** since battery **213** has been disconnected by the opening of contacts **211**. Also the counters **227** and **231** will remain in their recording position and will not be returned to zero because the opening of contacts **211** disconnects all four clutches and the movement of shaft W has no effect on them. Depressing the R_1 button opens contacts **105** and the locking circuits of both the A and B relays and normalizes them.

When the next player sets the machine for his stroke he first moves all the arms of the player switch to his own number. This action changes the picture on the screen to the picture which represents the distance position of the player's ball after his last stroke. Then the player depresses his button in the group which includes **214** and thereby sends current from battery **213** through the associated contact arm **200** to the relay circuit **201** to light the proper lamp **205**, **206**, or **207** and put out the previously lighted lamp. The projector now shows a picture on screen **42** which was taken from the approximate position of the ball and the computing circuit is ready for the player's stroke. The ball is placed on the tee and contacts **13** separated thereby permitting capacitor **100** to charge to the full battery voltage. The ball can now be hit.

An alternate arrangement for controlling the pictures shown on the screen is illustrated in Fig. 19. In this system only three pictures are taken and they are secured to a film rack **360**. The film rack may be moved transversely by magnets **361** and **362**, these magnets being connected to conductors **202** and **204** (Fig. 15). A self-focussing variable focus projection lens **363** is employed and to control the focus, a lever **364** is coupled to shaft **341**. In this system only one projection lamp is necessary (not shown) and the step gear and reducing gear are eliminated.

While there have been described and illustrated specific embodiments of the invention, it will be obvious that various changes and modifications may be made therein without departing from the field of the invention which should be limited only by the appended claims.

I claim:

1. A golf game for a plurality of players comprising; means for generating a primary electrical signal responsive to the displacement of a propelled missile from a starting position; a target combination disposed in the path of the missile and including two arrays of electrical contact means actuated by the propelled missile for locating the position of impact thereon by the generation of electrical impact signals; an electrical computing system electrically connected to the contact means of both arrays and to the means which generates the primary signal; said computing system including means responsive to said primary signal and one of said impact signals for generating a first pulse whose duration is proportional to the velocity of the missile, said computing system also including means responsive to said impact signals for generating a second and third pulse whose durations are proportional to the vertical and horizontal directions of the missile; a first projection system operated by electromagnetic means and responsive to said first, second, and third pulses for showing any one of a series of pictures of a playing field taken from a position where a missile may be propelled; said projection system including means which change from one picture to another in response to said pulses; a second projection system operated by electromagnetic means and responsive to said first, second, and third pulses for showing the path of the propelled missile in free space as viewed from a starting position; said path superimposed on the picture produced by the first projection system; a plurality of counters selectively coupled to the computing system by electromagnetic means and responsive to said first and third pulses for indicating the distance and lateral deviation of the propelled missile, and a selector switch which connects the computing system to any pair of said counters corresponding to a player.

2. A golf game for a plurality of players in accordance with claim 1 wherein said counters are each connected to a clutch which is engaged when said computing means is generating pulses and disengaged at the end of a computing cycle.

3. A golf game for a plurality of players in accordance with claim 1 wherein said target combination includes a third array of electrical contacts which are actuated by the propelled missile after sequential impact with one of the other contact arrays, said third array thereby generating a signal which is applied to the computing means to determine the missile's spin.

4. A golf game for a plurality of players in accordance with claim 1 wherein both of said contact arrays are connected to a source of potential and a voltage divider, thereby producing a voltage pulse when the array is struck by the missile, the amplitude of said pulse responsive to the impact position of the missile.

5. A golf game for a plurality of players in accordance with claim 4 wherein both of said arrays are connected to a rectifier and a capacitor for charging by said voltage pulse, and circuit means for coupling the capacitor to an input circuit of an electronic discharge device.

6. A golf game for a plurality of players in accordance with claim 4 wherein each of said counters contains means for indicating digits.

7. A golf game for a plurality of players in accordance with claim 4 wherein said electromagnetic means which couple the counters to the computing system include an electromagnetic resolver system for recording the distance the missile progresses along a path parallel to the line between the starting position and a predetermined terminal position.

8. A golf game for a plurality of players in accordance with claim 7 wherein a plurality of said counters are arranged to receive signals resulting from said third pulse to record the missile's deviation from a desired direction.

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