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(54) **Control circuit for a multiple power level solenoid.**

(57) The control circuit of the invention consists of a solenoid which generates a high propelling force when the player closes a flipper switch. A primary timer circuit decreases the power when the flipper switch is held closed by a player for more than a predetermined length of time such that only a lower holding power is delivered. Thereafter, if the flipper begins to slip from its holding or static position, a sensor activates a maintenance timer circuit which again generates the higher propelling force. The maintenance timer circuit lowers the power after another predetermined length of time has expired. If the flipper again begins to slip, the maintenance timer circuit is reactivated and the cycle is repeated. Once the player releases the flipper switch, the solenoid is de-energized and both timer circuits are reset until such time as the player again depresses the flipper switch. In this manner, only the power necessary to maintain the desired mode of operation is delivered to the solenoid such that overheating and failure of the solenoid is avoided.

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BACKGROUND OF THE INVENTION

The present invention relates generally to pinball games and, more particularly, to a circuit for controlling the power delivered to a multiple power level solenoid actuator of a flipper.

In the typical pinball game, an inclined playfield supports a rolling ball and a plurality of play features. The playfield also supports a pair of flippers, the activation of which allows the player to propel, hold and/or redirect the pinball during the course of game play.

The typical flipper is used both in a dynamic mode to deliver a sufficient force to the pinball to change its direction and propel the ball across the playfield and in a static mode to hold the pinball momentarily stationary to aim it for skill shots. On average, only one-tenth the power is required to hold the flipper in the static position as compared to that required to deliver a propelling force to the pinball.

A single solenoid is used to drive each flipper such that the solenoid must be able to deliver both the propelling or dynamic force and the lower, holding or static force. Failure to reduce the power delivered to the solenoid in the static mode can result in the overheating and failure of the solenoid. As a result, various techniques have been developed to lower the power delivered to the solenoid when the flipper is in a static or holding position. A description of the techniques developed in the prior art can be found in U.S. Patent No. 4,790,536 issued to Deger and U.S. Patent No. 4,384,716 issued to Power. While these prior art systems can lower the power delivered to the solenoid in the holding position, they are unable to compensate for slippage in the flipper that may occur when the flipper is held in the static position for extended periods of time. Therefore, an improved control circuit that can efficiently and automatically maintain the power delivered to the solenoid actuator in both the dynamic and static modes is desired.

BRIEF DESCRIPTION OF THE INVENTION

The present invention overcomes the above-noted short-comings of the prior art by providing a control circuit for a solenoid actuator that is capable of delivering high power to the solenoid in the dynamic mode, reducing the power delivered to the solenoid when the flipper is employed in the static mode, and increasing the delivered power in the static mode when slippage of the flipper is detected. The control circuit of the invention preferably controls either a double coil solenoid or a solenoid having a single coil which can be energized to at least two power levels. When the player closes a flipper switch the high propelling force is generated. If the flipper switch is held closed by a player for more than a short time the power is reduced so that only the lower holding power is delivered to maintain the flipper in the static position. Thereafter, if the flipper begins to slip from its holding or static position (due to the weight of the ball thereon), a sensor activates a maintenance timer circuit which increases the power delivered by the solenoid to again generate the high propelling force. The maintenance timer circuit decreases the power delivered by the solenoid after another predetermined length of time has expired. If the flipper again begins to slip, the maintenance timer circuit is reactivated and the cycle is repeated. Once the player releases the flipper switch, the solenoid is de-energized and the circuits are reset until such time as the player again depresses the flipper switch. In this manner, only the power necessary to maintain the desired mode of operation is delivered to the solenoid such that overheating and failure of the solenoid is avoided.

OBJECTS OF THE INVENTION

It is a general object of the invention to provide an improved control circuit for a solenoid actuator that can operate in both a high power or dynamic mode and a low power or static mode to thereby avoid overheating and failure of the solenoid.

It is a further object of the invention to provide a control circuit for a pinball flipper that can increase the power delivered to the solenoid actuator in the holding or static mode if the flipper should slip from its holding position.

Other objects of the invention, in addition to those set forth above, will become apparent to one of ordinary skill in the art from the following detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a partial bottom view of the solenoid actuating mechanism of the invention mounted to the underside of a pinball playfield.

