March 25, 1969 H. S. SCHWARTZ 3,435,299

CIRCUIT FOR ENERGIZING AN ELECTROMAGNET

Filed May 20, 1966 Sheet 1 of 2

Fig. 1.

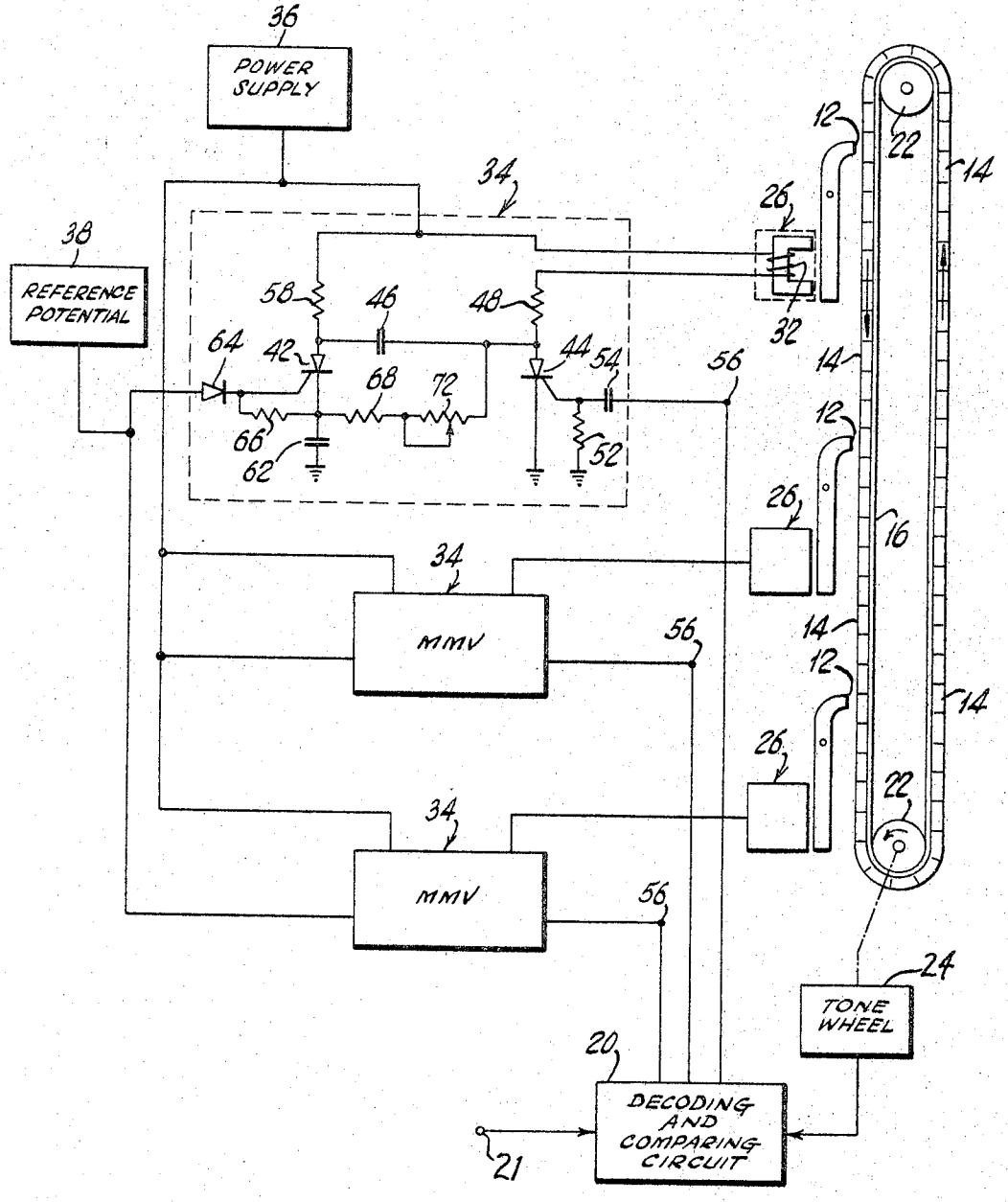

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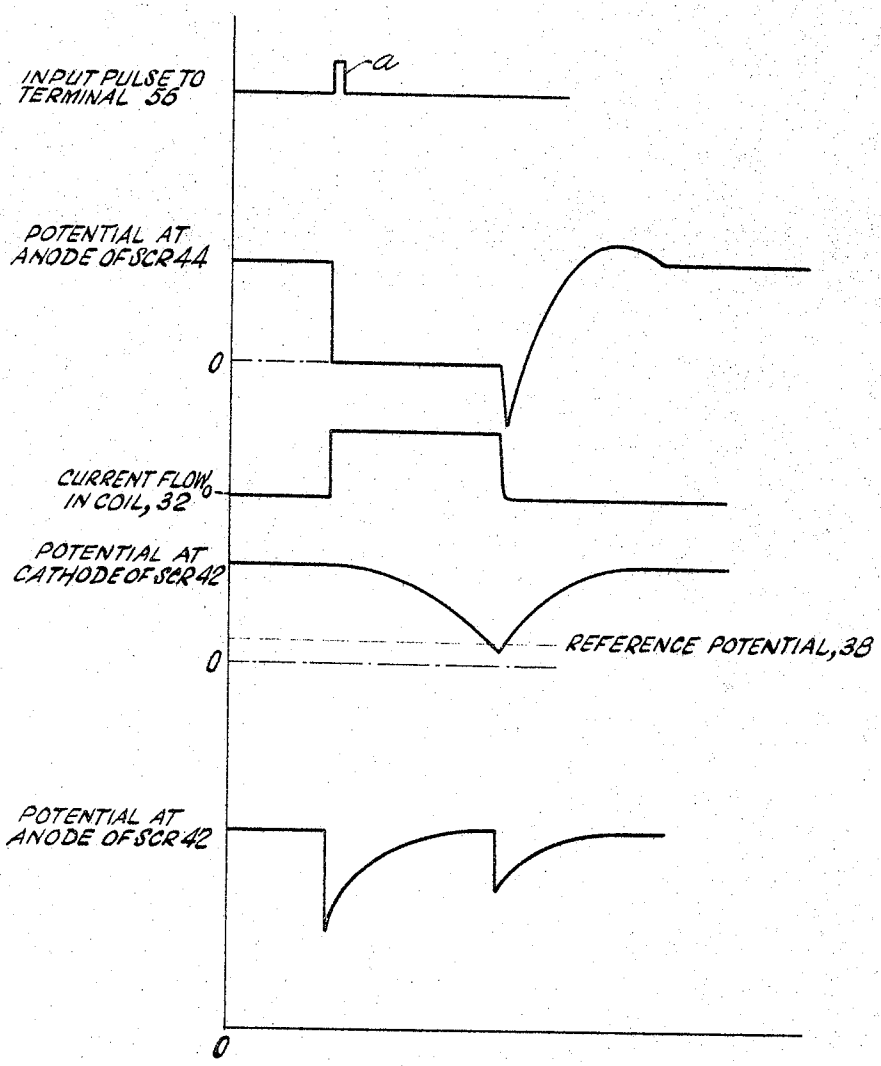
Fig. 2.



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CIRCUIT FOR ENERGIZING AN ELECTROMAGNET

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U.S. Cl. 317—148.5 3 Claims

ABSTRACT OF THE DISCLOSURE

A single-shot multivibrator circuit employing a silicon control rectifier for actuating an electromagnet in which a potentiometer is used to vary the time constant in the circuit.

This invention relates to a circuit for energizing an electromagnet and, more particularly, to an improved silicon control rectifier circuit for firing a solenoid actuated hammer in a high speed data printer.

Certain high speed impact printers known in the prior art employ a number of electromagnetically operated print hammers in combination with type faces which are mounted on a continuously circulating belt or drum. A tone wheel or other similar device produces an output signal consisting of a series of pulses indicative of the position of the type faces relative to the hammers. This output signal is coupled as one input to electronic circuit, the other input to which is an input data signal from a computer, for example. The electronic circuit produces an output pulse to fire a hammer when the type face opposite that hammer has the character specified to be printed by the input data.

In printing, each hammer must be rapidly accelerated from a rest position and rapidly returned to its rest position in order that the type face be correctly positioned and essentially stationary during the period of impact. To achieve the necessary acceleration and impact force necessary for printing, high energy (150 watts, for example) pulses are required for energizing the hammer solenoid. In addition, to achieve printing that is uniform in appearance, the duration and total energy of the drive pulses must be accurately controlled.

A number of circuits have been proposed in the prior art for firing electromagnetically operated printer hammers. However, these circuits have proved to be expensive in their construction or inefficient in their operation or require elaborately regulated power supplies or a combination of these disadvantages.

One object of this invention is the provision of an improved circuit for firing printer hammers, which is less expensive to construct than those of the prior art.

Another object of this invention is to provide an improved circuit which operates efficiently and at a relatively high voltage as compared to printer hammer firing circuits of the prior art.

A further object of this invention is to provide a printer hammer firing circuit, which can operate from relatively inexpensive power supply which supplies the firing circuits of all the hammers.

