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Imabori et al.

[11] **3,855,842**

[45] **Dec. 24, 1974**

[54] **APPARATUS FOR TESTING GOLF CLUBS**

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[30] **Foreign Application Priority Data**

May 24, 1972 Japan 47-51351

[52] **U.S. Cl.** ..... **73/13**, 73/432 SD

[51] **Int. Cl.** **G01m 3/00**

[58] **Field of Search** ..... 73/432 SD, 65, 13; 273/186 A; 35/29 A

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Assistant Examiner—Anthony V. Ciarlante
Attorney, Agent, or Firm—Sughrue, Rothwell, Mion, Zinn & Macpeak

[57] **ABSTRACT**

An apparatus for testing the dynamic performance of a golf club by simulating human golf swings including an arm driven by a first motor for simulating the rotation of the golfer's arms about his body and a club holder driven by a second motor for simulating the rotation of the golfer's wrists about his arms. The arm and club holder may be driven independently.

2 Claims, 10 Drawing Figures

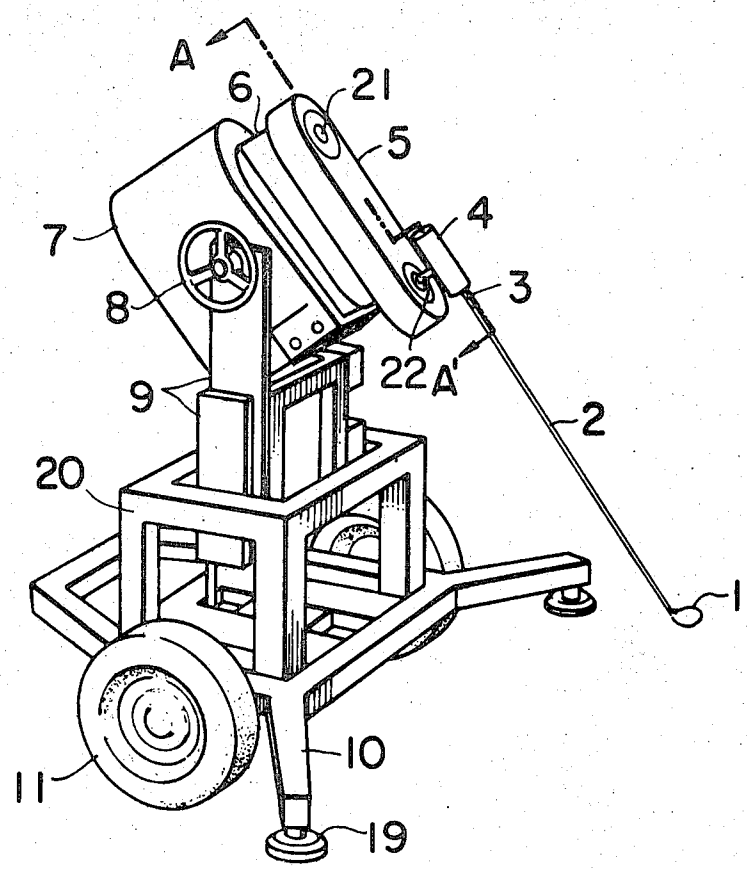


FIG. 1

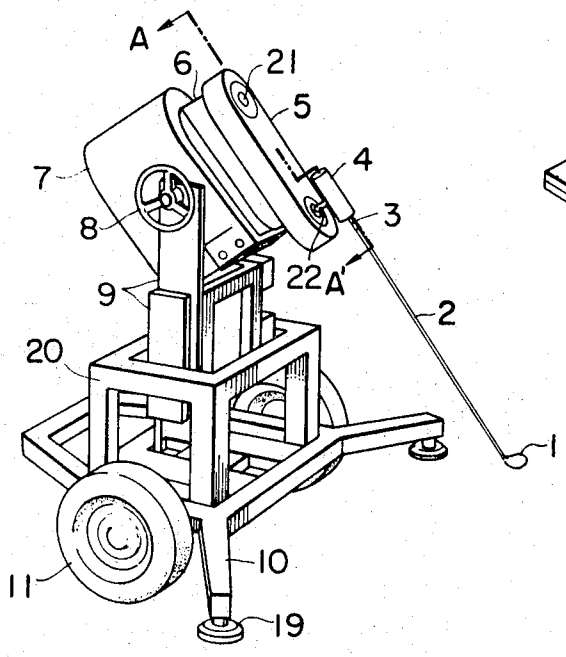


FIG. 3

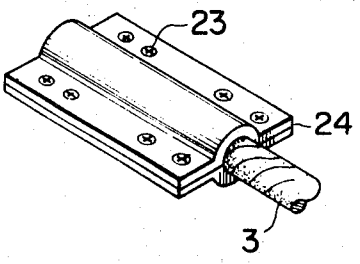


FIG. 2

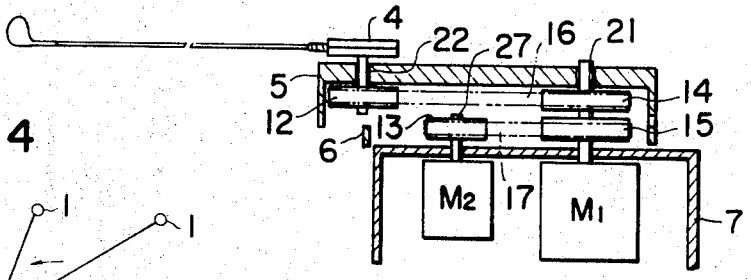


