June 4, 1968 H. HAIGHT 3,387,187

ELECTRICAL DRIVING CIRCUIT FOR SOLENOID-ACTUATED COUNTER

Filed Oct. 27, 1965

FIG. 1.

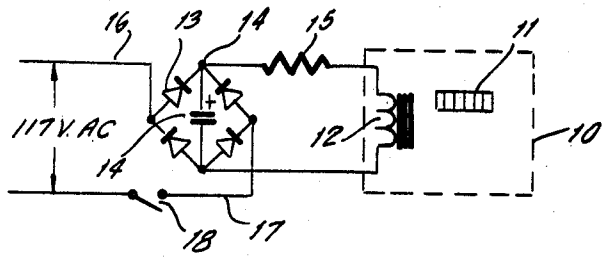
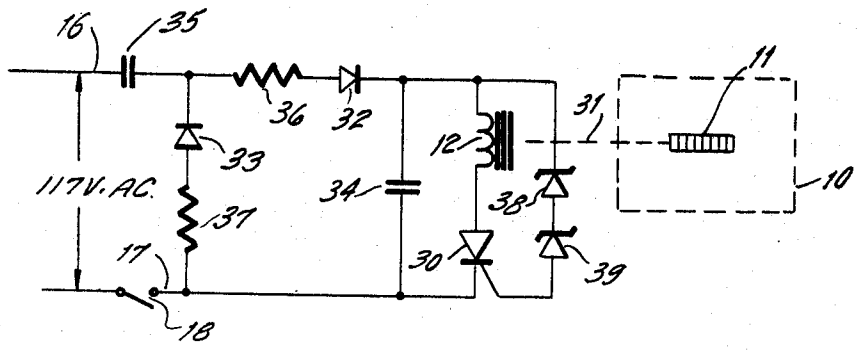


FIG. 2.



INVENTOR.
HARVEY HAIGHT

BY

OSTROLENK, FABER, GERB & SOFFEN
ATTORNEYS

United States Patent Office 3,387,187
Patented June 4, 1968

3,387,187

ELECTRICAL DRIVING CIRCUIT FOR SOLENOID-ACTUATED COUNTER

Harvey Haight, Costa Mesa, Calif., assignor to International Rectifier Corporation, El Segundo, Calif., a corporation of California

Filed Oct. 27, 1965, Ser. No. 505,337
3 Claims. (Cl. 317—148.5)

This invention relates to an electrical circuit for driving commercially available solenoid-driven counters, and more specifically relates to a novel circuit in combination with such counters wherein the counter will advance a full digit upon the closing of a momentary contact switch.

Electrically operable digital counters are well known to the art wherein an input circuit connection is available for the connection of a circuit which includes a momentary contact switch with the counter counting the number of operations of the momentary contact switch.

The usual drive circuit available with such counters and which is normally built into the counter is such that the closing of the contact switch will advance the counter only a half number with the full number showing only when the voltage is removed, whereupon the counter advances the remaining half number.

This type of display can be extremely misleading, since if the counter is observed with only the half number displayed, the counter dial cannot be easily read, and is subject to copying of erroneous data from the counter.

One of the primary reasons for this operation is that the counter may be actuated over an appreciable period of time so that the usual input RC circuit which provides energy to the operating solenoid of the counter must be so chosen that the solenoid will not overheat. Moreover, under these conditions, the energy available to drive the solenoid is insufficient to insure good reliability as the counter ages and lubrication within the counter dries and there is wear in the mechanical components of the counter.

In accordance with the present invention, a novel drive circuit is provided for energizing a standard counter solenoid which includes a controlled rectifier or thyristor driven from a voltage doubler circuit. This novel circuit permits the connection to the solenoid of a high energy pulse which has a relatively short length, thereby to insure the complete advancement within the counter of a full number within a relatively short time, even though the momentary contact signal is held closed for a relatively long time.