FIG. 2 shows a block diagram of the control circuit of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring more particularly to FIG. 1, the flipper mechanism of the invention includes a support 3 mounted to the underside of a playfield 9. A shaft 11 is rotatably supported in a bearing located in support 3 such that the shaft extends through an aperture formed in the playfield 9 and is disposed perpendicularly thereto. A flipper 15 is fixed to the end of the shaft 11 such that rotation of the shaft

11 results in a simultaneous rotation of flipper 15.

A solenoid 17 is secured to support 3 such that its retractable plunger 21 is arranged perpendicularly to shaft 11. A linkage 23 is fixed to shaft 11 and is pivotally connected to plunger 21 at joint 22 such that the linear reciprocating motion of plunger 21 is translated into rotational pivoting motion of shaft 11. A compression spring 25 is disposed coaxially over plunger 21 and is provided to return the plunger 21 to its extended position upon deactivation of the solenoid 17. Associated with the solenoid 17 is a player-operated flipper switch 35 (shown in FIG. 2) that energizes the solenoid thereby to control actuation of the flipper as will hereinafter be described.

An optical switch 27 is fixed to support 3 and linkage 23 carries a reflective member 29 extending therefrom such that optical switch 27 can detect the presence of the reflective member 29. Because movement of the reflective member 29 is concurrent with that of flipper 15, optical switch 27, in effect, detects the position of flipper 15. The function and operation of optical switch 27 will hereinafter be described.

Referring more particularly to FIG. 2, the control circuit for activating solenoid 17 is shown in block form. The solenoid 17 is associated with each of the game's flippers, as previously described, and consists of either a first power coil 31 and a second holding coil 33 or a single coil with a plurality of taps so that it is energizeable over a first number of turns to create the ball propelling force and a second lesser number of turns to create the holding force. In describing the operation of the control circuit, specific reference will be made to the dual coil solenoid, it being understood that the output from the control circuit can also control actuation a single coil solenoid having multiple taps.

One or more flippers may be provided for each pinball game; however, the typical game has two such flippers. The control circuit for one such flipper will be described, it being understood that, preferably, an identical control circuit would be associated with each flipper.

The player-operated switch 35 for controlling the activation of the flipper is mounted on the pinball game cabinet such that it can be activated by the player. When the player closes switch 35, a circuit is completed via line 36 whereby hold coil 33 is immediately energized and remains energized as long as the player keeps switch 35 closed. The closing of switch 35, also triggers a switch detect circuit 37. The switch detect circuit 37 is a typical NPN transistor switch. One output, 37a, is coupled to the input of the primary timer circuit 40. The other output, 37b, activates the timer reset circuit 39. The timer reset circuit 39 is also a typical NPN transistor switch.

The timer reset circuit 39 initializes the primary timer circuit 40 and a maintenance timer circuit 41 such that both timers are placed in an active mode. The primary timer circuit 40 may consist of one of the two timer circuits of a standard 556 dual timer integrated circuit chip. The primary timer circuit 40 also includes any additional support circuitry consistent with the application of the timer chip chosen, as will be readily understood by one having ordinary skill in the art of circuit design.

Once the primary timer circuit 40 has received both the signal from the timer reset circuit 39 and the trigger signal 37a from the switch detect circuit 37, it turns on the power output circuit 43 for a predetermined length of time. The power output circuit 43 is a typical two-stage transistor amplifier. The first stage includes a Darlington transistor. The second stage includes a typical PNP power transistor. Preferably, the primary timer circuit 40 turns on the power output circuit 43 for about 40 milliseconds. However, the time period can be changed by selecting different circuit components for the primary timer circuit 40 as desired. The power output circuit 43, in turn, energizes the power coil 31 for the length of time determined by the primary timer circuit 40.

It will be understood by one of ordinary skill in the art that the time delay between the time that the player activates switch 35 and the time that power coil 31 is energized is negligible. Therefore, activation of switch 35 causes the hold coil 33 and the power coil 31 to be energized virtually simultaneously. The effect is that the solenoid 17, acting under the force of both the hold coil 33 and the power coil 31, (or both portions of a multiple tap solenoid coil) quickly pivots flipper 15 thereby to deliver sufficient force to propel a pinball across the playfield.