One more object of this invention is the provision of an improved printer hammer firing circuit which provides a current pulse with a short rise time and a predetermined, adjustable magnitude.

Briefly, this invention contemplates the provision of a hammer firing circuit in which the anodes of a pair of silicon controlled rectifiers (SCR's) are cross coupled by a commutating capacitor to form a monostable multivibrator. Hammer firing pulses are coupled to the gate electrode of one (first) SCR and a fixed reference potential, which is common to all the hammer firing circuits of the printer, is coupled to the gate of the other (second) SCR.

The hammer solenoid is coupled in series between the positive terminal of a low impedance power supply and the anode of the first SCR; a timing capacitor is coupled in series between the cathode of the second SCR and the negative side of the power supply.

In the stable state of the circuit, both SCR's are in a high impedance state. Following a firing pulse, the first SCR switches to its low impedance state. The timing capacitor simultaneously commences to discharge at a predetermined, adjustable rate through a resistor and the first SCR. When the cathode potential of the second SCR drops below the reference potential, it switches to its low impedance state and thereby effectively couples the commutating capacitor across the first SCR, back biasing it and switching it to its high impedance state. Thereafter, the second SCR switches to its high impedance state since the current flow through it rapidly falls below the value necessary to sustain conduction owing to the series coupled timing capacitor. The circuit is thus returned to its stable state.

Having briefly described this invention, it will be described in greater detail along with other objects and advantages in the following detailed description of a preferred embodiment which may be best understood by reference in the accompanying drawings which form part of the instant specification and which are to be read in conjunction therewith and which like reference numerals are used to indicate like parts in the various views;

FIG. 1 is partially a schematic diagram of one embodiment of an improved hammer firing monostable multivibrator constructed in accordance with this invention, and is partially a block diagram showing certain components of a high speed printer in which the monostable multivibrator shown schematically is used; and

FIG. 2 is a timing diagram of typical, idealized wave forms for the firing circuit shown schematically in FIG. 1.

Referring now to FIG. 1, a high speed impact printer typical of those known in the prior art has a row of pivotally mounted hammers **12** disposed in a line adjacent a chain formed of type slugs **14** secured to a belt **16** in a manner known in the art. A pair of drive sprockets or pulleys **22** continuously circulate the belt **16** in a counterclockwise direction, for example, and a tone wheel **24**, or other suitable apparatus known in the art, coupled to one of the pulleys produces a series of output pulses which are indicative of the position of the slugs **14** relative to the hammers **12**. These output pulses are coupled as one input to a decoding and comparing circuit **20**. An input from a computer or magnetic tape transport or the like is coupled to another input terminal **21** of the circuit **20**.

As will be appreciated readily by those skilled in the art, the three hammers shown are merely representative. A typical printer actually employs from 60 to 120 hammers. Additionally, it will be understood that this invention is equally applicable to printers employing a continuously rotating drum as to printers employing a chain or belt as shown.

An electromagnet **26** is disposed to attract an armature secured to the shaft of the hammer **12** and to thereby cause the head of the hammer to strike a web of paper (not shown) passing between the hammers and the slugs **14** and to push the web against one of the type slugs. Each electromagnet comprises a U-shaped core of low permeable material such as iron and a coil **32** made of a large number of turns of low resistance wire wrapped around the base of the core.

In accordance with this invention, the solenoid **32** for each hammer **12** is energized by a respective SCR monostable multivibrator circuit generally indicated by the reference numeral **34**. All of the monostable multivibrators are coupled to a common low impedance direct current (D.C.) power supply **36**, and to a common D.C. reference potential source **38**. Since all of the multivibrator circuits are identical, only the circuit coupled to the uppermost hammer in FIG. 1 is shown in detail.

Each multivibrator circuit comprises a pair of silicon controlled rectifiers **42** and **44** whose anodes are interconnected by a commutating capacitor **46**. The coil **32** is connected in series between the positive terminal of the power supply **36** and the anode of SCR **44**. It should be noted that the D.C. impedance in series with the coil **32** determines both the rise time of a current pulse in coil **32** (the larger the series resistance the smaller the rise time) and, for a given power supply potential, the current flow through the coil (the larger the resistance, the smaller current flow). It is desirable, of course, that the rise time be short and the current flow large. It has been found advantageous to operate with series resistance of approximately 50 ohms in most applications and a relatively high source voltage. The coil **32** is advantageously made so that it has as low a distributed resistance as is practical in order that the amount of heat which must be dissipated from the coil be as small as possible. For this reason, preferably, an external resistor **48** is coupled in series with the coil to provide the desired operating characteristic.