Accordingly, a primary object of this invention is to provide a novel electrical drive circuit for driving a solenoid-operated counter.

Yet another object of this invention is to eliminate the display of half number advancement in a solenoid-driven digital counter.

These and other objects of this invention will become apparent from the following description when taken in connection with the drawings, in which:

FIGURE 1 illustrates a typical prior art electrical circuit which energizes the solenoid of a standard commercially available solenoid-driven digital counter.

FIGURE 2 illustrates the circuit of the present invention which replaces the circuit of FIGURE 1 and insures a strong snap action in the movement of the counter dials so that a complete full number advancement is available on the closure of the momentary closing signaling switch.

Referring first to FIGURE 1, I have illustrated therein a standard digital counter **10** having a digital dial readout **11** which is driven from the schematically illustrated solenoid coil **12**. In particular, the invention has been applied to a counter type number CE8008S602 which is

available from the Production Instruments Division of General Controls Corporation.

As pointed out above, the counter **10** has built therein a suitable mechanism which is not necessary to describe for purposes of the present invention and which is well known to those skilled in the art whereby the energization of solenoid **12** by an electrical pulse will cause the counter **10** to advance one digit.

Also built within the counter is a rectifier bridge **13** having capacitor **14** connected across its D-C terminals. The D-C terminals of bridge **13** are further connected in series with resistor **15** and solenoid coil **12**. It should be understood that the components **13**, **14**, **15**, as well as the solenoid counter **12**, may all be contained within the housing of the counter **10**. The housing may then be provided with external lead connections for receiving input terminals **16** and **17**.

In order to operate the counter, the leads **16** and **17** are connected to a suitable A-C voltage source which could be a standard 117 volt 60-cycle source with a switch **18** connected in series with lead **17**.

The switch **18** is then connected to other equipment which performs functions which are to be counted by the counter **10**. That is to say, the counter **10** will count the number of times that switch **18** is closed.

It will be apparent from FIGURE 1 that the circuit operates by charging capacitor **14** responsive to closure of switch **18** through the solenoid **12** and resistor **15**. Thus, the solenoid **12** conducts a pulse current, the time constant of which is determined by the value of resistor **15** and capacitor **14**.

In designing such a circuit, and where the counter is to be operated over an extended period of time, it will be apparent that the values for the resistor **15** and capacitor **14** must be chosen so that the solenoid **12** will not overheat. Under these conditions, however, insufficient energy is available to advance the counter a full number, whereby the application of an electrical pulse through this circuit will advance the counter only a half number, with the full number being shown only when voltage is removed by the opening switch **18**. Moreover, and as indicated previously, the energy available is also insufficient to insure reliable operation of the counter as the counter ages and lubrication dries out and the counter parts wear.

The novel circuit of the invention is shown in FIGURE 2 wherein the electrical circuit of FIGURE 1 is modified by the provision of a controlled rectifier **30** which is connected in series with the solenoid coil **12** which is contained within the counter **10**, as indicated by the dotted line connection **31**. The controlled rectifier **30** is driven by the voltage doubler circuit which includes rectifiers **32** and **33** and capacitors **34** and **35**. Current limiting resistors **36** and **37** are then connected in series with rectifiers **32** and **33**, respectively, while two series connected Zener diodes **38** and **39** are connected between solenoid **12**, input and the gate of series connected controlled rectifier **30**.

It should be noted that all of the components referred to above in FIGURE 2 can be contained within the housing of counter **10**.

The input terminals of the housing **10** are then connected to input conductors **16** and **17** which are connectable to a suitable source of voltage such as the 117 voltage A-C source with the lead **17** (or lead **16**) containing the operating switch **18**.

In operation, and when the switch **18** closes, the capacitor **34** begins to charge toward a peak voltage of approximately 2.8 times the line RMS voltage which is connected to leads **16** and **17**.