Upon expiration of the time period determined by the primary timer circuit 40, the power output circuit 43 is turned off and the power coil 31 is de-energized such that only the hold coil 33 remains energized. As long as the player continues to depress switch 35, the hold coil 33 will remain activated and will exert force upon the plunger to maintain the flipper 15 in the static or holding position. Thus, the control circuit of the present invention, like the prior art, reduces the power delivered to the solenoid during the holding or static mode such that the solenoid will not overheat and fail.

After prolonged activation of switch 35, the flipper 15 may have a tendency to slip back toward its non-activated position, particularly if an external force is exerted on the flipper such as that produced by a pinball. The control circuit of the present invention has the capability of boosting the

power to the flipper 15 by intermittently reactivating the power coil 31 such that slippage of the flipper can be avoided, as will hereinafter be described.

The optical switch 27 is activated when reflecting member 29 is aligned therewith, that is, when the flipper 15 is in its static or holding position as shown in dashed lines in Figure 1. In the holding position the signal generated by the optical switch 27 provides a continuous signal to the slip detect circuit 45. The slip detect circuit 45 includes a simple RC smoothing network. The output of the slip detect circuit is coupled to the trigger input of the maintenance timer circuit 41. Should the flipper 15 begin to slip, reflective member 29 will begin to move away from optical switch 27 such that the slip detect circuit 45 will trigger the maintenance timer circuit 41. If a standard 556 dual timer chip of the preferred embodiment is used for the primary timer circuit 40, the second timer contained thereon can be used as the maintenance timer circuit 41.

When the maintenance timer circuit 41 receives the trigger signal from the slip detect circuit 45, the power output circuit 43 reactivates the power coil 31 to again boost the power to the solenoid and maintain the flipper in the static or holding position. The maintenance timer circuit 41 is preferably preset for a 10 milliseconds countdown such that the power coil is energized for that period. Once the 10 millisecond countdown has elapsed the power coil 31 is again deenergized such that only the hold coil 33 remains energized and the slip detect circuit again awaits a signal from the optical switch 27 that the flipper is slipping. Thus, the control circuit of the invention can maintain the flipper in the holding or static position indefinitely so long as the player keeps the player-operated flipper actuating switch 35 closed.

Once the player releases the flipper switch, the hold coil 33 is deactivated and the timer reset circuit 39 places both timers in an idle mode such that neither coil is energized. If the player again closes the flipper switch, the above-described operation will be repeated.

While the control circuit of the invention has been described with particular reference to the use with a pinball flipper actuating mechanism, it will be understood by one of ordinary skill in the art that the control circuit can be employed whenever a solenoid is required to operate in both a static or holding mode and in active or dynamic mode. While the preferred embodiment of this invention has been shown and described in some detail, it will be understood by one of ordinary skill in the art that this description and the accompanying drawings are offered merely by way of example, and that the invention is to be limited in scope only by the appended claims.

Claims

1. A control circuit for a solenoid having higher and lower power levels for moving an associated plunger from a first position to a second position and for maintaining it in the second position, comprising:
   a. first means for: (1) actuating the solenoid to cause it to move the plunger from the first position to the second position at the higher power level; (2) maintaining the plunger in the second position at the lower power level; and
   b. second means for detecting and signaling said first means of undesired slippage of said plunger away from said second position, said first means temporarily reenergizing said solenoid to said higher power level in response thereto.

2. The control circuit according to claim 1, further including means connecting said plunger to a flipper such that movement of said plunger between the first and second positions results in pivoting movement of said flipper.

3. The control circuit according to claim 1, wherein said first means includes a timer circuit for lowering the power from said higher power to said lower power after the elapse of a predetermined period of time.

4. The control circuit according to claim 3, wherein said first means includes a power output circuit controlled by said timer circuit for energizing said solenoid to said higher power level for said predetermined period of time.

5. The control circuit according to claim 3, wherein said first means includes means for initiating said timer circuit.

6. The control circuit according to claim 1, wherein said first means includes means for energizing the solenoid to the lower power level.

7. The control circuit according to claim 1, wherein said second means includes a second timer circuit for raising the power from said lower power level to said higher power level for a predetermined period of time.