FIG. 4

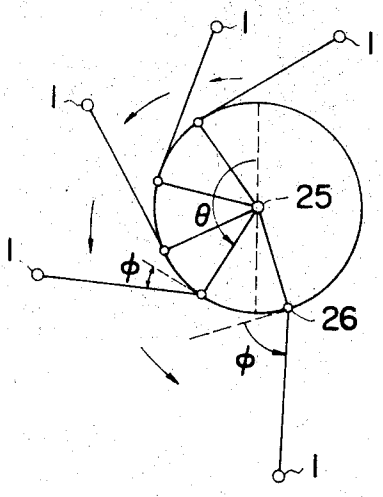


FIG. 5

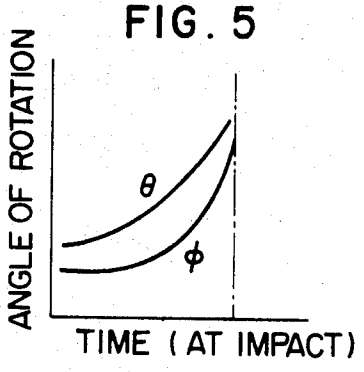


FIG. 6

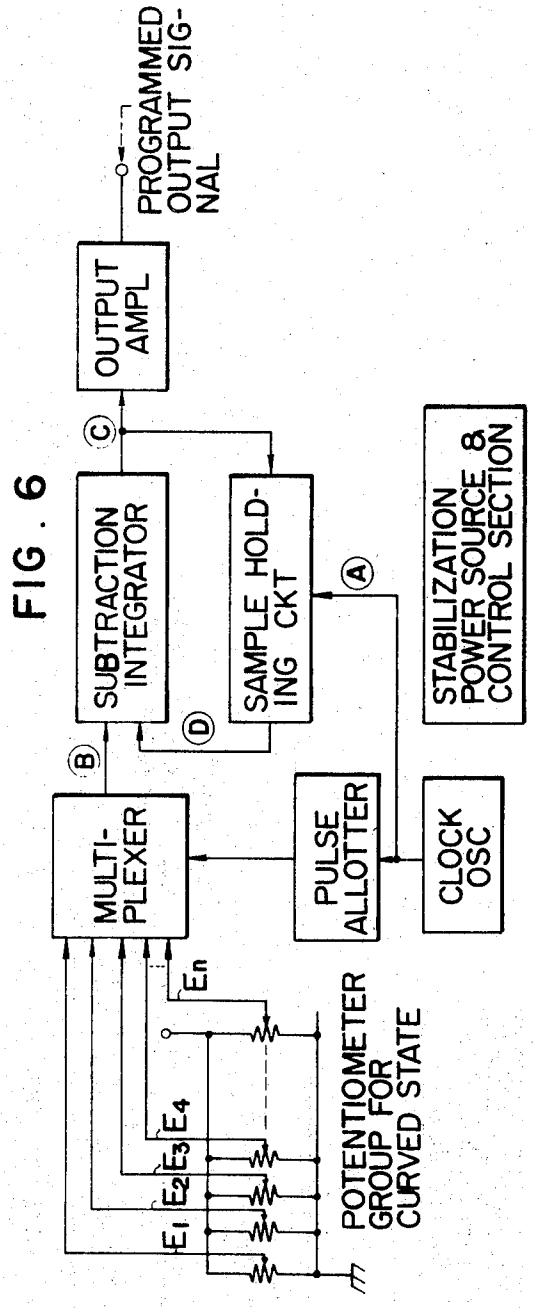

PROGRAMMED OUTPUT SIGNAL
OUTPUT AMPL
SUBTRACTION INTEGRATOR
SAMPLE HOLDING CKT
STABILIZATION POWER SOURCE & CONTROL SECTION
MULTIPLEXER
PULSE ALLOTTER
CLOCK OSC
POTENTIOMETER GROUP FOR CURVED STATE
E1
E2
E3
E4
En
A
B
C
D

FIG. 7

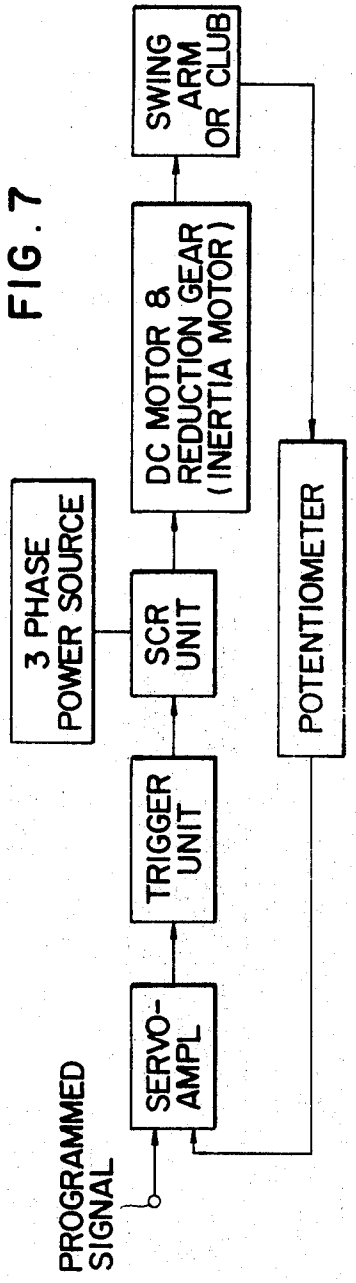

PROGRAMMED SIGNAL
SERVO-AMPL
TRIGGER UNIT
3 PHASE POWER SOURCE
SCR UNIT
DC MOTOR & REDUCTION GEAR (INERTIA MOTOR)
SWING ARM OR CLUB
POTENTIOMETER