However, prior to reaching this full peak voltage and in the particular example of the invention, when the volt-

age of capacitor **34** reaches 260 volts, the Zener diodes **38** and **39**, which are connected to the gate circuit of controlled rectifier **30**, conduct sufficiently to fire the controlled rectifier **30**. This permits the discharge of capacitor **34** through the solenoid **12** and controlled rectifier **30** with the substantial energy available from capacito **34** causing extremely sharp snap action of the digital dials of counter **10**.

After the initial discharge of capacitor **34**, the current from the half-wave doubler power supply becomes markedly limited by the resistors **36** and **37** so that the voltage across the solenoid immediately drops appreciably below its rated D-C value which is, in the example given, 120 volts D-C. Thus, the counter is advanced a full number shortly after the switch is closed, and there will be limited heat dissipation in the coil **12**, even though A-C voltage is sustained through the continued contact engagement at switch **18**. That is to say, the counter will immediately advance a full number rather than merely advance a half number due to insufficient energy available from the solenoid energizing source by virtue of limitations in the design of the RC circuit of FIGURE 1.

It will also be noted that the time constant set by the value of capacitor **34** and the solenoid resistance, as well as the inductive effect of the solenoid when switch **18** is opened, permits the controlled rectifier **30** to reset very rapidly. Thus, the maximum operation rate becomes dependent primarily on the values of resistors **36** and **37**, and capacitors **34** and **35**.

In a typical application of the invention, the following values were used in connection with the previously described counter which has a 115 volt D-C solenoid for driving the counter mechanism:

Capacitor **35**	10 mf. @ 450 v. DC.
Capacitor **34**	10 mf. @ 450 v. DC.
Zener diode **38**	IN3047B (130 v. @ 1 w.).
Zener diode **39**	IN3047B (130 v. @ 1 w.).
Diode **32**	10D6 (1 a. @ 600 v.).
Diode **33**	10D6 (1 a. @ 600 v.).
Thyristor **30**	5RC40 (5 a. @ 400 v.).
Resistor **36**	250 ohms 10 w.
Resistor **37**	250 ohms 10 w.

Although this invention has been described with respect to its preferred embodiments, it should be understood that many variations and modifications will now be obvious to those skilled in the art, and it is preferred, therefore, that the scope of the invention be limited now by the specific disclosure herein, but only by the appended claims.

The embodiments of the invention in which an exclusive privilege or property is claimed are defined as follows:

1. In a solenoid actuated counter; a solenoid coil, a counter dial operatively connected to said solenoid coil and advanceable by one number responsive to energization of said solenoid coil, and an energizing circuit connected to said solenoid coil; said energizing circuit comprising a voltage doubler circuit having A-C input terminals and D-C positive and negative output terminals, a controlled rectifier having anode, cathode and gate terminals, and Zener diode means; said input terminals connectable to a 117 volt A-C line; said anode and cathode terminals of said controlled rectifier connected in series with said solenoid coil and in series with said output terminals of said doubler circuit; said controlled rectifier having a forward conduction direction for conducting the D-C output current of said voltage doubler circuit; said Zener diode means connected in closed series relation with said solenoid coil and said anode terminal and said gate terminal of said controlled rectifier and having a forward conduction direction in said closed series connection to conduct in the same direction as the anode current of said controlled rectifier.

2. The device substantially as set forth in claim **1** wherein the dropout voltage of said solenoid coil is lower than the line voltage connected to said input terminals of said A-C line.

3. The device substantially as set forth in claim **1** wherein said voltage doubler circuit comprises a first and second diode, a first and second capacitor, and a first and second resistor; said first capacitor, resistor and diode connected in a first series connection and in series with said A-C terminals; said second capacitor, resistor and diode connected in a second series connection with one another; said second series connection being in parallel with said series connected first resistor and said first diode; said second capacitor being in parallel with said series connected solenoid coil and anode and cathode terminals of said controlled rectifier.

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LEE T. HIX, *Primary Examiner.*