8. The control circuit according to claim 1, wherein the solenoid has a single coil with a plurality of taps.

9. The control circuit according to claim 1,

wherein the solenoid has dual coils.

10. An activating device for the flipper of a pinball game, comprising:

a. a solenoid having a higher power level and a lower power level for moving its plunger from a first position to a second position and for maintaining the plunger in said second position;

b. means connecting said plunger to said flipper whereby movement of said plunger results in pivoting movement of the flipper;

c. first means for: (1) actuating the solenoid to cause it to move the plunger from the first position to the second position at the higher power level; (2) maintaining the plunger in the second position at the lower power level; and

d. second means for detecting and signaling said first means of undesired slippage of said plunger away from said second position, said first means temporarily reenergizing said solenoid to said higher power level in response thereto.

11. The control circuit according to claim 10, wherein said first means includes a timer circuit for lowering the power from said higher power to said lower power after the clasps of a predetermined period of time.

12. The control circuit according to claim 11, wherein said first means includes a power output circuit controlled by said timer circuit for energizing said solenoid to said higher power level for said predetermined period of time.

13. The control circuit according to claim 11, wherein said first means includes means for initiating said timer circuit.

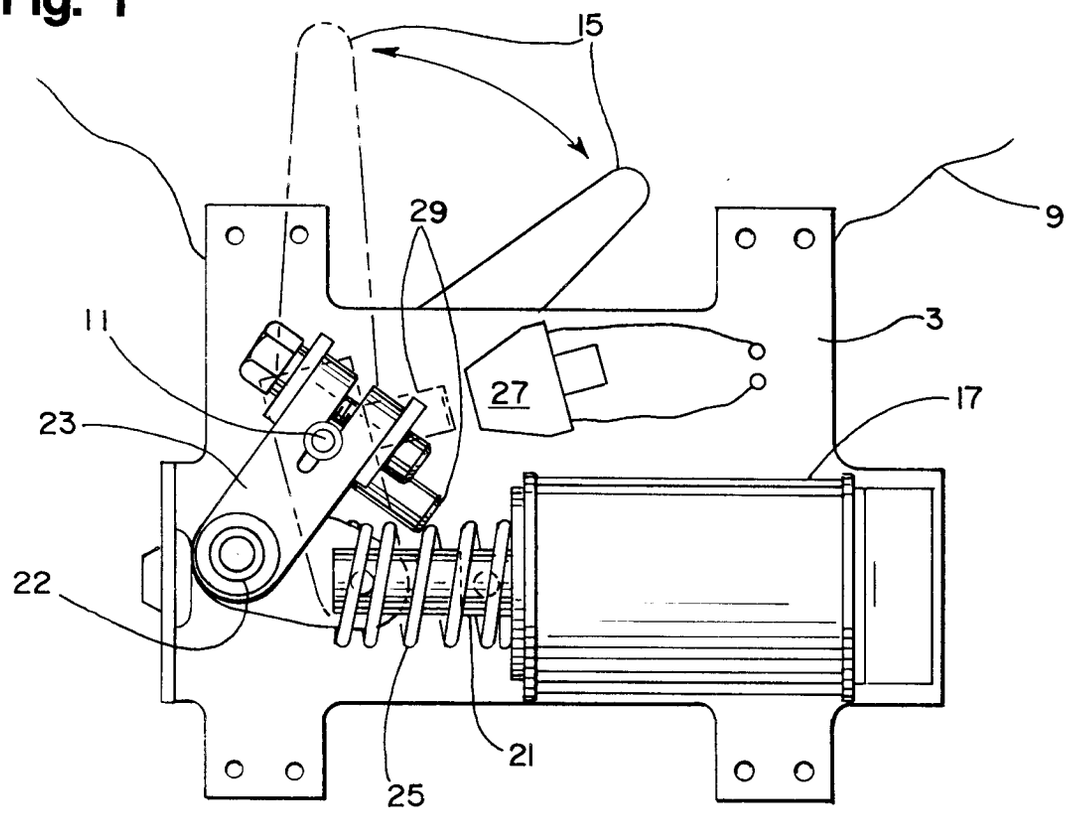
14. The control circuit according to claim 10, wherein said first means includes means for energizing the solenoid to the lower power level.