FIG. 8

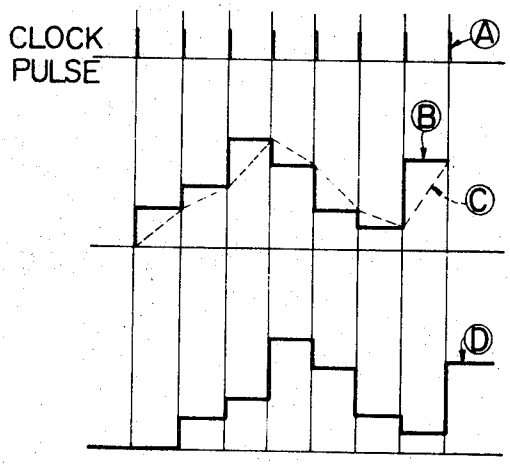


FIG. 9

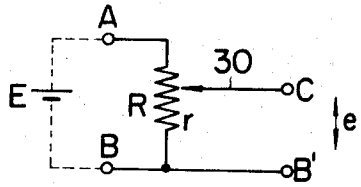
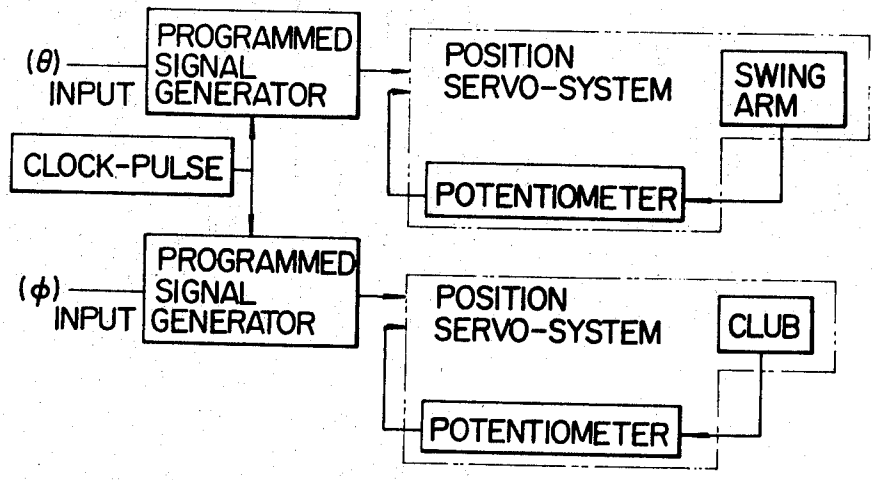


FIG. 10



APPARATUS FOR TESTING GOLF CLUBS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an apparatus for testing the dynamic characteristics of a golf club by swinging of the golf club in a manner simulating swing patterns of human golf players.

2. Description of the Prior Art

It is necessary in designing golf clubs for higher quality to test the dynamic efficiency or a property of a golf club which is appropriate for a particular swing form or pattern. This is because there are so many swing patterns among different golf players. For test purposes, absolutely identical swing patterns should be repeated. However, this requirement cannot be fully met by the human golf players because the reproducibility of a particular swing pattern is poor. Another difficulty resides in that one test player can present only one swing pattern at the most, and as such it is impossible to attain a variety of swing patterns.

SUMMARY OF THE INVENTION

According to the present invention, the difficulties encountered in testing golf clubs are eliminated, and a wide variety of swing patterns simulating those of human players are automatically obtained with complete and exact reproducibility.

Swinging motion, more specifically the downswing, of a golf club is composed of two motions: one is a rotational motion performed by a player in a plane inclined relative to the horizontal and including an over-head position in which the club-head is over the player's head with his body fully wound up and a hitting position in which the club-head just approaches impact with the golf ball with the player's body uncoiled. The other motion is also a rotational motion performed in the above plane concurrently with the former motion but its center of rotation is located at the moving wrists of the player. The apparatus according to the invention correctly simulates and puts the above two rotational motions into effect.

The main feature of the present invention resides in an apparatus for testing the dynamic efficiency of a golf club comprising an arm portion and a club-grip holder both adapted to firmly hold the grip of a golf club and to swing independently of each other with respect to a relatively stationary main body so that the golf club is caused to experience the composed swinging motion with respect to the two different centers of rotation; and driving means responsive to an electric control signal for effecting the independent swinging motions of the arm portion and of the club-grip holder.

The apparatus according to the invention is thus composed of a mechanical portion adapted to set a golf club and to cause the same to swing, and of an electric control portion adapted to effect the swinging motion of the golf club in a fashion to simulate a variety of swing patterns of human golf players.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of an apparatus for testing dynamic characteristics of a golf club according to the invention.