The gate electrode of SCR **44** is coupled through a pulse differentiating network (resistor **52** and capacitor **54**) to a terminal **56** to which is coupled one output terminal of circuit **20**. Positive pulses coupled to terminal **56** cause SCR **44** to switch from its high impedance to its low impedance state.

A resistor **58** couples the anode of SCR **42** to the positive terminal of the power supply **36**; a timing capacitor **62** couples its cathode to the negative or ground terminal of the power supply **36**. A forwardly biased diode **64** couples the gate electrode of SCR **42** to a positive terminal of the D.C. reference potential **38**, and the gate to cathode bias for SCR **42** develops across a resistor **66** which interconnects these electrodes.

Resistor **68** and potentiometer **72** couple the cathode of SCR **42** to the anode of SCR **44** so that, when SCR **44** is in its low impedance state, resistor **68** and potentiometer **72** form a discharge path for the timing capacitor **62**. As will be obvious to those skilled in the art, the time constant of the R-C circuit comprising resistor **68** and potentiometer **72** and capacitor **62** may be varied by varying the potentiometer **72**.

Referring now to FIG. 2 in addition to FIG. 1, in operation SCR **42** and SCR **44** are both initially in their high impedance (non-conducting) state so that the potential at the anode of each is approximately equal to the potential at the positive terminal of power supply **36**. In response to a trigger pulse *a* at terminal **56**, SCR **44** switches to its low impedance state and its anode rapidly drops to approximately ground potential. Current flow through coil **32** rises rapidly, energizing the solenoid and thereby firing the hammer. Current also flows from power supply **36**, through resistor **58**, commutating capacitor **46** and SCR **44**, charging capacitor **46** until the potential on the left-hand side of the capacitor equals the potential at the positive terminal of supply **36**.

Timing capacitor **62**, which had been charged to the potential of power supply **36**, commences to discharge through resistor **68**, potentiometer **72** and SCR **44**. When the potential of the cathode of SCR **42** drops slightly below the reference potential **38**, SCR **42** switches to its low impedance state, effectively coupling commutating capacitor **46** across SCR **44**, thereby back biasing SCR **44** and switching it to its high impedance state. Following the termination of conduction through SCR **44**, the value of current flow through SCR **42** rapidly falls below the value needed to sustain conduction owing to the series coupled timing capacitor **62**, and SCR **42** switches to its high impedance state.

Current flow through SCR **42** prior to its switching to its high impedance state charges capacitor **62** to approximately the potential of power supply **36**, thus returning to its initial stable state. The circuit will remain in this state until another positive pulse is applied to terminal **56**.

It should be noted that SCR **42** may not switch to its high impedance state if the leakage current through capacitor **62** is larger than that necessary to sustain conduction in SCR **42**. However, this does not affect the overall operation of the circuit since SCR **42** will be switched to its high impedance state in any event following the switching of SCR **44** to its low impedance state owing to the commutating action of capacitor **46** following the switching of SCR **44**.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims. It is further obvious that various changes may be made in details within the scope of the claims without departing from the spirit of the invention. It is, therefore, to be understood that this invention is not to be limited to the specific deals shown and described.

Having thus described the invention, what is claimed is:

1. A monostable multivibrator circuit for energizing an electromagnet comprising in combination:

a first silicon control rectifier (SCR) having an anode, a cathode and a gate electrode, and having a first state in which the impedance between said anode and said cathode is a high value and a second state in which the impedance between said anode and said cathode is a low value,

a power supply,

an electromagnet,

means for coupling said electromagnet in a series between one terminal of power supply and the anode of said first silicon control rectifier,

a source of pulses for switching said first SCR from said high impedance state to said low impedance state,

means for coupling said pulse source to the gate electrode of said first SCR,

a second SCR having an anode, a cathode and a gate electrode and having a first state in which the impedance from said anode to said cathode is a high value and a second state in which the impedance from said anode to said cathode is a low value,

means for coupling said one terminal of said power supply to the anode of said second SCR,

a reference potential source,

means for coupling the gate electrode of said second SCR to said reference potential source,

a timing capacitor coupled in series with the cathode of said second SCR,

means for charging said timing capacitor to a potential higher than said reference potential,

means including said first SCR and means for varying the time constant of said timing capacitor for discharging said timing capacitor at a predetermined adjustable rate to a potential below said reference potential, thereby causing said second SCR to switch to its low impedance second state, and

a commutating capacitor coupling the anode of said first SCR to the anode of said second SCR whereby said first SCR is back biased and switches to its high impedance state when said second SCR switches to its low impedance state.

2. An electronic circuit as in claim **1** wherein said time constant varying means includes a potentiometer.

3. An electronic circuit as in claim **2** further including a resistor coupled in series with said electromagnet and said anode.

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U.S. Cl. X.R.

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