15. The control circuit according to claim 10, wherein said second means includes a second timer circuit for passing the power from said lower power level to said higher power level for a predetermined period of time.

16. The control circuit according to claim 10, wherein said solenoid has dual coils.

17. The control circuit according to claim 10, wherein the solenoid has a single coil with a plurality of taps.

Fig. 1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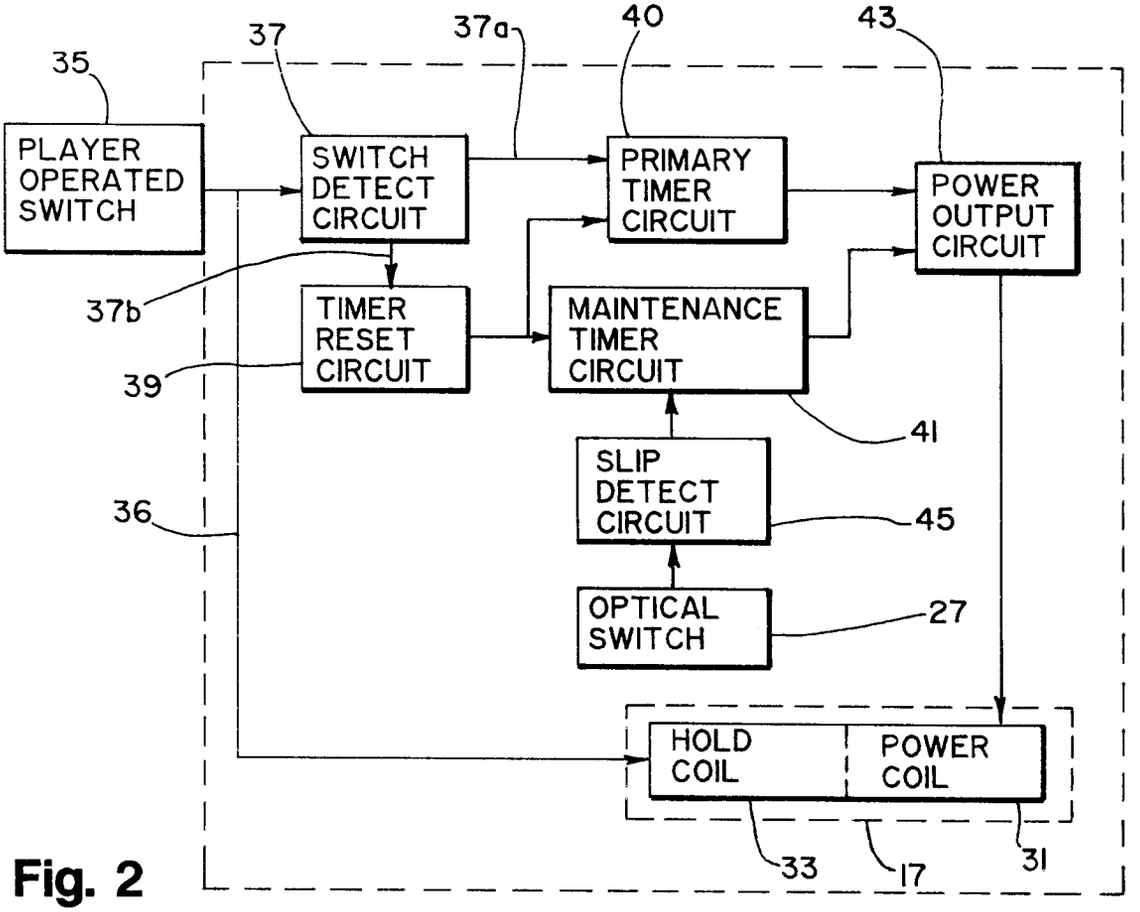
35
37
37a
40
43
PLAYER OPERATED SWITCH
SWITCH DETECT CIRCUIT
PRIMARY TIMER CIRCUIT
POWER OUTPUT CIRCUIT
37b
TIMER RESET CIRCUIT
MAINTENANCE TIMER CIRCUIT
39
41
SLIP DETECT CIRCUIT
45
36
OPTICAL SWITCH
27
HOLD COIL
POWER COIL
33
17
31

Fig. 2