FIG. 2 is a cross-sectional view taken along the line A—A' of FIG. 1.

FIG. 3 is an enlarged perspective view of an embodiment of a golf club grip holder as used in the apparatus of FIG. 1.

FIG. 4 is an explanatory view showing analyzed swing angles of a golf club when a human player makes a downswing of the club.

FIG. 5 shows characteristic curves of the swing angles of FIG. 4 which are plotted against time during the time interval between the initiation of the downswing and the instant of impart with a golf ball.

FIG. 6 is a block diagram showing a programmed signal generator used with a mechanical portion of the apparatus of FIG. 1.

FIG. 7 is similar to FIG. 6 but shows a displacement servo system as used with the signal generator of FIG. 6.

FIG. 8 is a graph showing the waveforms occuring in certain portions of FIG. 6.

FIG. 9 is a schematic diagram of the poteneiometer shown in FIG. 7. potentiometer

FIG. 10 is a block diagram of the electric control portion of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in FIG. 1, a relatively stationary main body includes a motor casing 7 fastened to one of coupled supporting posts 9 and movable up and down by turning a jacking handle (not shown). The other of the supporting posts 9 is secured to a base 20 provided with a plurality of foot members 10 and with a plurality of tires 11 used for moving the apparatus as a whole. At each lower end of the foot members 10 is a locking member 19 which is threaded for locking the position of the apparatus. A tilting handle 8 is mounted on the upper end of the supporting post 9 and is manually turned for controlling the inclination of the motor casing 7 with respect to the horizontal.

Turning now to FIG. 2, two electric motors M_1 and M_2 are installed within the motor casing 7. Two pulleys 14 and 15 are rotatably mounted on shaft 21 driven by the motor M_1 and an arm portion 5 is secured to the extending end of shaft 21. The pulleys 14 and 15 may be preferably integral or coupled with each other so as to rotate simultaneously. A pulley 13 is secured to a shaft 27 driven by the motor M_2. A club-grip holder 4 and a pulley 12 are secured respectively to a shaft 22 on the outside and inside of a casing 6 of the arm portion 5. Two endless belts 17 and 16 are respectively between pulleys 13 and 15 and between pulleys 14 and 12.

With this construction, the driving force of the motor M_2 is delivered from the pulley 13 through the pulleys 15 and 14 to the pulley 12, thus rotating the shaft 22. This rotational motion is then applied to the grip holder 4 and accordingly to a golf club which includes a grip portion 3, shaft portion 2 and head portion 1. The golf club is fastened in advance to the grip holder 4. The club is caused to swing about the shaft 22 which corresponds to the center of rotation of the player's wrists. The driving force of the motor M_1 is directly delivered to the arm portion 5 through the shaft 21, which corresponds to the center of rotation of the player's body. Thus, the golf club can swing with the two centers of rotation independent of each other. Therefore, it will be easily understood that a variety of desired swing patterns, correctly simulating those of human players, are

obtainable if the motors M_1, M_2 are properly controlled.

As shown in FIG. 3, the grip holder 4 is composed of two similar plates 24 respectively having a groove of semicircular cross-section sized to receive the grip portion 3 of the golf club. After having interposed the grip portion 3 between the grooves, the mating plates 24 are clamped by a suitable locking means such as a plurality of bolts 23.

The operation of the mechanical portion of the apparatus is electrically controlled by an electric control portion in a manner as will be explained in the following. In order to attain a wide variety of swing patterns correctly simulating those of human golf players, the rotation of the motor M_1 should closely simulate the movement of the player's wrists, while the rotation of the motor M_2 should closely simulate the swinging motion of a golf club with respect to the moving wrists.

For these simulating purposes, the movement of the wrists or arms and the swinging motion of the club both during the downswing are diagrammatically analyzed in a manner as shown in FIG. 4. Here, let it be assumed that the angles of rotation taken by both of the player's arms and of the club relative to the player's wrists during a time interval between the initiation of the downswing and the impact of the club head with a golf ball are respectively denoted by θ and ϕ. These two angles θ and ϕ are converted into electric signals, which in turn are introduced into respective programmed signal generators, one of which is illustrated in FIG. 6. A programmed signal thus produced in a generator as a voltage signal is then delivered to a servo-amplifier, an SCR trigger unit (phase control) and an SCR unit electrically connected to an A.C. power source as shown in FIG. 7. The output of the SCR unit is applied to the corresponding motor M_1 or M_2 to effect the rotational operations in a finely controlled fashion. The controlled rotations of the motors will lead to the swinging motion of a golf club, as has been described. The swinging motion thus obtained is observed by suitable potentiometers, one of which is shown in FIG. 7. Each potentiometer converts the characteristics of its associated motion into a voltage signal which in turn is fed back to the servo-amplifier and compared there with the programmed signal to produce an error signal which causes the motor to follow the programmed signal. In this way, inconsistency is eliminated between the obtained swinging motion and the simulated motion expected to be obtained in accordance with the input signals corresponding to the angles θ and ϕ.

A programmed signal generator, as shown in FIG. 6, can preset a desired angle of rotation in terms of electric potentials (E_1, E_2, E_3, E_4 - - - E_n), which are determined by resistance levels of a potentiometer corresponding to a number of segments of the time interval as previously defined. The preset potentials are then applied in consecutive order of the segmental time intervals so that a stepped waveform resembling a desired curve (see FIG. 5), which indicates the angle of rotation plotted against time during the downswing, may be obtained. With reference to FIG. 6, more specifically, a stepped waveform signal is transmitted into an automatic tangent determining circuit, formed by the subtraction integrator and sample-and-hold circuit, to produce a tangential waveform resembling the particular curve.

FIg. 8 illustrates the waveforms present at points A, B, C and D in FIG. 6.

Waveform C indicates the value of a prior step of waveform B immediately after a clock pulse. Since the sample and hold circuit samples and holds the value of the waveform c, the value of waveform D is kept constant until the following sample instruction or clock pulse occurs, even if the value of waveform C varies in accordance with the lapse of time. Accordingly, the difference between the inputs B and D in the subtraction integrator is the difference in height of the steps at the preceding and following clock pulses. The slope or tangent of the integrated output C is directly proportional to the difference between B and D, and the value of C equals the value of B immediately before the following clock pulse. Though being constant, the period of the clock pulse is increased twice or ten times for a slow-motion swing. Therefore, the integrating constant of the subtraction integrator may be changed by interlocking it with the change-over switch for slow-motion.

Referring to FIG. 7, the servo-amplifier may preferably be used with a control element of the SCR type, in which the three phase electric energy is supplied from the power source and rectified. With use of this SCR system, the electric control portion can feed a control signal of sufficiently high voltage and of sufficiently high instantaneous electric current to the mechanical portion, especially the motors. However, this SCR system is not necessarily indispensable; other control units using electronic elements such as transistors may be used for rectifying the high three phase electric energy. In order to improve responsiveness of the apparatus, it may be preferable to increase the frequency of the power source. Moreover, the motors may preferably be used with a reduction unit to minimize the resultant inertia.

A detailed description will now be made of the embodiment of the present invention in which the SCR control system of FIG. 7 was employed for rectifying the electric energy of the three-phase power source. The power source used was of the type having the maximum voltage of 180 volts, the maximum instantaneous current of 100 amperes, and a frequency of 400 Hz. If, however, a suitable generator is obtainable as the power source, the output frequency may preferably exceed 1000 Hz. The motors used were of a minimum inertia type motor, made by Yasukawa Electric Company, Ltd., which was designed to minimize the moment of inertia of the rotor. The motor M_1 for controlling the angle θ had the maximum instantaneous torque of 2.5 kg.m and was used in combiantion with a reduction gear unit having a reduction ratio of 1/17. The motor M_2 for controlling the angle ϕ had a maximum instantaneous torque of 1.3 kg.m and a reduction gear unit having a reduction ratio of 1/11. Since both of the angles θ and ϕ were controlled within a range of 200°, the feed-back detector used for observing each of the obtaining swing motion was a potentiometer of the type controlled by a single turn of its shaft. The SCR trigger unit was a thyristor gate FS 3G 24-B, made by Nippon Electric Co. The manner in which an SCR unit is triggered relative to the phase of an applied A.C. wave to control the power applied to a motor is well known. The embodiment as described hereinbefore revealed that the apparatus according to the present invention can produce the desired result.

FIG. 9 schematically illustrates one form of potentiometer which may be used to observe the actual swinging motion of the club.

The motor shaft 21 of arm portion 5 and the motor shaft 22 of the grip holder 4 are respectively coupled directly to the rotating sliding contact 30 of the potentiometer either directly, or indirectly through a non-slip belt, for example. Consequently, the angle of rotation of the slider contact 30 corresponds exactly to that of motor shafts 21 and 22.

In the schematic diagram of FIG. 9, a constant voltage E is applied to the terminals A and B. When the sliding contact connected to output terminal C traverses the resistance R in accordance with the angle α of rotation of a driving shaft, the resistance value r between terminal B or B' and terminal C is directly proportional to the angle α.

Accordingly, the voltage e between terminals C and B' becomes $e = r/R \times E$; i.e. voltage e is proportional to the angle α; or as applied to this invention, the voltage e is proportional to the rotating angle θ of the shaft 21 or arm portion 5 or to the rotating angle ϕ of the shaft 22 of the club-grip holder 4.

FIG. 10 is a block diagram illustrating the manner in which the proportional signal generators (FIG. 6) and the SCR control systems (FIG. 7) are interconnected to form the complete electric control portion of the invention.

Since the apparatus of the invention employs programmed signals for controlling the operations of the mechanical portion, the change of the swing angles during the time interval of the downswing can be set more freely within its maximum angular displacement and acceleration than in the conventional automatic testing apparatus of a purely machanical type. Moreover, the swing angle change can be easily performed by turning a set dial, thus providing for a wide variety of programmed swing patterns. The electric control portion of the apparatus is supplied with voltage signals dictated by the programmed angle changes during the time interval, and includes so-called displacement servo systems in which the resultant angular displacements of the golf club closely follow the commanding voltage signals. As a result, the programming can be carried out without any complicated calculation, and as such a servo system is considerably better than a conventional pneumatic servo system which is very complicated. It should be understood that the source of driving force is not limited to the D.C. motor as used in the example but may be a hydraulic pressure motor controlled by an electric signal. In addition, the apparatus of the invention may desirably be used with a photoelectric pick-up device which is positioned in the vicinity of the impact point of a golf ball so as to detect and record the velocities of a golf club and the ball both at the instant of the impact.

While the invention has been particularly shown and described with reference to the preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

We claim:

1. An apparatus for testing dynamic characteristics of a golf club, said apparatus comprising:

a. a main body;

b. arm means rotatably mounted on said main body, said arm means swinging relative to said main body;

c. club holder means for holding said golf club and rotatably mounted on said arm means, said club holder means rotating relative to said arm means;

d. first drive means for rotating said arm means independently of said holder means;

e. second drive means independent of said first drive means, for rotating said holder means independently of said arm means; and

f. signal generator means for applying first and second program signals to said first and second drive means, respectively, whereby said drive means are controlled independently of each other by said program signals so that a plurality of golf club swing patterns may be simulated by the combination of independent operations of said first and second drive means.

2. The apparatus as set forth in claim **1** wherein each of said first and second drive means comprises:

a. potentiometer means coupled to the associated drive means for producing a position signal indicative of the actual angle of rotation of the drive means; and

b. servo-amplifier means for receiving and comparing corresponding program and position signals to produce an error signal which causes the drive means to assume the actual position called for by the value of the program signal.

* * * * *